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Contextual factors that sustain innovative pedagogical practice using technology: an international study

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Abstract Pedagogical innovation—whether involving technology or not—is shaped by a complex interaction of the innovation with contextual factors such as school and school district policy, leadership, cultural norms and values, teacher attitudes and skills, and student characteristics. This study examined school and classroom contexts in which pedagogical innovations employing technology were successfully sustained. Data were obtained from 59 cases drawn from the Second Information Technology in Education Study—Module 2, a project that examined 174 cases of innovative pedagogical practice in schools in 28 countries. An explanatory model of sustainability was derived from a qualitative analysis of the cases using grounded theory techniques. Essential conditions for the sustainability of classroom innovation were teacher and student support of the innovation, teacher perceived value of the innovation, teacher professional development, and principal approval. Contributing factors for sustainability were supportive plans and policies, funding, innovation champions, and internal and external recognition and support.

Keywords Sustainability · Contextual factors · International studies · Technology · Pedagogical innovation

''*School is so beautiful—what a pity for us that it will end soon*,'' said Frederica, a 5th grade student at Scuola Bella Primary in northeastern Italy. She was talking about no longer being part of a long-standing cross-curricular technology innovation at her school. Dubbed the ''Anthill'' because of its extensive electronic archives of school activities, this project involves students, parents, and teachers in online discussions,

An interactive website that allows for searching of SITES-M2 case reports on various attributes such as sustainability, transferability, level of school, and evidence of supportive policies and plans is available at http://sitesm2.org.

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opinion polls on local town issues, and international project linkages. At the end of grade 5 Frederica finishes primary school and moves on to another school.

Scuola Bella is one of 174 schools studied in the recent Second Information Technology in Education Study Module 2 (SITES-M2), a large scale research project sponsored by the International Association for the Evaluation of Educational Achievement (IEA) (see Kozma, 2003 and article note). The project examined innovative pedagogical practices that use technology in schools from 28 countries across North America, South America, Europe, Australia, Asia, and Africa. One of the main goals of the project was to investigate why certain kinds of classroom-based innovations that use technology, like the one in Frederica's school, succeed and are sustained, while others do not. This paper, in particular, reports on a sub-study aimed at developing an explanatory model for the sustainability of technology innovations.

Framework of the study

The SITES-M2 study viewed innovative pedagogical practices as embedded in a model consisting of a concentric set of three contextual levels that affect and mediate change (Kozma, 2003). First is the micro level, consisting of such factors as classroom organization and personal characteristics of the teachers and students. At the micro level, the classroom research literature (Means & Olson, 1995; Sandholtz, Ringstaff, & Dwyer, 1997; Means, Penuel, & Padilla, 2001; Schofield & Davidson, 2002) documents a strong association between technology-based practices and changes in curriculum and pedagogy. For example in many countries, the use of educational technology is part of an instructional shift toward constructivist approaches to teaching and learning within a context of school improvement or reform (Pergrum & Anderson, 1999). Instead of focusing solely on increasing the acquisition of facts related to specific subject areas, teams of students are engaged in solving complex, authentic problems that cross disciplinary boundaries. Instead of dispensing knowledge, teachers set up projects, arrange for access to appropriate resources, and create the organizational structure and support that can help students succeed. This approach moves conceptions of learning beyond rote memorization of facts and procedures to learning as a process of knowledge creation. It moves school beyond the notion of place where knowledge is imparted, to one of classrooms, organizations, and societies as knowledge building communities (Bereiter, 2002; Scardamalia & Bereiter, 1994; Brown & Campione, 1994).

Subsuming the micro level is the meso level, which includes the school organization and personal characteristics of administrators and community leaders. At the meso-level, it is well known (Fullan, 2001; Van Den Akker, Keursten, & Plomp, 1992) that innovation benefits from leadership and a supportive organizational environment. Hence, innovative practices are likely to be part of an environment in which the school management is in favor of the practice and the practice is supported by the school organization, fits in the curriculum, and is part of the teacher's routine. In some countries, technology may be introduced as part of school improvement or reform—"a systematic, sustained effort aimed at change in learning conditions and other related internal conditions in one or more schools" (Van Velzen, Miles, Eckholm, Hameyer, & Robin, 1985, p. 48). These efforts often involve coordinated

changes in curriculum, instructional strategies, and learning focus for both teachers and students that place different demands on resource allocation and use (Louis & Miles, 1991). School improvement studies emphasize the central role of context and school culture in mediating change (Dalin, 1994; Huberman, 1992; McLaughlin, 1993; Fuller & Clarke, 1994; Stoll & Fink, 1996). Parental involvement appears to be especially critical to ensuring success provided parents and teachers work together while recognizing the complementary role they play in the children's lives (Fullan, 2001). Indeed, there is evidence that children whose parents are involved in their schooling tend to perform better (Henderson & Berla, 1994).

