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DEVELOPMENT ARTICLE

Technology enhanced feedback tools as a knowledge management mechanism for supporting professional growth and school reform

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Abstract Attempts at school reform and improvement have experienced difficulty creating and implementing feedback systems that energize and sustain change efforts. If the call for reform at all levels of education is to be met, attention must be given to establishing effective feedback mechanisms in educational institutions as they embark on improvement efforts. The purpose of this article is to describe application of an educational design metaphor to create a Knowledge Management System that provides teachers with timely and constructive feedback about their professional practice. This system includes the way in which a corpus of professional knowledge about differentiated content and instruction, classroom grouping, evidence-based practice and classroom management can be embedded in a set of tools that provides multiple stakeholders (teachers, students, administrators) the opportunity to generate feedback about instructional practice. Use of the approach is discussed within the broader context of Knowledge Management as a vehicle to extend the role of feedback in school reform and improvement within a long term pilot application in one school.

Keywords Knowledge management · Data driven decision making · School reform · Professional development · Information technology

Introduction

Efforts to improve schools depend in large measure upon the professional growth of their faculties (Fullan 2007). This means that schools must be in the business of Organizational Learning (OL), which can be defined as the "detection and correction of error" (Argyris and Schön 1978, p. 2). Unfortunately, the most contemporary efforts to build new and

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innovative models of school reform and improvement have experienced difficulty creating and implementing feedback systems that energize change (Berends et al. 2001). The inability to provide feedback to teachers as they implement interventions or to leadership designing and guiding the interventions has been identified as a critical point of breakdown in efforts to improve schools (Berends et al. 2002). In evaluating the New American Schools initiative, researchers found that many design teams, "had not created the feedback loop or data needed to further develop their designs and offer meaningful support" which in turn made it difficult to even "hazard a guess as to implementation levels in schools" (p. 149).

A fundamental concept in OL is single and double loop learning (Argyris and Schön 1978). Overcoming the dissonance between espoused theory and theory-in-use is a primary objective of double loop learning and a critical issue in school reform, where a lack of feedback has made it difficult for reforms to be implemented with the effect intended by their developers (Berends et al. 2002). Creating alignment between perceived and actual classroom practice often requires external input or feedback. The learning that takes place should be convergent on the organizational goals. In describing components of OL models, Spector and Davidsen (2006) point out:

> In an effective learning organization, the mental models of the individuals in the organization are expected to converge and result in a shared vision, expressed in the form of common goals and preferences. This shared vision should arise from the recognition of a common reality and constraints shared by members of an organization (p. 66).

In contrast, teaching is often constructed in an autonomous fashion in the absence of shared assumptions about the differential effectiveness of pedagogical approaches across classrooms, schools and systems (Lortie 1975; Goodlad 1984; Sizer 1984; McLaughlin and Talbert 2001). In her review of the school reform literature, Desimone (2002) states that "much of the criticism of past education reforms charges that although they changed institutional structures, policies, or organizations, they did not activate the proper mechanisms to affect what teachers do in the classroom" (p. 434). Often reform models have been chosen because they align with strategies already in place with existing practice (Datnow 2000). Piaget's theories of accommodation and assimilation provide a basis to conclude that a pitfall for OL is the assimilation of new ideas or pedagogies into pre-existing practice. The OL necessary for school reform partially hinges on providing robust feedback mechanisms that will fuel the improvement effort. Thus, one strategy to address these issues is to employ design metaphors that reconcile what we know about feedback with the design of Knowledge Management Systems (KMS), enabling the progress of reform efforts that to date have experienced great difficulty in terms of both their sustainability and scalability across schools and systems.

Qualities of feedback

Reviews of the literature on feedback by Brinko (1993) and more recently by Scheeler et al. (2004), provide a clear and generally consistent picture of the characteristics of effective feedback and the conditions under which it is likely to be most effective. Those characteristics and conditions include the following:

1. Feedback is most effective when it comes from multiple sources including the recipient and is shared in a variety of modes (Brinko 1993).
2. Feedback is most effective when the standing or status of the source is lower or equivalent to the recipient (Brinko 1993).
3. Feedback is most effective when it is immediate (Brinko 1993; Scheeler et al. 2004).
4. Feedback is most effective when it contains accurate irrefutable evidence (Brinko 1993).
5. Feedback is effective when it is positive, specific and corrective (Scheeler et al. 2004).
6. Feedback is most effective when the information shared is focused and concrete (Brinko 1993).

