# Chapter 2

# PREPARING TEACHERS
# TO DELIVER 21ST–CENTURY SKILLS

Many nations around the world have undertaken wide-ranging reforms of curriculum, instruction, and assessments with the intention of better preparing all children for the higher educational demands of life and work in the 21st century. What are the skills that young people need to be successful in this rapidly changing world and what competencies do teachers need, in turn, to effectively teach those skills to their students? The question that arises from this is, of course, what teacher preparation programs are needed to prepare graduates who are ready to teach well in a 21st-century classroom. This question is, however, still difficult to answer with available comparative evidence.

## CHANGES IN THE DEMAND FOR STUDENT SKILLS

The world is rapidly becoming a different place, and the challenges to individuals and societies imposed by globalization and modernization are widely acknowledged. Perhaps the most challenging dilemma for educators in the 21st century is that routine, rule-based, knowledge, which is easiest to teach and to test, is also easiest to digitize, automate and outsource. The issue of 21st-century skills[1] is by no means orthogonal to traditional school subjects but, in fact, equally relevant to the latter. Take *mathematics* as an example. Traditionally mathematics is often taught in an abstract mathematical world, using formalism first, removed from authentic contexts, and discouraging to the students that do not see its relevance – for example, students are taught the techniques of arithmetic, then given lots of arithmetic computations to complete; or they are shown how to solve particular types of equations, then given lots of similar equations to solve. In contrast, in the 21st century, students need to have an understanding of the fundamental concepts of mathematics, they need to be able to translate a new situation or problem they face into a form that exposes the relevance of mathematics, make the problem amenable to mathematical treatment, identify and use the relevant mathematical knowledge to solve the problem, and then evaluate the solution in the original problem context. Further, their creativity can be enhanced by devising novel solutions, and even new problems with non-standard solutions. *Literacy* provides another example. In the past, literacy was mainly about *learning to read*, a set of technical skills that individuals would acquire once for a lifetime in order to process an established body of coded knowledge. In the 21st century, literacy is about *reading for learning*, the capacity and motivation to identify, understand, interpret, create and communicate knowledge, using written materials associated with varying situations in continuously changing contexts. In the past, it was sufficient to direct students to an encyclopedia to find the answer to a question, and they could generally rely on what they found to be true. Today, literacy is about curiosity and self-direction, managing non-linear information structures, building one's own mental representation and synthesis of information as one finds one's own way through hypertext on the Internet, about dealing with ambiguity, developing healthy skepticism, an inquiring mindset, and interpreting and resolving conflicting pieces of information.

Similarly, the conventional approach of schools to problems was to break these down into manageable bits and pieces, and then teaching students the techniques to solve them. But today individuals create value by synthesizing the disparate bits. This is about openmindedness and making connections between ideas that previously seemed unrelated, which requires being familiar with and receptive to knowledge in different fields. The world is also no longer divided into specialists and generalists. What counts today are the versatilists who are able to apply depth of skill to a progressively widening scope of situations and experiences, gaining new competencies, building relationships, and assuming new roles. They are capable not only of constantly adapting but also of constantly learning and growing, of positioning themselves and repositioning themselves in a fast changing world.

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### Box 2.1  ATC21S – Assessment and Teaching of 21st-Century Skills

Starting from the premise that learning to collaborate with others and connecting through technology are essential skills in a knowledge-based economy, the Assessment and Teaching of 21st-Century Skills project brought together more than 250 researchers across 60 institutions worldwide who categorized 21st-century skills internationally into four broad categories:

**Ways of thinking.** Creativity, critical thinking, problem-solving, decision-making and learning

**Ways of working.** Communication and collaboration

**Tools for working**. Information and communications technology (ICT) and information literacy

**Skills for living in the world.** Citizenship, life and career, and personal and social responsibility

The project also outlines the nature of assessment systems that can support changes in practice, illustrates the use of technology to transform assessment systems and learning, and proposes a model for assessing 21st-century skills.

For further information, see *www.atc21s.org.*

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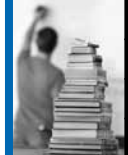
Charles Fadel[2] identifies the following dimensions of a 21st-century education, and the related challenges for curricula:

**Knowledge** – relevance required: students' lack of motivation, and often disengagement, reflects the inability of education systems to connect the content to real-world relevance. The author suggests a need to rethink the significance and applicability of what is taught, and in concert to strike a better balance between the conceptual and the practical.

**Skills** – necessity for education outcomes: higher-order skills ("21st-Century Skills") such as the "4 C's" of Creativity, Critical thinking, Communication, Collaboration. The author notes that curricula are already overburdened with content, which makes it much harder for students to acquire (and teachers to teach) skills via deep dives into projects. He notes further that, while there is some consensus on what the skills are, and how teaching methods via projects can affect skills acquisition, there is little time available during the school year given the overwhelming nature of content curricula, and that there is little in terms of teacher expertise in combining knowledge and skills in a coherent ensemble, with guiding materials, and assessments.

**Character** (behaviors, attitudes, values) – to face an increasingly challenging world: as complexities ramp up, humankind is rediscovering the importance of teaching character traits such as performance-related traits (adaptability, persistence, resilience) and moral-related traits (integrity, justice, empathy, ethics). The author describes the challenges for public school systems as similar to those for skills, with the extra complexity of accepting that character development is also becoming an intrinsic part of the mission, as it is for private schools.

**Meta-Layer** (learning how to learn, interdisciplinarity, systems thinking, personalization, etc.) – often neglected, or merely mentioned and not acted upon deterministically, this "meta-layer" enveloping the other three dimensions is essential for establishing lifelong learning habits, activating transference, building expertise, fostering creativity via analogies, enhancing versatility, addressing individual students' needs, and so on.

Of all 21st-century skills, creativity and innovation deserve a special mention: At the country, organization, and personal levels, the two have become the recognized hope for solving employability, personal, and societal crises. Schools need to nurture creativity and innovation in their students, deliberately and systematically, and across all disciplines not only through the Arts.

Last but not least, in today's schools, students typically learn individually and at the end of the school year, schools certify their individual achievements. But the more interdependent the world becomes, the more important the capacity of individuals to collaborate and orchestrate becomes. In the flat world, everything that is proprietary knowledge today will be a commodity available to everyone else tomorrow. There is a shift from a world of stocks – with knowledge that is stacked up somewhere depreciating rapidly in value – to a world in which the enriching power of communication and collaborative flows is increasing.

While there have been numerous efforts to systematize 21st-century skills (see Box 2.1 for an example) most of the resulting frameworks share the above features.

## A DEMANDING AGENDA FOR TEACHERS

Changes in the demand for skills have profound implications for the competencies which teachers themselves need to acquire to effectively teach 21st-century skills to their students. A generation ago, when teachers could reasonably expect that what they taught would last for a lifetime, teaching a fixed syllabus of content was at the center of education in most countries. Today, where individuals can access content on search engines, where routine rule based knowledge is being digitized or outsourced, and where jobs are changing rapidly, teachers need to enable people to become lifelong learners, to manage non-rule-based complex ways of thinking and complex ways of working that computers cannot take over easily. In the past, the policy focus was on the provision of education, today it is on outcomes, shifting from looking upwards in the hierarchy towards looking outwards to the next teacher, the next school. The past was about delivered wisdom, the challenge now is to foster user-generated wisdom among teachers and school leaders in the front line. In the past, different students were taught in

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similar ways; today teachers are expected to embrace diversity with differentiated pedagogical practices. The goal of the past was standardization and conformity, today it is about being ingenious, about personalizing educational experiences; the past was curriculum centered, the present is learner centered, which means that education systems increasingly need to identify how individuals learn differently and foster new forms of educational provision that take learning to the learner and allow individuals to learn in the ways that are most conducive to their progress.

In short, the kind of education needed today requires teachers to be high-level knowledge workers who constantly advance their own professional knowledge as well as that of their profession. Teachers need to be agents of innovation not least because innovation is critically important for generating new sources of growth through improved efficiency and productivity.[3] This is also true in the education sector, where innovation applied to both curricula and teaching methods can help to improve learning outcomes and prepare students for the rapidly changing demands of the 21st-century labor market. While innovative teaching is recognized in both school evaluations and teacher-appraisal systems in many countries, it is sobering to learn that three out of four teachers responding to the OECD Teaching and Learning International Survey (TALIS) in 2008[4] reported that they would not be rewarded for being more innovative in their teaching.[5] The incentives for encouraging innovation appear to be missing.