Third is the macro level, which encompasses the previous two levels, and concerns state and national policies and international trends. At this level, classroom practices can be influenced by state or national policies and international trends in areas such as curriculum and assessment, professional development, and telecommunications. Although there is often a gap between national or state/provincial policies and the classroom practices they are meant to influence, practices are more likely to be affected when there is coherence between curriculum, assessment, instructional materials, and instructional guidance (Cohen & Hill, 2001). This is particularly so when teacher professional development is directly related to policy in concrete, content-specific, and instructionally relevant ways.

Beyond the national or provincial level, current theories of comparative education (Arnove & Torres, 1999) identify a fundamental tension that affects contemporary educational change. This is a dialectical tension between massive global forces that affect social relations and institutions across national boundaries and the accommodation of these forces based on local cultural, political, and historical factors. Thus, the transnational, economically driven pressures to increase educational quality and efficiency play out differently in the United States, England, and Australia (Berman, 1999) than in Asia (Su, 1999), Eastern Europe (Bucur & Eklof, 1999), or Africa (Samoff, 1999). These global forces are modified and, in some cases, even transformed in the process by which international trends are reshaped to local ends.

The model assumes that successful technology-based innovations are affected by and, at the same time, influenced by this extended set of personal, pedagogical, curricular, and organizational factors that constitute the context of their use (De Corte, 1993; Salomon, 1991; Kozma, 1994). According to Kozma (2003) causality among these factors is not unidirectional; rather, successful practices depend on the ways the factors at these various levels fit together and reinforce each other. Classroom practices are affected by school organization and national policies, but school organization and national policies can also be shaped by successful innovations in the classroom. Consequently, underlying the model is the process by which innovations are adopted and diffused. This process is a function of the above contextual factors as well as the characteristics of the change or innovation itself (Fullan, 2001; Rogers, 1995). Fullan (2001) posits that four characteristics of change are relevant: *need*, which deals with the fit between the innovation and district or school needs; *clarity* of the goals and means of achieving them; *complexity*, which concerns the extent and difficulty of the change for those implementing it; and *quality and practicality*, which is about how good the innovation is and how attainable it is. On the other hand, Rogers (1995) suggests that there are five factors related to the nature of innovations and their rate of adoption: *relative advantage*, the degree to

which an innovation is perceived as better than the idea it supercedes; *compatibility*, the extent to which it is consistent with existing values, experiences, and needs of adopters; *complexity*, how difficult it is to use and understand; *trialability*, the degree to which it can be experimented with on a limited basis; and *observability*, the degree to which the results of the innovation are visible to others. Despite their extensive writings on the change process and the similarities between their analyses of the nature of innovations, neither Fullan nor Rogers cite each other's work. Fullan's complexity and need are similar to Rogers' concepts of complexity and compatibility, respectively, however, they diverge in their views on the remaining factors.

Sustainability of educational reforms

Even though many innovations become adopted in classrooms, very few are actually able to become institutionalized much less spread to other schools (Datnow, Hubbard, & Mehan, 2002; Elmore, 1996; Cuban, 1992). Miles (1983) developed one of the earlier models explaining how innovations become institutionalized. His empirically derived model emphasizes how institutionalization begins with administrative commitment, which he views as a necessary but not sufficient condition for it to happen. The administration then provides pressure on teachers to implement the innovation and assistance in mastering it. Through hard work teachers eventually become committed to the innovation which, in turn, leads to ''stabilization of use'' and, ultimately, institutionalization. Miles makes the point that teacher enthusiasm, skill, and effectiveness of the innovation are not sufficient to sustain it; rather administrators must make changes in organizational structure, rules, and procedures and ward off threats that could de-stabilize the innovation. Although Miles (1983) describes the process of an innovation becoming institutionalized as rather linear, most see it as an iterative process that begins with an initiation phase, followed by an implementation phase, which leads to institutionalization (Berman, 1981; Fullan, 2001). Decisions taken at any one phase can feed back to alter decisions made at previous phases, which then proceed to work their way through in a continuous interactive way (Fullan, 2001).