When viewed collectively, these findings about the content, source, form and timing of feedback provide strong evidence-based guidance for the design of processes or systems that generate feedback to teachers. Any system or process based on this research must include highly specific information from multiple sources, delivered from different perspectives, including that of the recipient, with a high level of immediacy. Moreover, if feedback is to fulfill its potential to improve practice, any system must be able to do these things for many teachers consistently over time.

Feedback and knowledge management

Knowledge Management (KM) can be viewed as a mechanism to support Organizational Learning (Klingner and Sabet 2005; Spector and Edmonds 2002). Because of this link, we argue that a central role of KM tools should be to provide the type of feedback necessary for building school capacity to implement and sustain reform efforts. Over the past decade there has been an increasing interest in the application of Knowledge Management (KM) principles and practices to the field of education (e.g., Petrides et al. 2002; Petrides and Nodine 2003; Sallis and Jones 2002; Santo 2005; Spector 2002; Thorn 2001). The rise of KM is directly tied to the use of information technology and while there is a tension among researchers and practitioners about whether KM is a technology-based field (Santo 2005), there is little doubt that technology plays an essential role in supporting contemporary KM initiatives.

To date, applications of KM in education include mission building and strategic planning, enrolment planning, attendance, academic counseling, and reporting student learning and behavior management (Petrides and Nodine 2003). Specific examples described in the literature include the use of KM for curriculum evaluation and high stakes testing where state test data, curriculum objectives or educational goals are analyzed in relation to student performance for perceived educational benefit (e.g., Mason 2003; Thorn 2001). The latter involves aggregating data on student achievement to benchmark the performance of local schools against those of other districts and the state (Celio and Harvey 2005).

These applications reflect current priorities, issues and challenges within the educational milieu and focus primarily on high stakes testing and school accountability. We consider these applications to be early stage examples of KM driven much more by the kind of data that are currently and commonly available than that which are required to realize the true potential of KM in educational settings. We contend that a KM system focused on genuine student learning requires much more detailed and atomistic (Thorn 2001) process information about how teachers are teaching and students are learning.

One way of thinking about such information involves categorizing data according to the extent to which they are distally or proximally located in relation to the transactions of teaching and learning in classrooms (Bain and Parkes 2006a). By *distal*, we mean data that while related to learning and teaching, are nonetheless removed from specific classroom transactions and work patterns that are critical to the learning process. Distal level data include such things as student demographics, attendance, behavioral incidents and suspensions, and the results of high stakes or achievement tests. We view this category of data as distinct from the proximal data that are foundational to the lesson-by-lesson transactions that occur between teachers and students that drive the processes of teaching and learning. *Proximal* data include documenting the quality of pedagogical implementation, student academic engagement, the differentiation of day-to-day instruction related to content, instructional process and assessment (Tomlinson 2001) and the way students respond to that differentiation.

Of course, any KM system and/or software tools developed by or for an educational setting will have to reflect the prevailing assumptions about teaching, learning and the broader culture of a given school to be successful. This is especially the case with regard to feedback delivered to teachers. Given this circumstance, it may be more beneficial to employ models for software development and dissemination that can be applied across settings than the end product of a software development exercise. As such, the goal of this article is to share a case of a process employed to design a KM system for supporting the professional growth of teachers. The approach outlined in this article can be viewed as a practical articulation of a systems orientation to educational change (Watson and Reigeluth 2008; Reigeluth and Garfinkle 1994).