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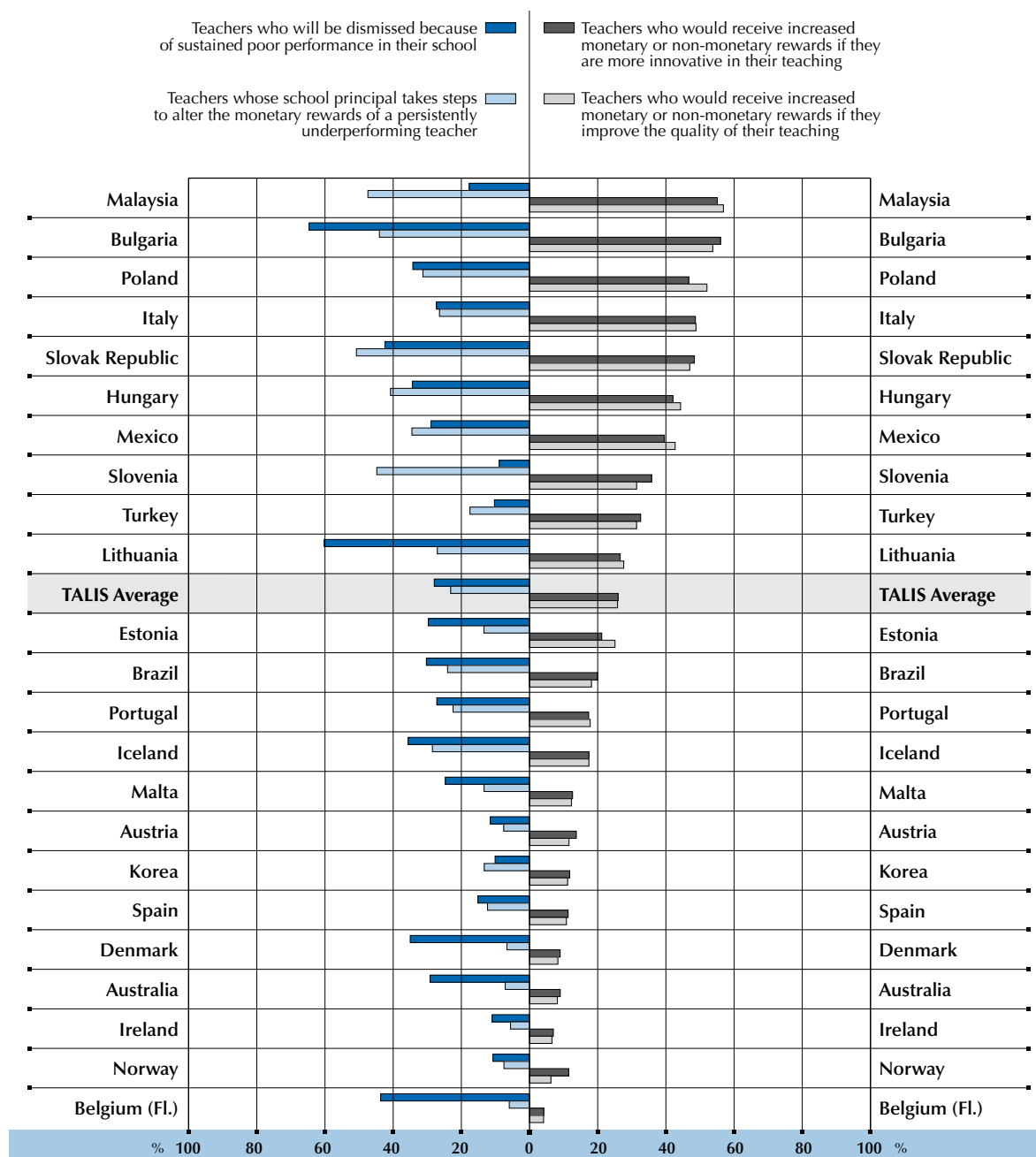### Box 2.2  Singapore's TE21 Model of Teacher Education

Singapore's National Institute for Education as a university-based teacher education institution seeks to provide the theoretical foundation to produce the "thinking teacher" whilst concurrently having strong partnerships with key stakeholders and the schools to ensure strong clinical practice and realities of professionalism in teacher development. Its new TE21 Model seeks to enhance key elements of teacher education, including the underpinning philosophy, curriculum, desired outcomes for our teachers, and academic pathways. These are considered essential prerequisites in meeting the challenges of the 21st-century classroom. The model (see figure below) focuses on three value paradigms: Learner-centered, Teacher Identity and Service to the Profession and Community. Learner-centered values puts the learner at the center of teachers' work by being aware of learner development and diversity, believing that all youths can learn, caring for the learner, striving for scholarship in content teaching, knowing how people learn best, and learning to design the best learning environment possible. Teacher identity values refer to having high standards and strong drive to learn in view of the rapid changes in the education milieu, to be responsive to student needs. The values of service to the profession and community focuses on teachers' commitment to their profession through active collaborations and striving to become better practitioners to benefit the teaching community. The model also underscores the requisite knowledge and skills that teachers must possess in light of the latest global trends, and to improve student outcomes.
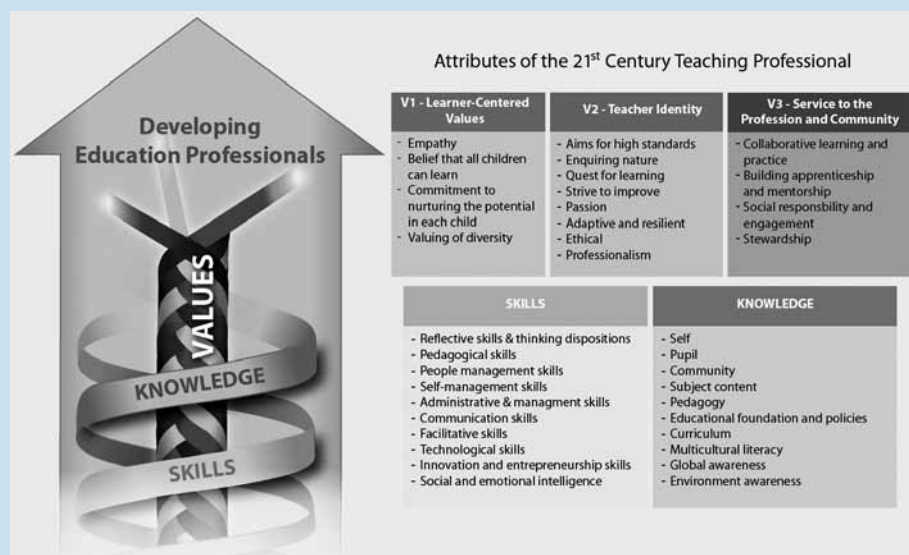


Source: *www.nie.edu.sg/files/spcs/TE21_Executive%20Summary_101109.pdf.*

## Figure 2.1

### Consequences of teacher performance as reported by teachers

Teachers who will be dismissed because of sustained poor performance in their school

Teachers who would receive increased monetary or non-monetary rewards if they are more innovative in their teaching

Teachers whose school principal takes steps to alter the monetary rewards of a persistently underperforming teacher

Teachers who would receive increased monetary or non-monetary rewards if they improve the quality of their teaching



*Countries are ranked in descending order of the percentage of teachers reporting to receive increased monetary or non-monetary rewards for an improvement in the quality of their teaching.*

Source: OECD (2009a), Table 5.9.

What can teacher preparation programs do to prepare graduates who are ready to teach well in a 21st-century classroom? Education systems generally struggle with finding answers to this question and there is no agreement across countries on how success should be measured and quality assured. However, there seems considerable agreement across countries regarding important attributes that 21st-century learning environments should provide.

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For example, the OECD's comparative review of innovative learning environments[6] concludes that, in order to be most effective, learning environments should:

- make learning central, encourage engagement, and be the place where students come to understand themselves as learners;

- ensure that learning is social and often collaborative;

- be highly attuned to students' motivations and the importance of emotions;

- be acutely sensitive to individual differences, including in prior knowledge;

- be demanding of every student, without overloading students;

- use assessments that emphasize formative feedback; and

- promote connections across activities and subjects, both in and out of school.

Taken together, these principles form a demanding framework on which teachers' professionalism is based. In addition to developing such individual skills, teachers also need to be able and have opportunities to work collaboratively with others in designing learning environments, addressing the learning needs of particular groups of students, developing themselves professionally, and teaching with others in team approaches. The OECD's comparative review of innovative learning environments concludes:

- Teachers need to be well-versed in the subjects they teach in order to be adept at using different methods and, if necessary, changing their approaches to optimize learning. This includes content-specific strategies and methods to teach specific content.