Others have examined factors contributing to or working against institutionalization from a broader organizational perspective. Kirst and Meister (1985), after an analysis of major reform initiatives in the US, found that reforms most likely to be sustained are those based on policies that: (1) promote change in organizational structure, such as the introduction of teacher aides into the classroom; (2) identify students for particular programs, such as English as a second language or special education; (3) legislate changes in teacher certification that can be easily monitored; and (4) establish compensatory rights and procedures, such as due process for students to be classified for handicapped programs. Reforms that did not take hold tended to be of a pedagogical nature, such as attempts to change the amount of time on reading or math instruction, or the introduction of inquiry methods of learning. Datnow, Hubbard, and Mehan (2002) classified reasons why reforms do not last into three categories: agency, culture, and structure. Agency reasons concern the actions taken by educators in not implementing reforms as intended or designers not being sensitive to local circumstances. Cultural explanations consist of how innovations are shaped by introducing them into new school settings: schools change the reform as

much as the reform changes schools. The third category deals with how state or district structures, including programs and policies, interact with and affect local school reforms efforts. More generally, Elmore (1996, p. 2) argues that innovations that require large changes in the ''core of educational practice,'' that is how teachers ''understand the nature of knowledge and the student's role in learning,'' seldom penetrate many schools and when they do, they seldom last for long. Thus, the further an innovation is from the normal practices in a school, the lower the likelihood is that it will be sustained.

More contemporary conceptualizations of sustainability advance the notion of sustainability beyond being an issue of simply maintaining an innovation. Hargreaves (2002) and Hargreaves and Fink (2000) argue from an ecological perspective that sustainability is not only a temporal matter, but, it ''addresses how particular initiatives can be developed without compromising the development of others in the environment, now and in the future'' (Hargreaves & Fink, 2000, p. 32). The authors state that in addition to maintaining educational improvement over time, there are four other interrelated characteristics of sustainability. First, sustainable improvements must support learning for the good of everyone and not just change some aspect of schooling or create model or magnet schools that benefit only a relative few. Second, sustainable improvements must be supportable by available or attainable resources so that they do not deplete resources needed by others in the school system. Third, sustainable improvements should not have a negative impact on other schools or the system by squandering valuable resources on, for example, pilot projects that disappear after funding ends. Finally, sustainable improvements must focus on creating environments that foster diverse (as opposed to standardized ''one size fits all'') and creative approaches that develop long-term capacity for improvement. Thus from the authors' perspective sustainability raises questions not only of endurance of an innovation, but of its ''arrangement and articulation through space and time'' (Hargreaves & Fink, 2000, p. 32).

Likewise Fullan (2005) sees sustainability as a much more complex and challenging undertaking than the mere maintenance of change. He views sustainability from the perspective of transforming a system, be it an educational system, a public service agency, or a corporation. Accordingly, sustainability begins with moral purpose, the idea that individuals must be committed to improving not only their own area of responsibility, but must be dedicated to transforming the larger organization. The contexts in which people work must be changed too. In the case of education, the contexts are schools/communities, districts, and the system. Capacity building laterally across schools and the district is another essential element of sustainability. Fullan sees learning communities and networks that work on shared problems and issues as an effective means to accomplish capacity building. Although these networks do provide some measure of accountability through self-evaluation, he also sees the need for system-wide accountability and vertical integration of innovations to maintain the coherence of a system. Additionally, sustainable systems must foster deep learning: this implies the need to create a culture of learning at all levels in the system that focuses on solving difficult problems and learning from previous mistakes and successes. For systems to be sustained energy levels must be managed to prevent individuals from becoming burnt out or being consumed by negative work as well. Lastly, Fullan stresses the need for leaders at all levels of the system to be the primary levers or drivers of change: leaders must work

simultaneously at putting into place all of the above elements that he sees are essential for sustainability.

As with Fullan (2005), Hargreaves and Fink (2006) stress the imperative of leadership to sustain systemic improvement, but acknowledge the difficulty of developing leaders for sustainability. They set out a framework of seven principles for sustainable leadership: deep learning, lasting leadership, distributed responsibility, not doing harm to others and sharing knowledge and resources, avoiding standardization and promoting diversity and cohesion, conserving leaders' energy, and building on past successes. While Fullan (2005) and Hargreaves and Fink (2006) generally agree with each other on what is required for sustainability, they diverge on the issue of setting achievement targets for educational reform. Hargreaves and Fink maintain that ''externally imposed, short-term achievement targets are incompatible with long-term sustainability'' (p. 252). On the other hand, Fullan contends that the ''new reality is that governments have to show progress in relation to social priorities...within one election term (typically 4 years)'' (p. 25). He sees short-term targets as essential for building public trust for long term investments. Hargreaves and Fink counter with the argument that, even though governments may want to impose them, short term targets violate each of their seven principles of sustainable leadership and learning.