Duffy and Reigeluth (2008) outline six factors that define systemic change as an initiative that: (1) alters the culture of an institution by changing select underlying assumptions and institutional behaviors, processes, and products; (2) affects the whole institution; (3) is enacted intentionally; (4) occurs over time; (5) creates a school system that continuously seeks an idealized vision of itself; and (6) creates a future system that is substantially different from the current one. While these are certainly desirable targets for any school, moving from intention to application is always a difficult transition. The introduction of technology can confound this transition. Telem (2001) studied a school where an information system had been implemented in such a way that use was frequent and pervasive throughout the school. He found that the implementation, through increased transparency, had led to a tightening of interactions between faculty and school leadership. Conversations between professionals at the school were more consistent and focused. While the study does not describe the quality of feedback that occurred during the interactions, it does illustrate how leadership can use explicit knowledge to drive tacit exchanges and social interaction. Of course for every successful case, there are implementations that do not have a transformative effect. As Visscher et al. (2003) summarize, the implementation of technology systems, "is a complex and ambitious enterprise (p. 364)." In their study, they surveyed personnel in over 400 secondary schools about the use of the information system that had been deployed across the educational system and found that it was "considerably under-utilized as a management tool" (p. 362).

A design process for creating feedback tools that promote school reform

The design process presented in the following sections extends the literature by providing leaders with a "lead sheet" (Harris 2008) for the use of technology in school reform. The

tools were developed as part of an 11-year reform effort at a private secondary school with approximately 50 instructional staff and 400 students. In the pilot phase of the reform effort, the necessity for a comprehensive system was realized when the use of spreadsheets and word processing documents made the reporting and feedback process bog down. What became quickly apparent was the requirement for a more sophisticated environment to support the constant exchange necessary for the reform to succeed. This spurred the creation of a networked relational database system that incorporated tools for authoring, implementing and evaluating instruction. All stakeholders in the school (administration, teachers and students) accessed the system to input and view data. For example, teachers designed unit and lesson plans, conducted peer observations and self-evaluations of their professional duties. Students would have access privileges to enter surveys about their experience in their various courses as well as access curricular materials. Department heads and academic deans would review curriculum, enter classroom observations and complete annual reports in the system and could look at aggregated data for an individual teacher, department, instructional team or entire school. The tools were employed by the school as a core mechanism to facilitate implementation of a comprehensive program of school reform.

The approach involves three stages: Solution Mapping, Component Building, and Design Integration. The school for which this software was developed was undergoing a reform process focused on the goal of differentiated instruction. To support this endeavor, KM tools were integrated into the design, implementation and evaluation aspects of the reform effort. The design process for the tools described here reconciles the extant literature on feedback reviewed previously within an environment where the driving goal was to provide an inclusive environment through differentiated instruction. The tools are designed to provided feedback about elements that reflect the professional knowledge and research related to a school reform based upon differentiated and inclusive teaching and learning. Another setting may have a different guiding mission, but could follow the same design process to address the instructional goals specific to their context. Figure 1 provides an illustration of the three stages of the design process. In the following sections, each of the steps is discussed in detail to provide a more complete description of the types of activities involved.

Solution mapping

Solution mapping means using the educational literature specific to the area of interest to build a concept map for the educational process the software will address. This involves mapping the educational territory related to the problem with a focus on connecting discrete approaches that have been subject to rigorous educational research to address or generate solutions. For example, research on inclusion and differentiation advocates the use of various approaches such as explicit teaching, peer assisted and cooperative learning (Mastropieri and Scruggs 2004; Tomlinson 2001; Vaughn and Arguilles 2000).

In the present example, we sought to map the areas of inclusive practice required by teachers and link those practices and model to the research-based tenets of effective feedback that determine how teachers receive feedback about their inclusive classroom practice. From a systemic change perspective, this part of the design process is where the holistic or "fuzzy" (Watson 2006) vision is created. In the next stage, *component building*, the clarity of the vision is operationalized.

