THE WAY UP, DOWN UNDER

INNOVATIONS SHAPE LEARNING AT SCIENCE AND MATH SCHOOL

By Kerry Bissaker, Jim Davies, and Jayne Heath

Professor John Rice, a pioneer of the Australian Science and Mathematics School (ASMS), posed the question: "How does teaching and learning in schools today speak to students about satellite navigation, biomimetics, laser tweezers, intelligent polymers, quantum computers, or artificial photosynthesis?" He recognized that schools' curricula were at odds with the kind of science and mathematics driving the new economy. In addition to curriculum that lacked relevance to contemporary life, negative student attitudes and a shortage of qualified science and mathematics teachers were creating a crisis in the field that required a total transformation of existing models of senior science and mathematics education (Masters, 2006; Tytler, 2007).

In 2002, a partnership between the South Australian Department of Education and Flinders University in Adelaide, Australia, responded to the crisis by building a purpose-designed school on the university's grounds to provide a state-of-the-art learning environment. The mission of the school was to re-engage senior secondary school students in the disciplines of science and mathematics through innovative and authentic curriculum, pedagogies that promoted group inquiry, and self-directed learning and capabilities to engage with and contribute to the 21st-century world.

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Jim Davies is interviewed by students Victoria Haar and Shaun Plumtree at Australian Science and Mathematics School.

The journey of transformation began with generating contextual and organizational conditions that prioritized teacher learning. The school's vision to provide leader-

Australian Science and Mathematics School in Adelaide provides a state-of-the-art learning environment.

ship of innovation and reformed science and mathematics teaching and learning was based on the recognition that students' learning environment would be derived from, and a reflection of, teachers' learning environment. To create such an environment, the school's founders created a professional learning strategy built around a license to innovate, powerful and sustained professional partnerships, interdisciplinary teams of teachers, multidimensional leadership, and a constant focus on what it means to be a learner in the 21st century.

For seven years, university researchers and school leaders tracked teachers' professional learning journeys in an environment that recognized they were the key to successful transformation. Their stories helped to identify which factors they perceived made a significant difference to their learning and enhanced outcomes for students. A major outcome was the recognition that different teachers needed different learning opportunities, and this was possible when the school's conditions and resources aligned with specific teacher needs. The school often intentionally created the enabling conditions, for example, by partnering university scientists with teachers to develop innovative curriculum. At other times, teachers' learning occurred in incidental ways as an outcome of the open space learning environment and collaborative learning culture that developed in the school.

INTENTIONAL LEARNING AS AN OUTCOME OF PROFESSIONAL PARTNERSHIPS

"It's the structures that aren't in place. You know you don't have a textbook to work with, you do not have a program to follow. You've got to start from scratch again, and as soon as you do that, then you get the freedom to do different things. We managed this because we worked in teams." — *ASMS teacher*

Keeping teachers in touch with developments in sci-

"This school is not new for the sake of being new but new because it matters."

— *Jim Davies*

ence was essential to their work at the school. Partnering teachers with scientists from the university provided opportunities for teachers to develop new content knowledge and insight into the changing ways scientists work. The emergence of cross-discipline fields of science such as nanoscience and biotechnology involves teams with discipline expertise in physics, biology, and chemistry. The school mirrored this model through cross-discipline teaching teams planning and teaching semester-long courses referred to as the central studies curriculum. The diagram below illustrates how educators interacted. The school also redesigned students' schedules so they had extended learning sessions around topical themes, such as sustainable futures and biotechnology. The thoughtfully designed model re-engaged teachers as well. One teacher noted:

"It's the environment. I haven't really invited other teachers into my classroom in the past, so even though I had good relationships with them, we didn't look towards team teaching and really working together. It just seems the natural thing to do here."

— ASMS teacher

"I felt so enthused by working with others in cross-discipline ways and seeing how the connections between disciplines generated some fantastic learning opportunities for students. This is the kind of science teaching I had wanted to be involved in, but it wasn't possible in the way other schools are structured."

University academics supported the teaching teams, and the cross-discipline knowledge at the weekly planning sessions created rich dialogue and many challenges. Creative endeavour and innovation emerges when people interact, share ideas, argue points of view, challenge orthodoxy, and shape each other's thinking. University staff brought deep content knowledge of the new sciences, while teachers contributed knowledge of adolescent learners and the state's requirement for achieving the standards required for high school completion. The lively curriculum writing sessions were built on respect for team members' content and pedagogical knowledge and a strong desire to shape innovative learning opportunities for students.