Educational technology and sustainability

Little has been written on the factors that sustain technology-based innovations in schools. Cuban (2001) argues that computers are adopted by teachers in the same way as any other educational innovation; that is, they use them to sustain existing instructional patterns. Therefore, one would not expect factors affecting sustainability to be any different than those affecting other kinds of innovations. On the other hand, Dede (1998) maintains that computers have unique attributes that pose special challenges when trying to sustain and scale up their use. These include the costs of equipment, its rapidly changing nature, and the specialized knowledge and skills required by teachers. One of the earlier studies that looked at sustainability of technology innovation was the Apple Classrooms of Tomorrow (ACOT) project (Apple Computer, 1990). Researchers documented the challenges that teachers faced over 5 years as large numbers of computers became integrated into the culture of project schools. Veteran teachers reportedly went through three stages of adaptation to the innovation—survival, mastery of the technology, and using the technology to manage the classroom—which were similar to the experiences they had as beginning teachers. Blumenfeld et al. (2000) extended Elmore's (1996) notion of distance from the norms of practice, to technology-based contexts. Their research on a technology-based reform initiative in science education suggested a three-dimensional model of sustainability with axes for: (a) policy and management, (b) school culture, and (c) technical capabilities. They posit that the closer an innovation is located in the space to the origin of these axes, the less challenging it will be to the teachers' existing capabilities, hence the more likely it will be adopted and sustained. Similarly, Zhao, Pugh, Sheldon, and Byers (2002), in a study of teachers who received classroom technology innovation grants, found that success of an innovation is lowered not only by the distance from existing school practices, but also by how

much it depends on acquiring new technological resources (e.g., hardware, software, or Internet connectivity), which may be slow in arriving or delayed being installed, and by how readily teachers can gain access to needed existing technology resources such as computer labs. The authors examined only the first year of implementation of the grants, so the question still remains as to how well the innovations became institutionalized and whether technology factors affected their continuation.

In this study, I examined a set of international cases of technology-based classroom innovations that became institutionalized. My goal was to develop an explanatory model for the sustainability of these classroom innovations, and to identify if there are any factors unique to these technology-based contexts that have not been described in the literature.

Methodology

The 174 schools that participated in SITES-M2 were selected through a nomination procedure by a national panel of experts formed specifically for the study in each country. Selection criteria were that (1) the innovation should show evidence of significant changes in roles of teachers and students, the goals of the curriculum, assessment practices, and/or the educational materials or infrastructure; (2) technology must play a substantial role; (3) preferably there would be evidence that the innovation is associated with positive student outcomes; (4) the innovation should be sustainable and transferable; and (5) the innovation meets national criteria for what is deemed innovative teaching practice. Common research protocols were developed by the international coordinating committee in collaboration with national research coordinators in each county, who were typically a combination of ministry of education personnel and university researchers. These protocols specified that on-site visits of 1 week per school were to be conducted; that lead teachers, principals, parents, and students be interviewed using common instruments developed for the study; and that classroom teaching be observed using common guidelines; and that local documents be collected. Descriptive reports were written for each school by research teams headed by the national research coordinator in each country. These reports had a common template that prescribed what was to be described and illustrated about the innovative practices. A quality control system was employed whereby the international coordinating committee provided ''friendly critiques'' of all reports, and national research coordinators critiqued each others' reports for adherence to the report guidelines and on issues such as comprehensiveness of the presentation, potential bias, and the warranting of assertions. The reports had a face sheet attached that provided a quick overview of salient characteristics of each case such as the grade level, subject area, type of curricular change involved, teacher classroom activities reported, student classroom activities reported, type of technology used, reported impact, and presence of evidence of sustainability and transferability of the case. The face sheets were coded by the international coordinating committee who, in turn, asked national research coordinators to verify the accuracy of the coding.

From this larger group of 174 cases 59 had evidence of both sustainability and transferability as indicated by the face sheets. Sustainability was operationally defined as the innovation having carried on for a period of more than 2 years without extra fiscal resources; transferability was defined as the innovation having been

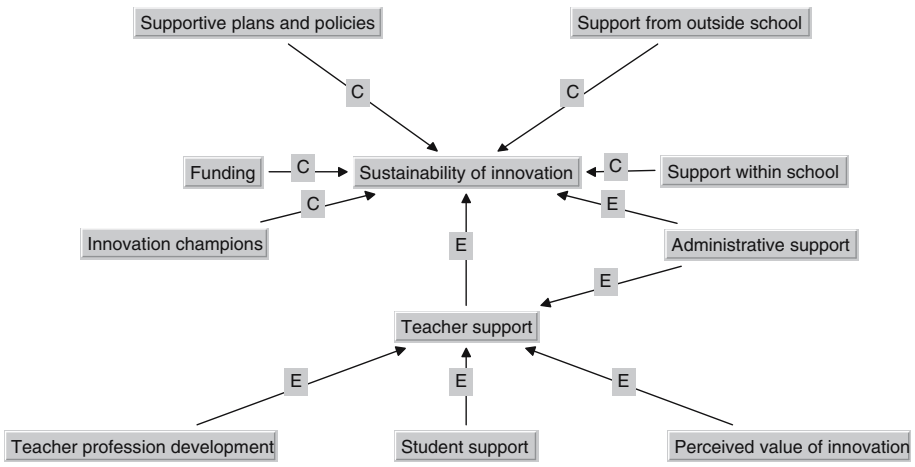
adopted in its essential form by another grade in that school, school, or school district. This set of 59 cases served as the data source for the present study.