- They need a rich repertoire of teaching strategies, the ability to combine approaches, and the knowledge of how and when to use certain methods and strategies.

- The strategies used should include direct, whole-group teaching, guided discovery, group work, and the facilitation of self-study and individual discovery. They should also include personalized feedback.

- Teachers need to have a deep understanding of how learning happens, in general, and of individual students' motivations, emotions and lives outside the classroom, in particular.

- Teachers need to be able to work in highly collaborative ways, working with other teachers, professionals and para-professionals within the same organization, or with individuals in other organizations, networks of professional communities and different partnership arrangements, which may include mentoring teachers.

- Teachers need to acquire strong skills in technology and the use of technology as an effective teaching tool, to both optimize the use of digital resources in their teaching and use information-management systems to track student learning.

- Teachers need to develop the capacity to help design, lead, manage and plan learning environments in collaboration with others.

- Last but not least, teachers need to reflect on their practices in order to learn from their experience.

These all imply extensive and intensive teacher learning. Some countries approach this with innovative materials and approaches to teaching in order to change entrenched perceptions about and attitudes toward learning. Innovative approaches also recognize that teacher learning will take place in the company of other teachers, not as a solitary exercise – an acknowledgement of the effectiveness of collaborative learning as part of a professional continuum (see Box 2.3).

The level of need for such teacher learning is significant. Data from TALIS 2008 suggests that teachers need development in key areas, including instructional practice. Indeed, more than half of the teachers surveyed reported that they wanted more professional development than they had received during the 18-month survey period. The extent of unsatisfied demand is sizeable in every country, ranging from 31% in the Flemish Community of Belgium to over 80% in Brazil, Malaysia and Mexico.[7]

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**Box 2.3  Teacher education in Finland**

Teacher education in Finland has at least four distinguishing qualities:

- Research based. Teacher candidates are not only expected to become familiar with the knowledge base in education and human development, but they are required to write a research-based dissertation as the final requirement for the masters degree. Upper grade teachers typically pick a topic in their subject area; primary grade teachers typically study some aspect of pedagogy. The rationale for requiring a research-based dissertation is that teachers are expected to engage in disciplined inquiry in the classroom throughout their teaching career.

- Strong focus on developing pedagogical content knowledge. Traditional teacher preparation programs too often treat good pedagogy as generic, assuming that good questioning skills, for example, are equally applicable to all subjects. Because teacher education in Finland is a shared responsibility between the teacher education faculty and the academic subject faculty, there is substantial attention to subject-specific pedagogy for prospective primary as well as upper-grade teachers.

- Good training for all Finnish teachers in diagnosing students with learning difficulties and in adapting their instruction to the varying learning needs and styles of their students.

- A very strong clinical component. Teachers' preparation includes both extensive course work on how to teach – with a strong emphasis on using research based on state-of-the-art practice – and at least a full year of clinical experience in a school associated with the university. These model schools are intended to develop and model innovative practices, as well as to foster research on learning and teaching.

Within these model schools, student teachers participate in problem-solving groups, a common feature in Finnish schools. The problem-solving groups engage in a cycle of planning, action, and reflection/evaluation that is reinforced throughout the teacher education program and is, in fact, a model for what teachers will plan for their own students, who are expected to use similar kinds of research and inquiry in their own studies. The entire system is intended to improve through continual reflection, evaluation, and problem-solving, at the level of the classroom, school, municipality, and nation.

Source: OECD (2011a).

## UNDERSTANDING LEARNING TO IMPROVE TEACHING PRACTICES

A central foundation for improving teaching is an understanding of learning. The body of evidence on how children learn has grown greatly over the past years. However, this knowledge base has not always had a profound impact on teacher practice in the classroom. Research shows that teachers, like most people, interpret new ideas through their past experiences[8] and their established beliefs about learning and teaching. As a result, innovative ideas are often simply absorbed into traditional classroom practices.

Interestingly, teachers' beliefs about teaching practice are remarkably consistent across countries. TALIS 2008 revealed that, on average, teachers in all but one of the 23 participating countries endorsed a constructivist view of teaching, which focuses on students as active participants in the process of acquiring knowledge, more strongly than they embraced a belief in the direct transmission of knowledge. However, countries did differ in the strength of their teachers' endorsements of each of the two approaches. Teachers in Australia, Korea, north-western Europe and Scandinavia show a stronger preference for a constructivist view than teachers in Malaysia, South America and southern Europe. Teachers in eastern European countries fall somewhere in between.[9]

While changing entrenched beliefs is a challenge in itself, broadening teachers' repertoires is not just about assisting teachers with change; it is also about developing and continually updating a base of professional knowledge about teaching practices.

There are several dimensions that OECD's comparative review of innovative learning environments suggests hold significant promise which are examined in this report.

### Inquiry-based teaching and learning

Inquiry-based teaching and learning – which includes a family of approaches such as design-based learning and problem-based learning (for an example see Box 2.4) – can be effective when used with small groups of students, particularly when guided by a curriculum that establishes clearly defined goals and when students are regularly assessed.[10] Consequently, professional development for teachers needs to include assessing student work. The design of assessments is also critical. Specifically, if only traditional learning outcomes are assessed, then inquiry-based and traditional methods of instruction appear to yield similar results. The additional benefits from inquiry learning – namely that it nurtures communication, collaboration, creativity and deep thinking - become apparent when the assessments try to determine how well the knowledge that has been acquired is applied and when they measure the quality of reasoning.

At the same time, the pedagogies required to implement inquiry-based approaches are more complex than the direct transmission of knowledge to students via textbooks or lectures. These pedagogies tend to be highly dependent on the knowledge and skills of the teachers involved.[11] Teachers who don't understand how these student-centered approaches work are more likely to consider them "unstructured", as they may not appreciate the need for constant assessment and revision of the approach, if necessary, as the lessons unfold.

Classroom research[12] has shown that simply providing students with a rich source of information and an interesting problem is not enough to develop a successful inquiry-based approach. Students need help in understanding the problem, applying the knowledge they already have or are acquiring, evaluating their designs, explaining failures, and revising, if necessary. They usually need some explicit instruction in using resources, finding information, organizing and communicating ideas, setting goals and assessing their progress. Teachers must encourage student self-assessment, the use of evidence, and collaboration for these approaches to work effectively.

The available evidence suggests that the prevailing teaching practices around the world have yet to embrace these approaches. In TALIS 2008, teachers reported using more traditionally structured teaching practices in the classroom, and using student-oriented practices and enhanced teaching activities relatively less frequently. The size of the reported differences varies greatly among countries, but the pattern is the same across all TALIS countries, suggesting that more use should be made of student-oriented and enhanced activities, as these may promote inquiry-based learning.[13]

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**Box 2.4**  **Teach less, learn more**

In 2004, Prime Minister Lee Hsien Loong introduced the idea of "Teach Less, Learn More" as the next step under the Thinking Schools, Learning Nation umbrella. Its aim was to open up more "white space" in the curriculum to engage students more deeply in learning. Despite the system's widely-recognised successes, learners were still seen as too passive, overloaded with content, driven to perform, but not necessarily inspired. Teach Less, Learn More aims to "touch the hearts and engage the minds of learners by promoting a different learning paradigm in which there is less dependence on rote learning, repetitive tests and instruction, and more on engaged learning, discovery through experiences, differentiated teaching, learning of lifelong skills, and the building of character through innovative and effective teaching approaches and strategies." (Ho Peng interview). Further moves in this direction were made in 2008 with an envisioning exercise that led to Curriculum 2015. According to Ho Peng, Director General of Education in the Singapore Ministry of Education, this review asserted that the Singapore education system had strong holding power and important strengths in literacy, mathematics and science, and that these should remain. However, it needed to do better on the soft skills that enable future learning. In addition, "the overload of information has put a premium on the ability to do critical analysis. Working across cultures will require language skills and a larger world view".

Source: OECD (2011a).