Beyond weekly curriculum planning meetings, university academics were also involved in designing and delivering eight-week modules in areas such as cryptography, robotics, and politics, oil, and terror. These modules were delivered as 100-minute weekly sessions, and teachers participated along with the students. This gave students direct access to university scientists and mathematics and was also designed to provide teachers with rich professional learning. An outcome of the model was that much of the content of the university modules was ultimately embedded in the central studies courses and taught by the teachers. The university academics then developed new modules, and the cycle of teacher learning and the generation of new curriculum possibilities were sustained over time.

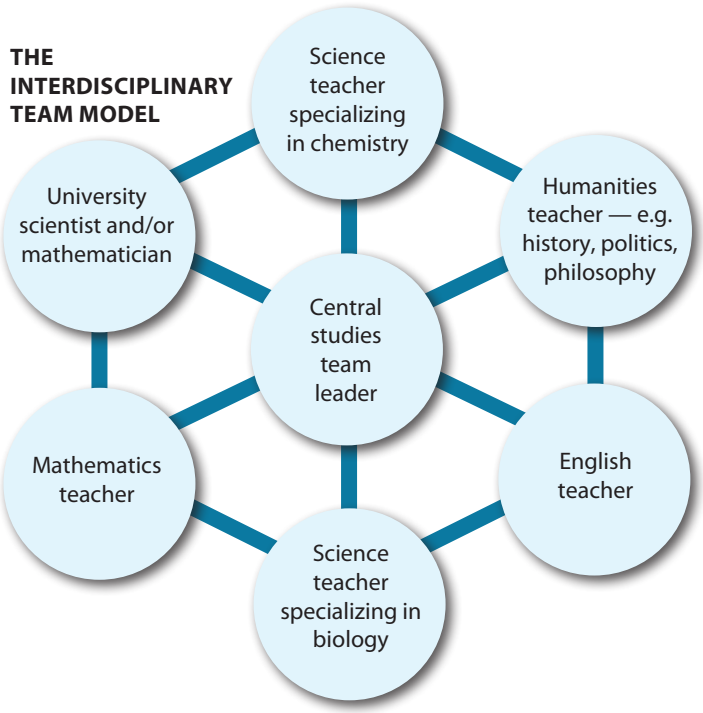
One teacher reflected on the outcome of the university modules experience and highlighted that they were not only opportunities to learn about new content but provided time to reflect on the pedagogical practices as well:

"The university modules have been of interest to me. Initially, I wondered whether they would seem like elective programs in other schools and that the students would not take them that seriously and that I might even have time off, too. They proved to be very different. The university staff were keen to put on a good show and so there were lots of interesting things for the students to engage in. Some were more popular than others, and, at times, I think this had more to do with the teaching styles rather than the content, but it certainly highlighted to me the power of good teaching."

Teachers and academics intentionally focused on good teaching through constant attention to what it means to be a successful learner in the 21st century. University academics also specialized in teaching and learning and partnered with teachers around this topic. Jayne Heath, assistant principal in charge of professional learning, ensured that teachers engaged in action research teams in collaboration with academics to reflect on pedagogical practices that would support students to become successful 21st-century citizens. She said:

"We provided a lot of time for teams to work on central studies development, but we also needed to keep our underpinning principles about effective learning in the forefront of everyone's mind — meta-cognition and demonstration of learning

THE INTERDISCIPLINARY TEAM MODEL



in a variety of ways, just to name a couple. Teachers can get all bound up in 'what lesson am I teaching tomorrow?' We wanted to challenge people to think about the key features of our school — understanding what effective learning and teaching looks like."

Action research teams supported teachers' examining and reflecting on practice. The teachers' most important question — "What did I do that helped students learn?" — drove the examination of practice. Such questions didn't inform a formal evaluation of a teacher's practice but were a means of establishing a dialogue between teacher and student. Teachers were encouraged to view students as their professional partners as well. Teacher-student dialogue created opportunity for teachers to reflect on practice and for student to reflect on learning. The process created mutual understanding that was at the heart of the teacher-student relationship. One teacher reflected:

"I've learned to listen to the students. Collaboration was something I had given lip service to in the past, but I really understand the power of it now, between teachers, students and teachers learning with and from students and other teachers."

The box above illustrates the transformation of teacher and student roles.

PEDAGOGICAL SHIFTS	
Teacher-directed →	**Student-directed**
Teacher	Teacher
• Knows. • Tells. • Examines.	• Facilitiates learning. • Coaches. • Challenges. • Verifies learning.
Student	Student
• Boundaries to learning defined for student. • Learning quantified by others.	• No boundaries to learning. • Demonstrates learning — verified by others.