A grounded theory approach (Glaser & Strauss, 1967; Strauss & Corbin, 1998) was taken as the goal was to derive a model of sustainability based on the 59 cases selected. This qualitative analysis approach provides a means to build from systematically gathered and analyzed data explanatory frameworks that specify relationships among concepts. Because grounded theory is developed from actual raw data, Strauss and Corbin (1998) maintain that the resulting theory is more likely to resemble ''reality'' and offer ''insight, enhance understanding, and provide a meaningful guide to action'' (p. 12). Grounded theory researchers typically begin with an area of study and allow theory to ''emerge'' from their data; however, the data analysis for this study was also guided by the conceptual framework described above that pointed to key contextual factors *a priori*.

The constant comparative method was used to analyze the selected cases and build a theoretical model for sustainability, following steps outlined by Bodgan and Biklen (1998, pp. 67–68). This iterative method began with looking for key issues, recurrent events, or activities in the data that became categories of focus. The data were further examined for more incidents of the categories of focus, with an eye to seeing the diversity of the dimensions under the categories. An attempt was then made to describe and account for all the incidents in the data, while at the same time continuing to search for new incidents. The data next were worked with to discover basic social processes and relationships in the emerging model. Finally, the model was tested to see if it accounted for the data through additional sampling, coding, and writing.

A model for sustainability of classroom innovation

The model of sustainability that emerged from the case analysis is illustrated in the figure below. It is comprised of two sets of conditions underlying sustainable innovative teaching practices using technology—one set labeled *essential*, the other *contributing*. These are represented by ''E'' and ''C'', respectively, in links between factors. Essential conditions were defined as those that my analysis found were necessary, but not sufficient, for innovations to be sustained. Evidence of these factors



was found in *all cases* in the sample. Contributing conditions were those that I found facilitated the sustainability of innovations. These factors appeared in *50% or more* of the cases, an arbitrarily chosen criterion that I believed justified their inclusion in the model. The essential (E) and contributing (C) factors are now described.

The essential role of teachers

Most fundamental to sustaining an innovation is teacher support, for without this, the innovation simply cannot occur. All of the cases I studied cited instances of how supportive teachers were of their classroom innovations. Typical was the principal of an Israeli secondary school who stated: ''*the key to the sustainability of the innovation is the teachers, their willingness and readiness to take part.*'' He went on to describe how teachers became ''hooked'' on their innovation and saw this form of commitment as one that will even transcend shortfalls in resources. The school's innovation, known as the Peace Network, brought together students from Palestinian and Arab Israeli schools in online forums to foster cross-cultural understanding. The project culminated in face-to-face meetings of the students, where its success was demonstrated as there were none of the tensions normally found when bringing students of these diverse cultures together.

What seems to make teachers commit to an innovation according to the case report of a Canadian elementary school is:

> ... \the professional and personal satisfaction they derived from being able to teach in what they found to be a more meaningful and effective manner, and from seeing the positive impact their work was having on students.

This school took a cross-disciplinary, inquiry-based curricular approach that integrated technology and focused on projects in areas of relevance to the students, their families, and the local community.

Many other case reports cited the positive attitude of teachers as an essential element of sustainability as well. For example, in the report for a primary school in The Netherlands, teachers were cited as being ''enthusiastic about the innovation,'' had taken ownership of it, and wanted to continue developing teaching materials even though the technology coordinator who led the innovation was leaving the school. This school's innovation, which saw students developing multimedia projects for publication on the Web, reported significant improvement in student collaborative skills and engagement in their work compared to traditional methods. Teachers at an upper secondary school in the Philippines were also very positive about their innovation on animating Filipino literature with technology, and wanted it to continue even if the school's agreement with an external educational resource and service provider is terminated. Similarly, the Comenius project in a German secondary school that used the Internet to connect with schools in other parts of the country—and with those in Finland, Great Britain, France, and Poland—became so ingrained into the school's culture that teachers said they wanted to continue it even without funding and support from its sponsor, the European Union. In this project, students collaborated with peers in other schools on tasks such the joint writing of a novel. The case reported significant improvement is students' foreign language and geography skills.