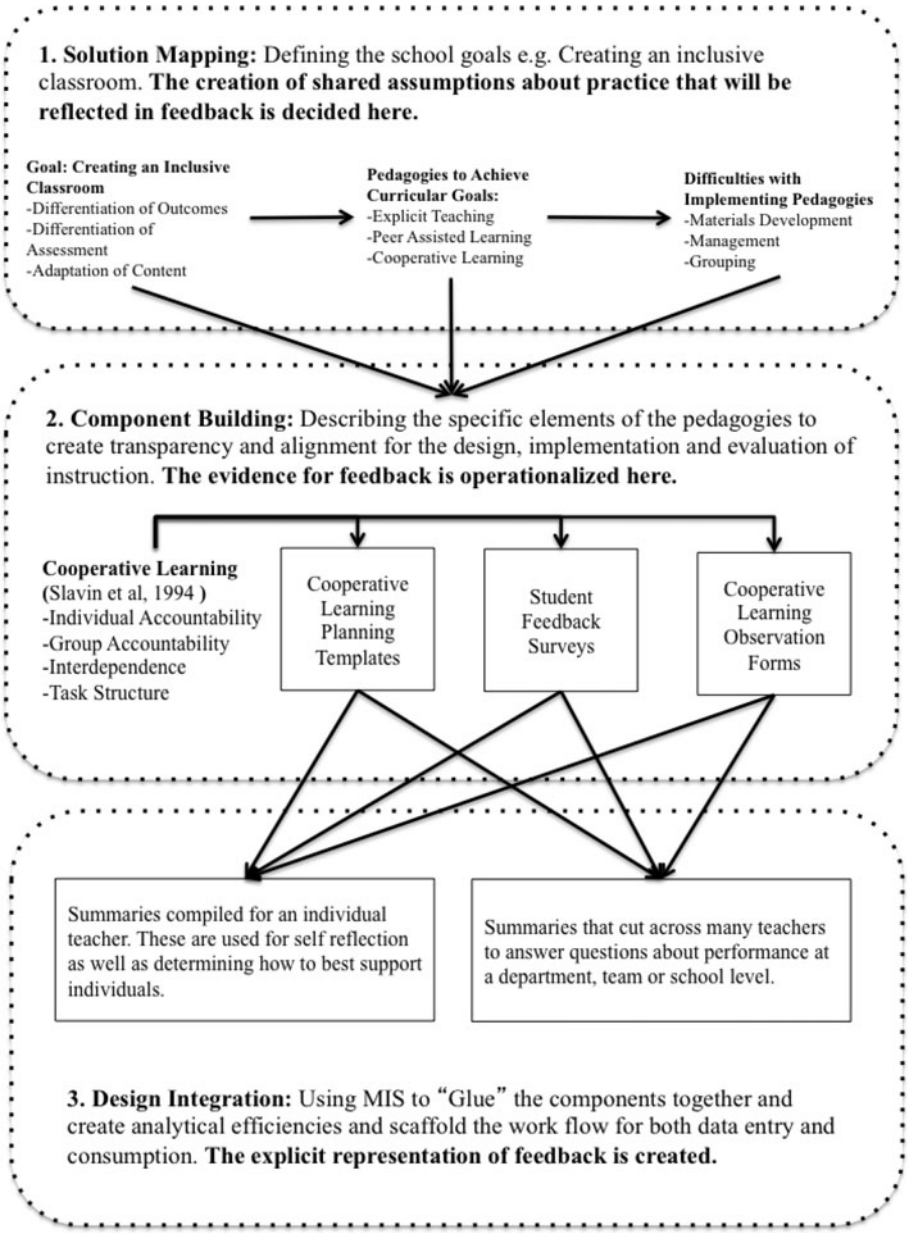

Fig. 1 Overview of a three-stage approach for the design of a KM feedback system

Component building

The second step involves using educational research to articulate the key features of specific practices and elements described on the concept map. This involves identifying the most effective versions or forms of those elements and then using that information as a

guide to design specific scaffolds. For example, a predominance of research indicates that collaboration is most effective when teams of teachers share an agreed upon collaborative process (e.g., solution evaluation, shared accountability, open and clear communication) (Friend and Cook 2003; West et al. 1989). Teachers seem to have most success with collaboration when they work in well organized, problem-focused, and solution-oriented teams (Friend and Cook 2003). These features of collaboration or any other inclusive practice or solution included in the concept map are interrogated in the component-building step. The component-building phase generates the detail required to make feedback specific, accurate and irrefutable (Brinko 1993) by providing the detailed research-based dimensions of inclusive practice. At this stage, creating hard copy or digital versions of skeletal outlines may be a helpful process as shown in the second panel of Fig. 1.