Figure 2.2

**Approaches to teaching**
*Country mean of ipsative scores*
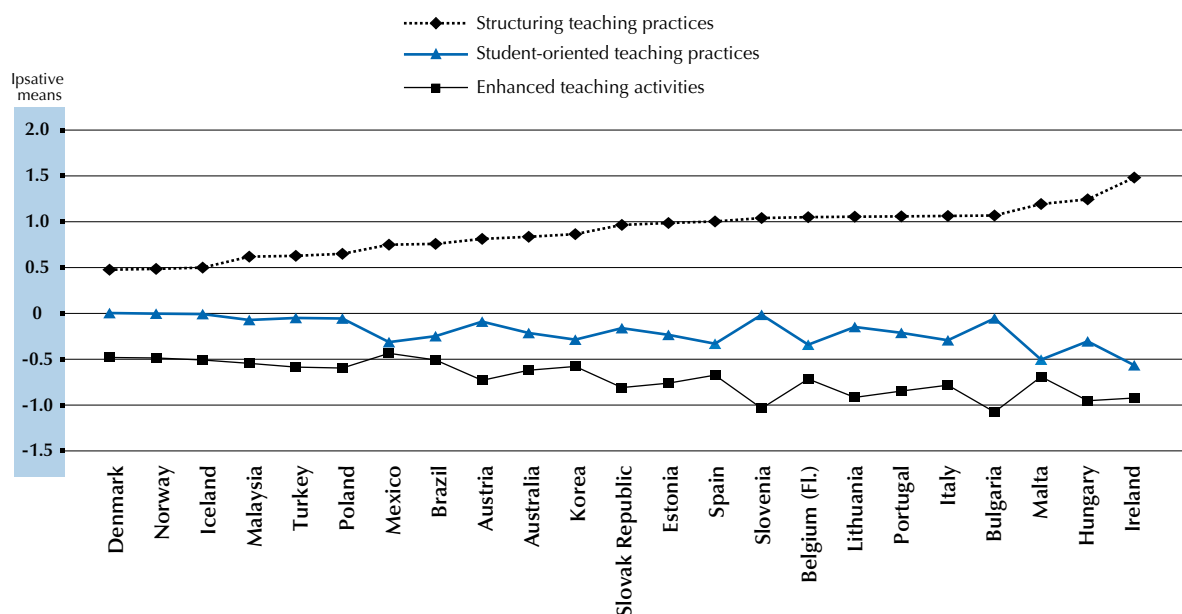


*Countries are ranked by the relative frequency with which they engage in structuring teaching practices, student-oriented teaching practices and enhanced activities. So, teachers in Denmark adopt the different practices to a fairly similar degree, while teachers in Ireland use structuring teaching practices much more than they do either student-oriented practices and enhanced activities.*
Source: OECD, *TALIS Database.*

## Incorporating assessment into teaching

The OECD considers an effective learning environment as one that encourages students to be engaged as learners and is well-regulated. If, for example, learning is not happening as intended, then adjustments need to be made in the methods used, in the sequence of information presented, or both. Intervention by teachers or other professionals can occur at any time during the teaching process: before lessons begin, during the lessons, or later, for example, when a teacher sees that a certain pedagogical method works better with one group of students and then applies that method to other groups. Intervention also occurs when teachers encourage students to consult with and support each other during the learning process.

Student assessments are a crucial element of effective learning environments. At the same time, assessments that just offer feedback about students' current achievements are of limited benefit in the long run. While the approaches and methods that countries use for assessment vary widely, there is broad agreement among countries on key features that 21st-century assessments need to possess: For example, they should be multi-layered, extending from classrooms to schools to regional to national levels. They should also be aligned with the development of significant 21st-century learning goals, standards and instructional systems; be adaptable and responsive to new developments; be largely performance-based; add value for teaching and learning by providing information that can be acted on by students, teachers, and administrators; and, of course, meet the general criteria for good assessments (i.e. be fair, technically sound; valid for purpose, and part of a comprehensive and well-aligned system of assessments at all levels of education). In addition, to improve student learning, assessments should also involve: encouraging pupils to be involved in their own learning; adjusting teaching practices to take account of the results of assessments; recognizing the profound influence assessment has on students' motivation and self-esteem, both of which are crucial influences on learning; and fostering students' ability to assess their own work and understand how to improve.[14]

There are many promising initiatives underway in these areas (for examples, see Box 2.5). And yet, a significant share of teachers are not confident about their abilities to assess students effectively. For example, TALIS 2008 shows that in countries such as Italy, Lithuania and Malaysia, one quarter or more of lower secondary teachers report a great need for professional development in this area.[15]

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**Box 2.5  Curriculum-embedded assessments: Scotland and Sweden**

Curriculum-embedded assessments address several of the challenges of developing assessments that are instructionally useful. Curriculum-embedded assessments avoid problems of generalisability and reliability associated with teacher-designed assessments. Well-designed curriculum embedded or on-demand assessments may also improve the validity of teachers' assessments – helping to ensure that teachers are able to make appropriate inferences about student learning in relation to learning goals – while providing information in a timely manner.

Sweden has developed "on-demand" assessments. Teachers may decide when students are ready to take a test in a particular subject or skill area, drawing from a central bank of assessment tasks. Control over timing of tests means that teachers are able to provide students with feedback when it is relevant to the learning unit.

In Scotland, assessment of progress and development needs for pupils is based on the experiences and outcomes for Curriculum for Excellence. Teachers assess progress across the breadth of learning, in challenging aspects and the ability to apply learning in different contexts. Quality assurance and moderation practice in conjunction with guidance and an on-line National Assessment Resource, which provides a wide range of examples of assessment practice, supports teachers in having a shared understanding of standards and expectations and applying these consistently.

Source: Janet W. Looney (2011).

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## Collaborative learning

When students engage with each other during learning, classrooms become vital, creative environments not only for acquiring knowledge, but also for learning the communication skills required in today's society and economy[16] (see Boxes 2.6 and 2.7). The widespread use of information and communication technologies, and the breakneck speed at which these technologies are evolving, are changing the nature of co-operative learning for the 21st century.

Research on collaborative learning[17] provides evidence of its positive impact on academic achievement. However, research also suggests that it would not be wise to abandon individual learning. Co-operative learning and individual learning are not mutually exclusive; rather, they can and should complement each other.

Many teachers claim that they use co-operative learning techniques regularly, but observational studies find that these techniques are mostly used informally and do not incorporate the group goals and individual accountability that research has identified as essential to this type of learning. Co-operative learning is relatively inexpensive to support and easily adopted. Yet, despite evidence of its effectiveness, it remains at the fringe of school policy and practice.

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**Box 2.6  A Learning Community, CEIP Andalucía, Seville, Spain**

This is a pre-primary and primary state school with all learners at risk of exclusion. The teachers fostered the change and considered *learning communities* to be a key concept in providing quality education and to break the circle of poverty and social exclusion. These are realised through such activities and approaches as: weekly tutorship; students' representative meetings; discussion on the subjects for project work; the monthly family assembly; and the assessment tool elaborated by staff together with the Regional Administration for Education which comprises indicators of achievements and obstacles while also guiding improvements. A key feature are the interactive groups based on co-operative learning. The learners split up into subgroups of 5 or 6 students each; lesson time is divided in periods of 15-20 minutes, each devoted to a different activity but all subject related, with subgroup dynamics coordinated by volunteers from families, the university, and collaborating associations. Project work in a single class or in a grade or group of different grades aims to overcome curriculum fragmentation around four stages: planning, searching, organizing, and assessing.

Source: Country case for the OECD "Innovative Learning Environments" project.

**Box 2.7  Student Team Learning (STL) group work methods**

The majority of all experimental studies of practical co-operative learning methods involve *Student Team Learning* (STL) methods. All co-operative learning methods share the idea that students work together and are responsible for one another's learning as well as their own. STL also emphasises team goals and collective definitions of success, which can only be achieved if all members of the team learn the objectives being taught. That is, the important thing is not to *do* something together but to *learn* something as a team. Three concepts are central to all such methods: *i)* team rewards, *ii)* individual accountability, and *iii)* equal opportunities for success.

*Student Teams-Achievement Divisions* (STAD) has been used in a wide variety of subjects, and is most appropriate for teaching well-defined objectives, such as mathematical computations and applications, language usage and mechanics, geography and map skills, and science facts and concepts. Students typically work in 4-member heterogeneous teams to help each other master academic content and teachers follow a schedule of teaching, team work and individual assessment. The teams receive certificates and other recognition based on the average scores of all team members on weekly quizzes. Numerous studies of STAD have found positive effects of the program on traditional learning outcomes in mathematics, language arts, science, and other subjects.

*Teams-Games-Tournament* (TGT) uses the same teacher presentations and teamwork as in STAD, but replaces the quizzes with weekly tournaments. In these, students compete with members of other teams to contribute points to their team score. The winner at each tournament table brings the same number of points to his or her team, regardless of which table it is; this means that low achievers (competing with other low achievers) and high achievers (competing with other high achievers) have equal opportunity for success.

Source: OECD (2010b), Chapter 7.