School reform leaders often assume that teacher support will always be forthcoming simply because they themselves are convinced of the value of the innovation they are introducing. This is a risky assumption. Teachers have to believe that what they are doing in the classroom has merit before they are likely to give wholehearted support. I found that teachers who believed that they engaged in a worthwhile activity approached their innovative practice with high levels of motivation and determination to sustain it despite the inevitable setbacks and difficulties of implementing any technology-based program. This essential factor, which I labeled ''perceived value'' in the model, is a combination of what Rogers (1995) calls the ''relative advantage'' and ''compatibility'' of an innovation. In Rogers' terms an innovation will be adopted more rapidly if it is seen as better than what it supercedes and if it is compatible with the existing values, past experiences, and needs of the adopters.

Teachers in the SITES-M2 study tended to express their views on the value of their innovations in terms of the how it affects their students. In another case report, this time of a lower secondary school in England, student benefits were succinctly described: ''Teachers noted that the children involved in the E-pals project developed improved attitudes to school work, better communications skills, increased motivation, and raised awareness of the world of work.'' Through this project students from low income families were mentored via e-mail by employees at a nearby mobile phone factory. The point I wish to emphasis here is that teachers *believed* that their innovation was of value. Whether there is convincing evidence to support their beliefs is another matter. My contention is that teachers' beliefs led to them wanting to carry on with their innovation after initially trying it. Ultimately, teachers will question their beliefs if there is contradictory evidence, but this belief appears to be a necessary factor to lead teachers to persist with their innovation.

For an innovation to be successful teachers need to learn new skills—and equally as important they may need to unlearn beliefs about students or instruction that have dominated their professional careers (Darling-Hammond & McLaughlin, 1996). Thus, teacher professional development is at the heart of sustaining an innovation. My analysis supports this view and classifies professional development as an essential factor in the sustainability model. The manner in which teachers acquire their knowledge and skills—be it through pre-service teacher education programs, formal professional development courses, learning in informal groups with colleagues, or self-study—is not distinguished in the model. I use the term professional development in the very broadest sense to indicate that teachers need to have or acquire technical competencies and other related pedagogical knowledge and skills to implement sustainable technology-based innovations. Important to note is that teacher professional development should not necessarily be thought of in terms of formal courses because informal learning and learning on the job with peers can be equally if not more powerful (Hiebert, Gallimore, & Stigler, 2002). There were compelling examples of this in schools from Canada, Israel, Singapore, and the United States; however, traditional workshops and short courses tended to prevail in most countries' cases.

The principal as gatekeeper

Support from the school principal is another essential factor that contributes to sustainability according to the model. Of the 59 cases in the sample, 7% had leaders

classified as ''neutral'' toward the innovation, 66% were ''supportive'' but not directly involved, and 27% of the cases had leaders ''actively involved'' in the innovation. Neutral leaders, as the term suggests, tend to be passive towards innovations in their schools, neither promoting nor discouraging them. An example of a neutral leader was the principal of a Russian secondary school. The principal said that he does not ''*...prevent the innovation. But I cannot insist on [teachers participating] because they are overloaded with work.*'' At the same time the principal acknowledged that changes ''*are coming: the demands of parents are growing...in the near future, I suppose, they will insist on changing the teaching and learning practice.*'' Supportive principals, on the other hand, were proactive in establishing conditions for the innovation to flourish. Typical was the principal at an upper secondary school in England who saw himself being ''*a manager with a charge of facilitating, stimulating and encouraging both staff and students to extract the full potential of individual students*'' in using the school's innovative student database tracking system that stored all informal and formal test results and facilitated development of individual programs and targets for students. The third category, the actively involved leader, is frequently the visionary behind the school's innovation, identifies personally with the innovation, often persuades and cajoles others to adopt his or her vision, and models the use of technology in daily work. Said the principal of a private girls' school in the Philippines who was this type: ''*I cannot push as much unless I myself see its value. I cannot facilitate the learning process unless I'm a learner myself.*'' She believed that by being at the forefront of change herself, she would encourage teachers to strive to look for new ways to incorporate technology in the mathematics and science curriculum, which was the focus of the innovation.

Of special note is that no principals resisted nor discouraged the innovation in their school. This is perhaps not too surprising because if the principal did not at least tacitly approve of the innovation it would be very difficult for it to flourish in the school. It suggests that, as a minimum, principals play a ''gatekeeper'' kind of role in sustaining the innovation by approving of its existence and not undermining it. The notion of the principal playing a gatekeeper role is regarded as being inadequate in current leadership literature (e.g., Fullan, 2001); nevertheless, the data suggest that sustainable reform can occur when principals assume that role.