In the development of the Professional Growth Tools (PGT), templates were developed to structure the design and implementation of cooperative learning activities. These templates were aligned with templates used by peers and supervisors to observe cooperative learning lessons. The templates incorporate key features of cooperative learning derived from the extensive literature on effective use of the practice (Jacob 1999; Johnson et al. 2000; Slavin 1990). All of these components directly linked to the overarching goals and research base established in the solution mapping stage. In addition to these templates, the survey tool used by students to provide feedback to their teachers includes elements tied to the use of cooperative learning techniques expressed in student friendly language. This addresses the tenet that shows feedback to be most effective when it is derived from members of a learning community who are perceived to be equal or subordinate.

The component building process can result in dozens of forms, screens and tools that reflect both content areas of interest (pedagogy, collaboration and adaptation of content) and the feedback requirements (multiple sources and methods). This detail is then employed in the *design integration* stage to build a technological solution that involves using the software interface to provide the "glue" for connecting the components. This is especially important in addressing the timing of feedback and form in which it is reported.

Design integration: connecting the components

In this stage, each of the components is translated into a software design and navigational structure that connects them together. It is in this stage that the KM processes of combination and internalization are enabled. From a design perspective, this step of PGT development was heavily influenced by research-based requirements for effective feedback, especially conditions under which feedback occurs. This involved capturing and connecting multiple methods (observations, ratings permanent product of student performance) and dimensions (pedagogy, collaboration, differentiation) in order to make it possible to triangulate the multiple sources requirement of the feedback literature (Brinko 1993). It includes:

1. Building reports that accurately and specifically reconcile multiple sources of information and make that information available immediately (Scheeler et al. 2004).
2. Ensuring that feedback scales up from individuals to groups and through different levels of the school (Bain 2007).
3. Ensuring that the system does not add an excessive time or personnel burden especially in terms of managing the database and generating reports (Berends et al. 2002).

The design objective of this phase is intended to ensure that the navigational structure is amenable to hypothesis testing about different aspects of instructional performance within the organization. The power of relational database technology resides in the ability to bridge related, but separate, tables of data through linked fields. For example, feedback from a classroom observation by a peer or a lesson self-evaluation can be cross-referenced with the lesson design (i.e. the lesson design can be compared to its implementation). The following vignette gives an example of the how the tools are used in the day-to-day context of the school.

> Daniel is a physics teacher in his second year who has just had his department chair, Mr. Bruce visit his classroom for the first observation cycle of the school year. The lesson Daniel is teaching involves a direct teaching component during the first 20 min after which students break off into a cooperative learning exercise. Mr. Bruce takes notes using a direct teaching form during the first part of the class period and then switches to a cooperative learning form for the latter part. The forms describe the key features of the respective teaching approaches that would be observed by Mr. Bruce in Daniel's class. At the end of the period, Mr. Bruce takes a few minutes to review his comments and submits the two observation forms he used. He and Daniel plan to meet at the end of the school day to discuss the classroom observation. Before the meeting, Daniel uses his planning block to look at the observational feedback formally submitted by Mr. Bruce. He is pleased to see that Mr. Bruce had not marked any of the elements for his cooperative learning exercise as missed elements of instruction.
>
> Daniel was trying a new way to structure the way students would review the material covered in class and Mr. Bruce noted that all the students were engaged in lively conversation about the various problems. However, Daniel's shoulders sank when he looked at the direct teaching protocol and saw that the guided practice aspect had not been checked. Guided student practice is a critical pedagogical feature of the direct teaching approach. Daniel looked back at the direct teaching observations from the previous year to compare what went wrong. Implementing guided practice was something Daniel had struggled with. The class would bog down when he stopped to help out individual students or circulated to check each student's work. Sometimes Daniel would feel pressure to move through the lecture efficiently, skip or cut short the guided practice, and fix issues during extra help sessions outside of class.
>
> As he looked through the various observations, Daniel noticed that he had included multiple guided practice components earlier in class rather than waiting until later in the direct teaching. When meeting with Mr. Bruce later that afternoon, he agreed with Daniel's self-assessment. He also offered that Daniel could use the same type of structure that he had employed during the cooperative learning part of the lesson to have students help each other in the corrective process. During the next three observations, Daniel did much better in his execution. He created a graph for his annual review showing how the rate of implementation had improved over his first 2 years.