## Advanced technology in the classroom

It is essential for teachers to understand how young people learn, play and socialize outside the classroom and there are many efforts to provide opportunities for this (see Boxes 2.8-2.12). Digital media have the potential to transform learning environments and empower learners to become active in shaping their own education.[18] Yet young students and teachers in traditional learning environments often do not have access to or are discouraged from using computers and other information and communication technologies in the classroom. Evidence from PISA also finds that the use of computers at school varies substantially across different countries and economies.[19]

**Box 2.8  Teacher collaboration in cyberspace**

In the Netherlands, a 2008 report on open educational resources spurred interest in developing a way for teachers across the country to collaborate on educational materials and practices. The result is *Wikiwijs,* literally "Wikiwise", an Internet-based platform where teachers can find, download, develop and share educational resources. Developed by the Open Universiteit Nederland and Kennisnet at the request of the ministry of education, the platform is based on open-source software, open content and open standards. The *Wikiwijs* platform was launched in December 2009; then, after eight months of testing, a revised version was launched in September 2010.

Teachers can freely use anything they find in the *Wikiwijs* database in their classrooms. While the scope of *Wikiwijs* covers the entire Dutch education system, from primary schools to universities, during this trial phase, the only school subjects examined on the platform are mathematics and the Dutch language. All documentation on *Wikiwijs* is in Dutch.

Source: *http://www.wikiwijs.nl/task/international.psml.*

Using technology should not be confused with taking a technology-driven approach. The problem with the latter is that it often fails to take the student into account, and assumes that students and teachers will adapt to the requirements of the new technology and not vice versa.[20] The use of new technologies should be adapted to fit the needs of students and teachers; it should not be an end in itself. In TALIS 2008, lower secondary teachers reported a great need for professional development in information and communication technologies. More than one in three teachers in Brazil, Ireland, Lithuania and Malaysia reported high levels of need for development in this area.[21]

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### Box 2.9  The Le@rning Federation, Australia and New Zealand

A joint venture called The Le@rning Federation, was developed as a major digital content project for Australian and New Zealand schools. The Le@rning Federation developed learning objects for schools as well as learning and content management systems. Some initiatives involved the development of content to meet the curriculum, professional development, and other educational priorities of education systems.

The Le@rning Federation began as a major digital content project for Australian and New Zealand schools. It developed specifications for educational soundness and new delivery systems such as web portals, learning management systems, and content management systems. A number of schools implemented major software packages to support these functions. The Le@rning Federation also developed a "Basic E-Learning Tool Set" to provide schools with the basic functionality for managing learning objectives, until comprehensive learning content management systems could be implemented within jurisdictions. State and territory education authorities also operated various initiatives for providing their schools with digital content.

Source: OECD (2010d), Chapter 10.

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### Box 2.10  1:1 Initiatives - one student, one digital device

Handhelds (more affordable than notebooks) opened the door to 1:1 in education. Over the last decade, more and more public and private stakeholders across the world have been supporting 1:1 initiatives in education. In the United States, the state of Maine was the first to equip every 7th and 8th grade student and every 7th through 12th grade teacher state-wide with personal access to learning technology. The One Laptop per Child initiative (OLPC) initiative may have inspired the development of a new category of low-cost devices, netbooks, which, together with smartphones, seem to be the technological drivers of contemporary initiatives.
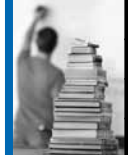
The decreasing cost of ICT devices, combined with the lighter weight of laptops and increasing availability of wireless connectivity, have been the main enablers of the rapid spread of such initiatives and their implementation at a broad scale. Despite the limitations of available evidence, research supports the positive impacts of 1:1 initiatives in writing and ICT skills.

Source: Oscar Valiente (2010).

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### Box 2.11  Courtenay Gardens Primary School, Victoria, Australia

This is a primary school (students age 5-12) in a low-socio-economic area which intensively uses multimedia facilities and research-based personalized learning frameworks. Students have access to a multimedia television studio and a radio broadcasting station, which foster students' development of organizational skills, social behavior, literacy and numeracy, and connect them with the community. There is a performing arts center and outdoor fitness stations. Classrooms are technology-rich and purpose-built with shared learning spaces for team teaching and group work. Teacher teams meet weekly for planning, evaluation and peer support and the staff engages in regular, research-based instructional coaching activities. Student progress is registered in an electronic school-wide data tracker that allows evaluation against whole class and year performance. Parents can follow a training program to provide assistance in the classroom.

Source: Country case submitted to the OECD "Innovative Learning Environments" project.

> ### Box 2.12   Community Learning Campus, Olds, Alberta Canada
>
> The Community Learning Campus (CLC) is an innovative approach to high school, post-secondary and community education, sharing resources and working jointly with a variety of community groups and agencies. It focuses on providing an active, constructive, and holistic educational environment that brings together high school and post-secondary education in one place (which may be virtual), seeking to create a seamless transition for students wishing to enter the workforce, apprenticeship, college, or university. The CLC is both a virtual and a physical learning space in four multi-use facilities: 1) core high school; 2) fine arts and multi-media center; 3) health and wellness center; and 4) the Bell eLearning Center. Delivery is either seminar-based or class-based, both of which are constructivist and organized around project work. Programs are organized around four pillars – personal, knowledge, community, and global – and navigation relies on the CLC Learner Map, which is both a framework for individual learner pathway decisions and a graphic enabling community access.
>
> Source: Country case submitted to the OECD "Innovative Learning Environments" project.

## *No single best method*

One of the professional skills of a teacher is to know how to use all of these different approaches and when to apply them. There is no single best way of teaching and that is even more true in the 21st century than in the past. Teachers today need to know how to combine "guided discovery" with "direct instruction" methods, depending on the individual students, the context of instruction and the aims of the teaching. One extensive review[22] concludes that innovative learning environments are characterized by a good balance between discovery and personal exploration on the one hand, and systematic instruction and guidance on the other, all the while bearing in mind individual differences in students' abilities, needs and motivation. It also finds that the balance between external regulation by the teacher and self-regulation by the student will vary during the student's education: as the student's own competence increases, the share of self-regulation can also grow while explicit instructional support can diminish.

Research finds that most of the preferred methods and approaches result in positive learning outcomes when they are done well. This means that teachers must have a good understanding of how particular approaches are used and must be flexible enough to adapt and apply them to different situations or students. The drive to enlarge teachers' repertoires is, then, less a matter of encouraging innovation than of improving student learning.

## DESIGNING ECOSYSTEMS FOR A 21ST-CENTURY TEACHING PROFESSION

Consider what would happen if you were on an airplane and the pilot came on the intercom as you were starting your descent and said, "I've always wanted to try this without the flaps." Or if your surgeon said to you in your pre-surgical conference, "you know, I'd really like to do it this way. I originally learned how to do it in 1978." Would you be a willing participant in this?[23]

One of the key challenges for the teaching profession is to strengthen the "technical core" of its professional practices. What does it take to improve the use and dissemination of proved and promising teaching practices? How do we generate and share cumulative knowledge in education? This requires the development of educational ecosystems that support the creation, accumulation and diffusion of this professional knowledge.

Turning teaching into an even more knowledge-intensive profession implies a re-consideration of how knowledge is generated and applied within education. An ecosystem conducive to innovation and constant improvement is based on the attitudes and prevailing culture of the various players in the sector, the development and transmission of knowledge, and initiative and calculated risk-taking. Such ecosystems need to draw on four sources: innovation and knowledge inspired by science (research and evaluation); innovation inspired by firms (entrepreneurial development of new products and services); innovation and knowledge inspired by practitioners (teachers, school heads); and innovation inspired by users (students, parents, communities) (see Box 2.13).

*45*

**Box 2.13**  **Funding innovation – The UK's Sinnott Fellowship**

The UK's Department for Children, Schools and Families introduced the Sinnott Fellowship in 2009 to fund the work of outstanding teachers who create innovative links between the school and the outer community with the aim of improving student aspirations and outcomes. The Fellowship, named after educator and trade unionist Steve Sinnot, selected 15 talented secondary-school practitioners and allows them to spend two days a week, over two terms, creating a program of outward-facing activities for their school. The Fellowship offered support to these individual projects through a network of contacts and resources. These projects, in turn, were expected to include all or some of the following components: activities for children/young people; community and voluntary groups; the world of work and business links; parental engagement; further and higher education and adult learning; international understanding; and access to statutory support and services. In the end, these projects aimed to anchor schools at the heart of their communities.

Dozens of projects had been developed and implemented since the program began. One, developed by the head of the physical education faculty at a London high school, involved training a group of students in basketball coaching so that those students would then train younger students in the game. With a Paralympian champion engaged as mentor, the project improved students' abilities in planning, budgeting and marketing, helped to boost students' self-confidence and enhanced the students' leadership qualities.