The often neglected role of students

Students are often neglected in the school reform literature even though they are the entire reason why schools exist! My research dramatically illustrates the essential role students play in motivating teachers to sustain an innovation.

All cases that I examined contained comments that students were supportive of the innovations in their schools. In fact, the adjective ''enthusiastic'' was used repeatedly by report authors. For example, the physics teacher in a Thai secondary school commented that since the introduction of technology: ''*The children want to attend class more than before. They are eager, enthusiastic, and want to use computers to search for knowledge.''* And in Netlibris, a project that joins a primary school and a lower secondary school in Finland for students to share ideas online about literature, students are ''*really interested in literature and they are very motivated, enthusiastic and they learn easily*'' according to teachers. No achievement data were gathered to determine whether student enthusiasm actually translated into improved student

learning, but on the whole teachers perceived that achievement increased as a result of the innovation. In 43 (73%) of the 59 cases teachers reported that the innovation ''had a positive impact on student acquisition of new subject matter skills'' compared to 66 (57%) of the remaining 115 cases in the entire SITES-M2 study that did not report sustainability; comparable figures for teacher reports of the ''impact of the innovation on metacognitive skill acquisition'' were 32 (54%) and 35 (30%), respectively.

On the whole I concluded that student support—and indeed enthusiasm—for the local innovation played an essential role in motivating teachers to continue to carry out and improve the innovation. Teachers want to do what is best for students to enhance their learning. If they believe that students are benefiting from and are supporting a particular innovation, they in turn will be more inclined to devote the additional time and effort required to maximize the advantages brought on by the innovation. Metz (1993) provides a plausible explanation for this phenomenon in terms of teacher intrinsic rewards. She argues there are so few extrinsic rewards gained by merit or persistent effort in teaching that teachers turn to intrinsic rewards for establishing job satisfaction. The most influential intrinsic reward comes from student cooperation and success. Therefore, teachers are bound to invest time and effort into activities that lead to student accomplishment.

Contributing conditions for sustainability

More diffuse are the contributing conditions for sustaining an innovation. I identified four main conditions in the model, but I make no claim that these are exhaustive. Support for the innovation from others within the school and external to the school are two of the conditions. Inside support may come from other teachers not directly involved in the innovation, whereas outside support may come from peers, parents, school district officials, municipal leaders, or ministry of education personnel. Both groups of actors tend to provide recognition and validation of a teacher's efforts. Most innovations seem to have a ''champion,'' an individual who provides leadership and direction to the initiative so that it is sustained. The innovation teacher may be the champion, or it may be a technology coordinator, another teacher, or the principal. Funding plays a hand in sustaining innovations, too. Many innovations are provided with extra start-up funds, and when this funding is inevitably withdrawn, the stronger innovations tend to survive when the essential conditions for sustainability are met. The final contributing condition for sustainability is the presence of school, school district, or national policies and plans that support the innovation. While many innovations function successfully in the absence of policies or plans, those that have a supportive framework are more likely to endure according to my analysis. I found that national technology policies and plans that provide special funding for hardware, software, school network infrastructure, and teacher professional development were more closely linked to sustainable innovations than other types of more general educational policies.

Notably absent from the model are issues of technical support and adequate reliable computer hardware, factors that are frequently cited in the literature as critical to the sustainability of innovations (e.g., Means & Olson, 1995). Although these issues were raised in cases I examined, none considered them as a significant threat to the sustainability of their innovation, so they were not included in the model.

Discussion and conclusions

The model developed in this study for sustainable innovations should not be considered as definitive. It is grounded in an analysis of 59 cases from the SITES-M2 study, and hence, represents the ''best fit'' for the cases. Nevertheless, it provides a starting point for discussion and conjecture about the reasons why some technology-based innovations fail while others flourish. What emerged in the model were two sets of conditions: those that are essential and those that contribute to sustainability. The foremost essential requirement for sustainability in the model is teacher support of the innovation. Support from the school principal and students is also essential, as is the need for teachers to perceive the innovation to be of value and for teacher professional development. The contributing characteristics of the model consist of support from others in the school and from external sources including parents, school administrators, and other organizations; innovation champions; financial factors; and supportive policies and plans. Contrary to the conclusions of Dede (1998) and Zhao et al. (2002), no new factors emerged that suggest that technology-based innovation is in any way different from other kinds of educational innovation. Indeed, not even hardware reliability or technological infrastructure were salient in sustaining the innovations. Overall, the findings of this study support what previous research has indicated are critical factors for the sustainability of innovations. At the same time, however, the study brings to light several important differences from what other studies about school innovation have found.