INCIDENTAL LEARNING AS AN OUTCOME OF THE PHYSICAL AND CULTURAL ENVIRONMENT

"I think this building has been one of the biggest contributors to my learning purely because you can't escape. It's the open nature. I can just sit at my desk, and someone will walk past and I'll think, 'What's he doing? Oh, that is interesting. I never thought about doing it like that'— even if it's just a small idea or activity."

— ASMS teacher

As a key design element of the school, teachers were not tucked away in staff rooms or offices. Their workstations were part of the open space learning commons, and teaching was occurring around them when they had nonteaching time. Teaching practice became completely deprivatized. Because teachers had worked in curriculum design teams, they could observe each other teaching material that they may have designed. Teachers were often surprised by how others interpreted their ideas, and many highly experienced teachers gained significant insight into their teaching practices through reflecting with colleagues on teaching sessions. A teacher's story encapsulates the powerful outcomes of learning with and from peers in incidental ways.

"He [a teaching colleague] was impressed by my mathematics and curriculum designs, and I was impressed by his teaching. I'd watch him work with students and thought, 'This is the essence of constructivism. What is he doing that feels different?' We'd talk about that. He encouraged me to be less of a control freak, without using those words. I think as a team we achieved some significant shifts in the way we taught, and the students' reactions were interesting. I don't know whether it's because I've been around for too long, but in any school I have every been in, I've always heard kids say, 'Oh, no, not maths again.' You don't hear it here because of what we do, whether it's the maths or the teaching. Probably both, but kids seem to do better when they connect with teachers."

"My learning has been supported by participatory observation of learning in action. As a mentor teacher, I learn and help other teachers to learn. It's an ongoing cycle."

— ASMS teacher

The teacher acknowledged the power of positive student-teacher relationships, but his story also captures the power of trusting teacher relationships that enabled colleagues to constantly provide critical and constructive feedback to each other. Working with teacher colleagues became a primary form of professional learning embedded in the daily work of the school. The plan for teachers to work together in teams provided the foundation for building relationships, respect, and knowledge, while the nature of the physical and cultural environment that emerged over time generated easily accessible and powerful incidental teacher learning opportunities.

LEARNING AS AN OUTCOME OF MULTIDIMENSIONAL LEADERSHIP

"There is an important culture here. Learning is an expectation, and everyone is a leader of learning. That, in itself, is fundamental because what it provides opportunity to search for new ideas and not be constrained by seeing the world as being known or as black-and-white."

— ASMS teacher

Quality leadership is an essential ingredient in all transformative activity, and this was fundamental at the Australian Science and Mathematics School. School leaders continually reinforced a message to all teachers in the school that profes-

sional learning was their most important work priority. The principal of the school commented:

"It's critical that the school as a whole maintains a high profile and professional learning approach, a learning culture that is articulated frequently by its leaders, and that these leaders show that they value learning in everything that they do, and that not engaging in that is not acceptable as a professional. It's not about toeing the line. It's about a belief that when visitors come to our school and interact with us about our knowledge and professionalism or ask us questions that challenge us, we can all show that, even if we don't have the answers, it's evident we have thought very deeply about and understand what it means to be an effective teacher and a learner. Getting to this stage requires an ongoing belief and valuing of professional learning by the leadership team."

Andrew Downing, professor of electronics and engineering, describes a stepper motor to students Kane Elson and Becky Hartman at Australian Science and Mathematics School.

Defining and shaping leadership was a significant aspect of the school's professional learning journey, and the leaders of the school shaped their thinking practices around Nelson Mandela's perceptive understanding that "leadership is about liberating cleverness." Its evolution at the school involved the leadership team in creating circumstances where all teachers accepted responsibility to contribute as leaders through their ideas and contribution to others' learning. Leadership was multidimensional and collaborative; it ultimately generated a respectfulness and recognition of others' cleverness. Through the many intentional and incidental learning opportunities provided by the school, teachers began to redefine their sense of professional identity. One teacher commented:

This article is based in part on Kerry Bissaker's 2010 doctoral thesis entitled "The processes and outcomes of professional learning in an innovative school: The construction of an explanatory model."

"I came to the school as a teacher of visual literacy but now view myself as a supporter of innovations in science and mathematics teaching. What I look for in professional learning now is peers examining the work we've done in curriculum and information and communications technology to improve my practice. This can all happen within the school because we are developing our own areas of expertise and sharing them."

Leadership emerged as powerful and pervasive, a joint endeavor to achieving the vision of truly transforming senior secondary science and mathematics. As one teacher noted:

"Change is more rapid and ongoing when there is support for these beliefs from leadership. I am also able to operate with a high degree of autonomy and be recognized as a professional, able to make good decisions in relation to my sphere of control."

The professional learning journey for all members of the school continues and shapes and reshapes experiences for teachers and students.

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