In another project, created by the enrichment leader in a disadvantaged school in Nottingham, the school developed links with national and international businesses with the aim of demonstrating to students why education is important in today's labor market. A representative from a construction company explained how part of the local university was constructed and took students on a tour of the building; a lawyer from a European legal firm explained England's justice system and led a mock trial; and a representative from a national energy company explained the relevance of science study to the company's work. All discussed career opportunities in their field. As part of the program, a national department store chain offered students an interview skills day, running a series of mock job interviews to show students what to expect when they try to enter the world of work.

A third project was designed by the head of the creative arts faculty at a disadvantaged secondary school in Great Yarmouth. The school, which specializes in mathematics and computing and suffered from financial and personnel problems, teamed with a private boarding school to provide mutually beneficial opportunities to both sets of students. A scholarship award was created to allow one student from the disadvantaged school to study at the private boarding school. Meanwhile, students from the more advantaged school act as literacy and numeracy mentors to students from the disadvantaged school and provide technical assistance for theatrical productions, while the disadvantaged school's expertise in information technologies helps the private school develop its own information infrastructure.

The UK government's evaluation of the Sinnott Fellowship program is available at the Fellowship website.

Source: *http://www.outwardfacingschools.org.uk/the-sinnott-fellowship/*.

The ecosystem for a knowledge-intensive teaching profession includes research and development; education systems; school organization; mobilizing general-purpose technology, particularly information and communication technologies; and measuring innovation and improvement in education.

## *Research and development*

In most sectors, public and private research and development (R&D) expenditure is a good indicator of the breadth and depth of innovation and knowledge acquired. Part of the knowledge applied by teachers is developed by scientists. For example, teachers' practice must be informed by the latest discoveries about dyslexia and dyscalculia so that they can diagnose these conditions and develop appropriate teaching and learning strategies for affected students (see Box 2.14).

But research and development should not be limited to public research. In the health sector, for example, it is not only the doctors, surgeons and other professionals who innovate; they also use the procedures and administer the medication developed by the pharmaceutical and medical-imaging industries. In education, too, businesses could develop products and services that improve both the effectiveness and efficiency of education systems, and transform the latest knowledge into equipment that teachers can use in classrooms.

It is striking that there is generally little public funding for educational research. Private businesses do not seem to invest heavily in knowledge that can be applied to the formal education sector, and policy makers do not seem to have a clear strategy for stimulating business investment in education R&D. In 2008, the public R&D budget for education stood at 1.8%, on average, of the total public-research budget in the 26 countries for which this information was available. In contrast, the public R&D budget for health stood at 8.6% of the total public-research budget. On average, OECD countries allocated 15.5 times more of their public budgets to health research than to education research, but only 1.2 times more of their public expenditure to education than to health.

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### Box 2.14  Best Evidence Synthesis Program, New Zealand

The Iterative Best Evidence Synthesis Program is a government brokerage agency through which effective R&D has enabled educational practice to make a much bigger positive difference for diverse learners. The magnitude of positive impact for, the responsiveness of, the sector ownership gained, and the futures orientation of the most effective R&D are compelling.

Often such R&D has gone through many iterations to create the kind of educational development that can work powerfully for diverse learners. As an initial step, through funding educational researchers and the collaborative and iterative processes necessary to undertake first iteration BES developments, BES is seeking to build the capability of the national research community to transform relevant but fragmented research knowledge into a more useful tool for both policy makers and practitioners. BES is also seeking to steer the research community towards a greater focus on informing educational development through R&D.

Source: OECD (2007), Chapter 5.

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### *School organization*

The importance of turning schools into learning organizations where teachers can improve and learn from each other's accumulated knowledge has long been acknowledged. There are many examples of such policies and practices (see Boxes 2.15- 2.18) but there is little empirical evidence available yet to support the argument that such schools are associated with better performance and more innovation.

Teachers can do more, and should be encouraged to do more, to share their expertise and experience systematically in ways that go beyond the mere exchange of information. OECD data show that teachers report relatively infrequent collaboration with colleagues within the school, beyond a mere exchange of information and ideas; direct professional collaboration to enhance student learning is more rare.[24]

Understanding that collaboration takes time, some countries are providing teachers with some scheduled time to encourage them to engage in such co-operation. Data from TALIS[25] show that teachers who exchange ideas and information and co-ordinate their practices with other teachers report more positive teacher-student relations at their school. Thus, it may be reasonable to encourage teachers' co-operation in conjunction with improving teacher-student relations, as these are two sides of a positive school culture. Positive teacher-student relations are not only associated with student achievement, they are also closely related to individual teachers' job satisfaction (see Figure 2.3). This finding emphasizes the role of teachers' positive evaluations of the school environment for effective education and teacher well-being. Efforts to improve school organization are particularly important in larger public schools attended by students with mainly low to average ability. Several of the East Asian countries provide interesting models for building on professional teacher collaboration to make the most of their top-performing teachers (Box 2.15).

**Box 2.15** **Preparing teachers to lead improvement in Japan and China**

***In Japan, all teachers participate in regular lesson studies in their schools.***

The Japanese tradition of lesson studies in which groups of teachers review their lessons and how to improve them, in part through analysis of student errors, provides one of the most effective mechanisms for teachers' self-reflection as well as being a tool for continuous improvement. Observers of Japanese elementary school classrooms have long noted the consistency and thoroughness with which a mathmatics concept is taught and the way in which the teacher leads a discussion of mathematical ideas, both correct and incorrect, so that students gain a firm grasp on the concept. This school-by-school lesson study often culminates in large public research lessons. For example, when a new subject is added to the national curriculum, groups of teachers and researchers review research and curriculum materials and refine their ideas in pilot classrooms over a year before holding a public research lesson, which can be viewed electronically by hundreds of teachers, researchers and policymakers.

The tradition of lesson study in Japan also means that Japanese teachers are not alone. They work together in a disciplined way to improve the quality of the lessons they teach. That means that teachers whose practice lags behind that of the leaders can see what good practice is. Because their colleagues know who the poor performers are and discuss them, the poor performers have both the incentive and the means to improve their performance. Since the structure of the East Asian teaching workforce includes opportunities to become a master teacher and move up a ladder of increasing prestige and responsibility, it also pays for the good teacher to become even better.

***In Shanghai, China, teachers are trained to be action researchers in effective practice, with the best teachers going on to support new teachers and helping to improve lesson quality.***

The authorities in the Shanghai province of China emphasize giving prospective teachers the skills they will need for action research, and their method for improving their education system over time relies on research performed by teachers. As in Finland (Box 1.3), all students in Shanghai are expected to perform at high levels and teachers are expected to make sure that no student, literally, will be allowed to fall behind. This makes it essential that teachers identify students who are just beginning to flounder, diagnose the problem, and have the skills and knowledge needed to create a large and constantly updated reservoir of solutions for the student performance problems they have diagnosed.

During the course of their careers, teachers in Shanghai are involved in subject-based "teaching-study groups" to improve teaching at the grassroots level on a day-to-day basis. There are timetabled sessions when the study group meets, often with related personnel, such as laboratory assistants, to draw up very detailed lesson schemes for a particular topic for the following week. The lesson plan serves not only as a guide for the teacher during the lesson, but also as documentation of the teacher's professional performance. During actual teaching, teachers may observe each other or may be observed by peers. For example, when a change in curriculum introduces a new teaching topic, teachers may be observed by new teachers, so these can learn from more experienced colleagues; by senior teachers, for mentoring purposes; or by the school principal, for monitoring or to provide constructive development assistance. Sometimes, teachers are expected to teach demonstration lessons, called public lessons, for a large number of other teachers to observe and comment upon.

This structured organization of teaching in Shanghai is not only a means for administration; it is also a major platform for professional enhancement. Teachers in Shanghai are classified into four grades that indicate their professional status. Promotion from one grade to the next often requires the capacity to give demonstration lessons, contribute to the induction of new teachers, publish in journals or magazines about education or teaching, and so forth. The provincial office often identifies the best teachers emerging from evaluation processes and relieves them of some or all of their teaching duties so that they can give lectures to their peers, provide demonstrations, and coach other teachers on a district, provincial and even national level.

...

Carefully picked schools are often asked to pilot new programs or policies before they are scaled-up, and the best teachers in those schools are enlisted as co-researchers to evaluate the effectiveness of the new practices.

The practices described here for Shanghai are similar in other East Asian countries. The East Asian countries taking part in PISA all provide interesting models for building on professional teacher collaboration to make the most of their top-performing teachers.

Source: OECD (2011a).