The findings agree with Fullan (2001) in that three categories of factors—characteristics of change, local characteristics, and external factors—affect the continuation of innovations. First, with regard to the characteristics of the change or the innovation itself, there was evidence of Fullan's *need* and *practicality*, and for three of Rogers' (1995) five factors: *compatibility, relative advantage*, and *observability*. Stated in terms of the cases studied, the innovation had to be one that fit with the goals of the teacher and, better still, with those of the school (need); it had to be achievable within the constraints of the school in terms of resources and facilities (practicality); teachers had to feel comfortable with the pedagogical approach used in the innovation (compatibility); they had to believe that students were benefiting more from the innovation than past practices (relative advantage); and the recognition that came from the innovation being seen by others tended to motivated teachers to continue with it (observability). The findings do not suggest that the remaining factors of *clarity* (Fullan), *complexity* (Fullan; Rogers), or *trialability* (Rogers) are unimportant—they just did not emerge as being influential in the cases studied. The reason they did not surface may be related to the fact that in almost all of the cases I examined, teachers voluntarily undertook their innovations, developing the innovation themselves or adopting one they fully understood from another teacher. Another possibility may have been the design of the study that took a ''snapshot'' of the innovation over a 1- to 2-week period and the data collection procedures were unable to capture changes over time. Therefore, matters related to how clear the goals were, how complex the innovation was, and whether it could be experimented with in parts were not particularly influential. What was also particularly interesting with regard to the nature of the sustainable innovations in this study was that they were of a pedagogical nature. As pointed out earlier, Kirst and Meister (1985) suggested that pedagogical reforms tend to be unsustainable, but this

study suggests that pedagogical innovation can be sustained if other conditions in the model are satisfied.

As for the local characteristics of the innovation, clearly the teachers, the principal, the school district, and the community all play roles in sustaining the innovation. As stated above teacher support is absolutely essential for classroom-based innovations to be successful. The reform literature acknowledges the central role of teachers, but this study to some extent contradicts Miles' (1983) contention that reform cannot be sustained if it relies largely on teacher enthusiasm and skill. Teacher enthusiasm for and skill at using technology were certainly influential in sustaining the innovations in this study, particularly when teachers saw how student learning benefited from its use. Teachers need to be supported in their professional learning. A variety of professional development approaches were in use in the cases studied, however, most common were traditional models of professional development based on ''delivery'' of technical skills to teachers, which current research suggests is not the most effective approach (e.g., Hiebert, Gallimore, & Stigler, 2002). Principals, at a minimum, needed only tacitly approve of the innovation. This finding is somewhat inconsistent with Miles' (1983) assertion that administration pressure is essential for a reform to become institutionalized. Most principals in this study, however, took a more pro-active role, and I saw evidence of the traditional visionary and the enlightened leader described by Senge (1990), and of Fullan's (2005) ''system thinker'' who looks beyond the walls of their school to lead in district reform. Direct community and district involvement was relatively limited in cases I studied. They mostly gave only passive support to the innovation, or in the case of some districts (or equivalent in countries not having school districts), provided funding for the innovation. The extent to which cultural factors, particularly in non-Western countries, influenced community is not known. One characteristic not specifically raised in Fullan's (2001) description of local characteristics, but significant in this study, is student support. While Fullan acknowledges that their voices should be heard in the reform process, he does not specifically describe how students can affect the continuation of innovations as this analysis does.

With regard to Fullan's (2001) third category, national ICT policy and plans were the most prevalent external factor affecting sustainability. These policies and plans typically provided special funding for hardware, software, and network infrastructure in schools, and to a lesser extent for teacher professional development. Moreover, they provided an added rationale to support and give priority to local ICT-based innovation. Therefore, this study confirms Fullan's (2005) more recent thoughts on the importance of connecting policy development with capacity building as a strategy to sustain reform, as well as Elmore's (2004) contention that shifts in policy must accompany investments in professional development if reform is to be sustained. A less common external factor that I found was partnerships with universities and the private sector, although when partnerships were present they were cited as being critical to the success of the innovation.

In conclusion, our goal should be to make all schools as inviting for their students as Frederica's described at the beginning of this article. Clearly, as this research demonstrates, the process starts with involving teachers—and ideally the principal—in the design of the innovation so that they see how it can help in solving a problem for them or improve student performance. Then both before and during implementation teachers need regular professional development opportunities to share ideas with colleagues, reflect on implementation issues, and

learn more about the innovation itself. But unless teachers ultimately see students benefiting from an innovation or other evident advantages of the innovation, the likelihood is small of them being motivated to sustain it even with extra funding, equipment, support from others inside or outside of the school, or policy directives.

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