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

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"*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 northern 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, 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). 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[1]

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 (Pelgrum & 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

[1] The author is indebted to Dr. Robert B. Kozma, Emeritus Director and Principal Scientist of the Center for Technology in Learning at SRI International, for his significant contributions to this section of the paper.

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 et al. 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 (Fullan, 1991, 1993; 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 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.

What is not clear from the literature is the relative importance of the factors that affect the sustainability of innovations; nor is it clear how the various factors relate to each other. Moreover, the innovation literature deals with innovations more generally, and does not refer to specifically to technology-based learning contexts. Are the factors that Fullan and Rogers posit relevant to these contexts? Are there additional factors that are unique to these contexts? What is the relative importance of these factors for technology-based contexts? These are the questions that this study explored through the development of a contextual model derived from studying international cases of technology-based innovations.

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 ministry of education personnel or university researchers.

These protocols specified that on-site visits of one 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 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.

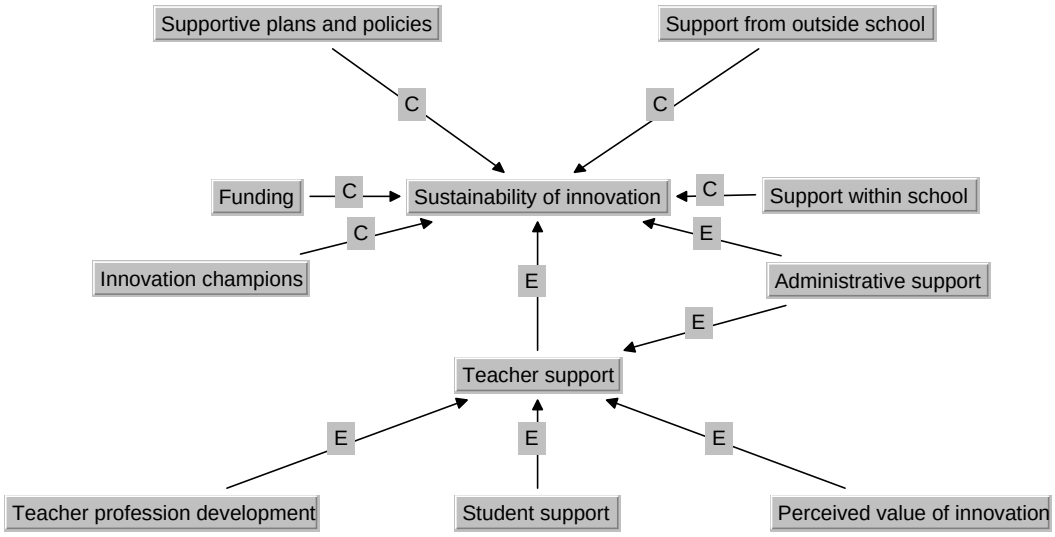
From this larger group of 174 cases 59 had evidence of both sustainability and transferability as indicated by the face sheets. Sustainability was operationally defined as the innovation having carried on for a period of more than two years without extra fiscal resources; transferability was defined 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, p. 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 finally 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 and contributing 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, significant improvement was reported 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. I found that this definitely was not the case. Teachers have to believe that what they are doing in the classroom has merit. Knowing that they are engaged in a very worthwhile activity, I found that teachers approach 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-Hamilton & 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 exciting 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 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.

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 willing to devote the additional time and effort required to maximize the advantage brought on by the innovation. Metz (1993) provides a plausible explanation for a phenomenon like this 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 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.

Summary 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 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.

Overall, 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 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. I merely note that they 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 one- to two-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.

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. Teachers need to be supported in their professional learning. A variety of professional development approaches 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. Most principals, however, took a more pro-active role, and I saw evidence of both the traditional visionary and the enlightened leader described by Senge (1990). Direct community and district involvement was relatively limited in the set of sustainable cases. 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. One characteristic not specifically raised is Fullan's (2001) description of local characteristics, but significant in this study, is student support. While Fullan would not deny their importance, he does not specifically cite students as a factor affecting continuation of innovations as my analysis does. Another characteristic not referred to directly by Fullan is the teaching and learning environment. While the findings suggest a possible link between certain teacher and student practices and sustainability, the area is ripe for further exploration and research.

With regard to Fullan's 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. A less common external factor that I found was partnerships with universities and the private sector, although where 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. 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 solve 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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