## Figure 2.3

### Student-teacher relationships and student performance
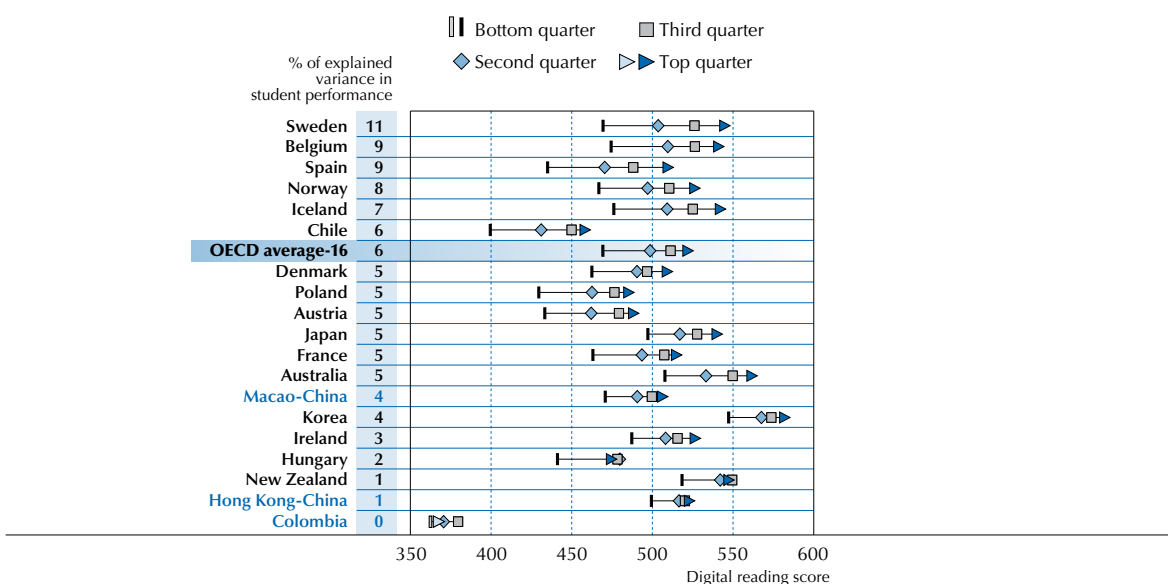


Note: Countries in which differences between the top and bottom quarters of this index are statistically significant are marked in a darker tone.
*Countries are ranked in descending order of the percentage of explained variance in student performance.*
Source: OECD, *PISA 2009 Database,* Table VI.4.9.

With its famous "lesson studies" or "teaching research sessions" (*jugyokenkyuu*), Japan provides a good illustration of the fact that certain distinctive characteristics of work organization in the education sector can help to establish a culture of ongoing development and allow for an intense exchange of knowledge. Other organizational routines or models based on "communities of practice" have the same aim, namely to create a web of professional relations that will generate a continual dynamic of learning and improvement within establishments.

Too many policies have focused on individual teachers and leaders instead of trying to improve and change how teachers work. A lot of time can be wasted "waiting for superman", when small changes that put improvement, professional discussions and collegiality at the center of the schools are actually achievable. In Ontario, for example, improvement has been based on a change in teachers' working conditions and school routines.

It is important to identify the conditions in which different types of learning organizations can emerge and how teachers can share the knowledge that they have accumulated during their working lives. Some policy programs have managed to influence work organization in the business sector. In education, which is predominantly public in all OECD countries, there is no reason why public authorities should not try to do so.

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### Box 2.16  The Pedagogy and Content Routine (PCR) – a "Kernel Routine"

There is growing interest in different organizational "routines" designed to ensure that learning is center stage in schools, through social practices that help to create strong learning communities and reinforce teachers' knowledge, professionalism, and their ability to act on what they learn. "Kernel routines" start with a basic process that can then be extended and adapted over time.

An example of such a routine – the Pedagogy and Content Routine (PCR) – has been developed by the University of Pittsburgh. This routine involves highly participatory training for teachers specific to the demanding programs they must teach, practiced in a continuous cycle of observation and professional learning. It meets six criteria critical to such routines. First, it is centered on the technical core of teaching and learning. Second, it is anchored in the official curriculum of the school *and* the enacted curriculum of the classroom. Third, it uses principles of learning and disciplinary literacy, and model lessons that are all based on research. Fourth, it builds trust and mutual access among staff and provides safe venues for educators to work with new practices. Fifth, it provides a route by which new knowledge can enter a school's practice through training, observation and discussion. Sixth, it can be tailored by school staff and transformed over time – the "kernelling" aspect.

Source: OECD (2010b), Chapter 12.

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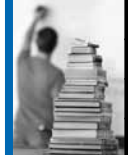### Box 2.17  Open Access College, South Australia

Those who are not able to attend regular schooling are given the opportunity to continue their education in the Open Access College. This innovative distance education alternative features mixed-aged grouping, effective use of ICT, and collaborative and individualized learning. All learning within the program is personally tailored to meet the diverse needs of individual students. Individual learning plans are developed for all students, and ongoing contact occurs between teachers and individual students, interdisciplinary themes are developed based on student interests and resources are accessible for each student online to access in their own time. Both quantitative and qualitative data reveal improved student engagement and attendance.

Source: Country case of the OECD "Innovative Learning Environments" project.

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### Box 2.18  Culture Path, Kuopio Finland

The Culture Path Program is targeted at students aged 7-16. It aims at enhancing the social, emotional, and physical well-being of the children through culture and art, by ensuring that every student has access to the city's cultural services. This is realized with practical tools for teachers to implement goal-oriented cultural education, and by strengthening the cooperation between schools and cultural institutions, supporting the development of schools as cultural communities. The program is divided into nine "paths" related to art, libraries, theatre etc., which are designed for the needs and curriculum objectives of a particular grade level, within and across different subjects. As part of the paths, students visit at least one local cultural institution outside the school environment every year. After eight years on the Culture Path, 9th graders can use the city's cultural services for free.

Source: Country case of the OECD "Innovative Learning Environments" project.

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**Box 2.19  Projektschule Impuls, Rorschach, Switzerland**

Projektschule Impuls is a school characterized by mixed-age groupings, with a student parliament, and high learner responsibility and co-determination of directions. There is a particular organization of the typical school day beginning in a circle and (for grades 3-6) foreign language learning, before working on the "weekly plan" and then project groups. One feature is the 25 minutes of "sand glass" time, when the students work in total silence. All students write a diary on a daily basis, which is also intended to improve written abilities. The teaching is organized in teams, and the teachers spend part of their time in the school and the rest of their time in the teacher education college.

Source: Country case for the OECD "Innovative Learning Environments" project.

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## Designing expert systems for teachers

Effective teachers work collaboratively with their colleagues and are continually learning and growing in ways that improve their teaching practice and enhance student learning. To support this, education authorities need to invest in creating learning communities that design and implement professional development and assess its impact on teacher practice. By defining the content and design of a professional development program, teachers can ensure that their professional learning and classroom practice are connected, which in turn strengthens student learning.

One way to change the culture of the teaching profession is to use data analysis more widely (Box 2.19). Using information and communication technologies in education is most often perceived as using new technological equipment – digital boards, computers, laptops, handheld devices – in the course of instruction. Another way to look at the transformative power of these technologies is through the design of "expert" or "knowledge-management" systems, like the ones that support the professional activity of doctors.

Longitudinal information systems in education systematically collect information on students and schools. These systems were initially designed to provide information about student and school performance at the system level. A new generation of systems aims to give immediate feedback to teachers, schools and students, allowing them to benchmark their performance in "real time" and to use also large-scale data collections in a formative way.

Technology also makes it possible to build a new generation of longitudinal information systems that go beyond performance data and can contribute to the development of a professional culture of continuous improvement and innovation in education systems. Those systems allow for better empirical assessment of practices, rapid diagnoses of the problems encountered by students or schools, better informed decision-making, and wider dissemination of knowledge. The quick feedback given to teachers, parents and students on students' performance can, in turn, help inform the design of remedial strategies for students who are falling behind. These systems can bring in a more personalized culture of teaching, with individualized reports on students and incentives to use evaluation in formative ways. They could thus help to put continuous improvement at the center of the teaching culture.

These systems can also be used as knowledge-management platforms where instructional materials, including course materials, tests, quizzes, diagnostic tools, videos and other resources that support both teachers and students, are shared. A good policy in open educational resources could make them even more effective. Thanks to social-network technology, the platforms can connect teachers facing similar difficulties and create a more collaborative culture of teaching, which, in turn, could foster innovation and acquisition of knowledge. With good visualization tools, these systems will allow teachers in different schools to compare the performance of, say, underprivileged students, with the ultimate aim of improving teaching practices to reach these students.

Last but not least, such systems can enhance the precision of education research and allow for more systematic evaluations of teaching practices and innovative or experimental programs. Generating evidence on the outcomes of a new method or product is a key step towards wider dissemination and use in education systems.

## CONCLUSIONS

Many nations around the world have undertaken a wide range of reforms of curriculum, instruction, and assessments with the intention of better preparing all children for the higher educational demands of life and work in the 21st century. Various frameworks have been developed to systematize the skills that young people need to be successful in this rapidly changing world and to identify the competencies which teachers need, in turn, to effectively teach those skills to their students. The demands placed on teachers in the 21st century are high: Teachers need to be well-versed in the subjects they teach in order to be adept at using different methods and, if necessary, changing their approaches to optimize learning. They need a rich repertoire of teaching strategies, the ability to combine approaches, and the knowledge of how and when to use certain methods and strategies. Such strategies should include direct, whole-group teaching, guided discovery, group work, and the facilitation of self-study and individual discovery. They should also include personalized feedback. Importantly, teachers also need to have a deep understanding of how learning happens, in general, and of individual students' motivations, emotions and lives outside the classroom, in particular. Teachers need to be able to work in highly collaborative ways, working with other teachers, professionals and para-professionals within the same organization, or with individuals in other organizations, networks of professional communities and different partnership arrangements, which may include mentoring teachers. Last but not least, teachers need to acquire strong skills in technology and the use of technology as an effective teaching tool, to both optimize the use of digital resources in their teaching and use information-management systems to track student learning.

This leads to the question: What teacher preparation programs are needed to prepare graduates who are ready to teach well in a 21st-century classroom? One of the key challenges for the teaching profession is to strengthen the "technical core" of its professional practices which requires the development of educational ecosystems that support the creation, accumulation and diffusion of this professional knowledge. Such ecosystems need to draw on four sources: innovation and knowledge inspired by science (research and evaluation); innovation inspired by firms (entrepreneurial development of new products and services); innovation and knowledge inspired by practitioners (teachers, school heads); and innovation inspired by users (students, parents, communities). While the evidence base in this area is only emerging, this chapter has identified a range of promising practices in these areas.
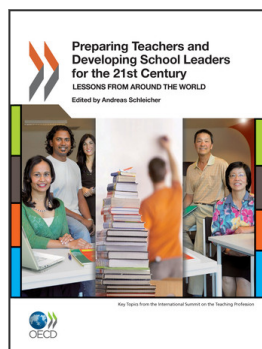
# Notes

1. Trilling, B. and C. Fadel (2009).

2. Charles Fadel is the founder and chairman of the Center for Curriculum Redesign, *http://curriculumredesign.org* and co-author with Bernie Trilling of *21st Century Skills* (Wiley, 2009), *www.21stcenturyskillsbook.com/index.php.*

3. OECD (2010a).

4. TALIS (implemented in 2007-08) focused on lower secondary education (level 2 of the 1997 revision of the International Standard Classification of Education, ISCED 97) teachers and the principals of their schools and seeks to provide data relevant to policy on the role and functioning of school leadership; how teachers' work is appraised and the feedback they receive; teachers' professional development; and teachers' beliefs and attitudes about teaching and their pedagogical practices. TALIS is a collaborative effort by member and partner countries of the OECD. Twenty-three countries participated in TALIS 2008: Australia, Austria, Belgium (Fl.), Brazil, Bulgaria, Denmark, Estonia, Hungary, Iceland, Ireland, Italy, Republic of Korea, Lithuania, Malaysia, Malta, Mexico, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain and Turkey. TALIS 2008 was also conducted in the Netherlands but as the required sampling standards were not achieved, their data are not included in the international comparisons.

5. For data, see OECD (2009).

6. OECD (2010b).

7. For data, see OECD (2009).

8. Remillard (2005).

9. For data, see OECD (2009).

10. Barron and Darling-Hammond (2010).

11. Good and Brophy (1986).

12. Barron, et al. (1998); Gertzman and Kolodner (1996); Puntambeckar and Kolodner (2005).

13. For data, see OECD (2009).

14. Wiliam (2010).

15. For data, see OECD (2009).

16. Slavin (2010).

17. Lehtinen (2003); Salomon (1993); van der Linden, et al. (2000).

18. Mayer (2010).

19. OECD (2010c).

20. Norman (1993).

21. For data, see OECD (2009).

22. Mayer (2004).

23. Elmore, R. (2002).

24. For data, see OECD (2009).

25. For data, see OECD (2009).

# References

**Barron, B.J.S.,** et al. (1998), "Doing with understanding: Lessons from research on problem- and project-based learning", *Journal of the Learning Sciences,* Vol. *7* (3-4), pp. 271-311.

**Barron, B.,** and **L. Darling-Hammond** (2010), "Prospects and Challenges for Inquiry-based Approaches to Learning" in OECD (2010), *The Nature of Learning: Using Research to Inspire Practice,* OECD Publishing.

**Elmore, R.** (2002), "The limits of change", *Harvard Education Letter*, January-February.

**Gertzman, A.** and **J.L. Kolodner** (1996), "A case study of problem-based learning in middle-school science class: Lessons learned", in the proceedings of the Second Annual Conference on the Learning Sciences, Evanston, Illinois, pp. 91-98.

**Good, T.L.** and **J.E. Brophy** (1986), *Educational Psychology* (3rd ed.), Longman, New York.

**Lehtinen, E.** (2003), "Computer-supported collaborative learning: An approach to powerful learning environments", in E. De Corte, L. Verschaffel, N. Entwistle and J. van Merriënboer (Eds.), *Powerful Learning Environments: Unravelling Basic Components and Dimensions*, Advances in Learning and Instruction Series, Elsevier Science Ltd., Oxford, pp. 35-53.

**Looney, J.W.** (2011), "Integrating Formative and Summative Assessment: Progress Toward a Seamless System?", *OECD Education Working Papers*, No. 58, OECD Publishing.

**Mayer, R.E.** (2004), "Should there be a three-strikes rule against pure discovery learning?" *American Psychologist,* Vol. 59 (1), pp. 14-19.

**Mayer, R.E.** (2010), "Learning with Technology?" in OECD, *The Nature of Learning: Using Research to Inspire Practice,* OECD Publishing.

**Norman, D.A.** (1993), *Things That Make Us Smart: Defending Human Attributes in the Age of the Machine*, Addison-Wesley Longman Publishing Co., Boston, Massachusettes.

**OECD** (2007), *Evidence in Education: Linking Policy and Research*, OECD Publishing.

**OECD** (2009), *Creating Effective Teaching and Learning Environments: First Results from TALIS*, OECD Publishing.

**OECD** (2010a) *Innovation Strategy A Head Start on Tomorrow,* OECD Publishing.

**OECD** (2010b), *The Nature of Learning: Using Research to Inspire Practice*, OECD Publishing.

**OECD** (2010c), *Innovative Workplaces: Making Better Use of Skills within Organisations*, OECD Publishing.

**OECD** (2010d), *Inspired by Technology, Driven by Pedagogy*, OECD Publishing.

**OECD** (2011a), *Strong Performers and Successful Reformers in Education: Lessons from PISA for the United States,* OECD Publishing.

**Puntambekar, S.** and **J.L. Kolodner** (2005), "Toward implementing distributed scaffolding: Helping students learn science from design", *Journal of Research in Science Teaching,* Vol. 42 (2), pp. 185–217.

**Remillard, J.T.** (2005), "Examining Key Concepts in Research on Teachers' Use of Mathematics Curricula", *Review of Educational Research*, Vol. 75, No. 2, pp. 211-246.

**Salomon, G.** (Ed.), (1993), *Distributed Cognition: Psychological and Educational Considerations,* Cambridge University Press, Cambridge.

**Slavin, R.E.** (2010), "Co-operative Learning: What Makes Groupwork Work?", in OECD, *The Nature of Learning: Using Research to Inspire Practice,* OECD Publishing.

**Trilling, B.** and **C. Fadel** (2009), *21st Century Skills – Learning for Life in our Times,* Wiley.

**Valiente, O.** (2010), "1-1 in Education: Current Practice, International Comparative Research Evidence and Policy Implications", *OECD Education Working Papers*, No. 44, OECD Publishing.

**van der Linden, J.,** et al. (2000) "Collaborative learning", in R.J. Simons, J. van der Linden and T. Duffy (Eds.), *New Learning*, Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 37-54.

**Wiliam, D.** (2010), "The Role of Formative Assessment in Effective Learning Environments" in OECD, *The Nature of Learning: Using Research to Inspire Practice,* OECD Publishing.