This vignette provides one example of how an individual teacher could use the feedback system as a launching point for engaging in reflective practice. In Daniel's case the feedback system helped him refine his practice to better integrate the school-wide instructional toolkit. Being able to cross-reference observations with curriculum facilitated Daniel's growth as he worked through an area of difficulty. With any system, the time spent entering data is a concern. The feedback forms and observation protocols all have

between 10 and 20 check boxes and a commentary field that take a few minutes to complete, depending on how extensive the comment is.

Figure 2 shows an example of the reporting functions produced by accumulating data using individual tools created during the component building stage in addition to other distal and proximal sources collected in the school such as attendance, curriculum based measures, non-academic performance and levels of curriculum. This tool allows feedback on the quality of teaching to be connected to student performance. Combining all of these sources presents teachers with a portal through which they can begin to reflect on performance over time. Teams of teachers can use the data to problem-solve areas of strength and weakness and as a summative indicator of individual, team and school performance. By clicking on any of the data fields, the user can access the original report and associated narrative from which the data were derived. Often invoked by information system designers, this approach is consistent with the "overview first, zoom and filter, then details on demand" mantra taken from Shneiderman (1998, p. 523).

Where the feedback tool in Fig. 2 brings together various sources of proximal and distal data (i.e., levels of best practice implementation, attendance, etc.), other tools compile proximal data from one source, such as all classroom observations on cooperative learning, which are compiled into color coded person-by-item matrices to provide visualizations of data for examining the level of implementation of the instructional program. The example shown in Fig. 3 allows a team member, leader or administrator to look at individual performance by the row and program performance by the column. In this example, the data source is a class observation form for a specific semester. The darker columns and row are program level implementation areas and individuals that need attention (in the color version the darker cells are red). In this example, there are five areas that school leadership would want to examine more closely. These areas could shape the focus of professional

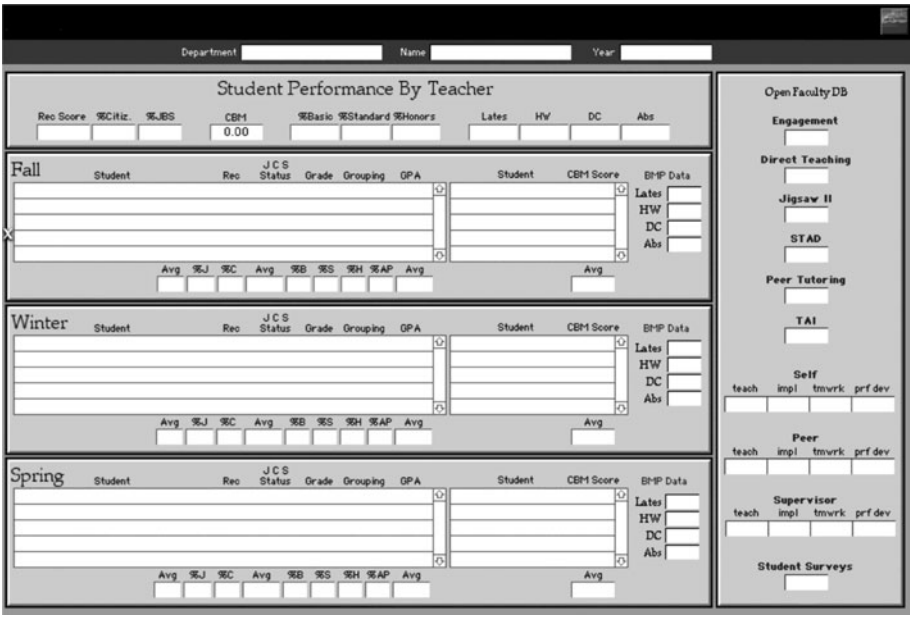

Fig. 2 An interface that combines both proximal and distal sources of data to prompt professional reflection

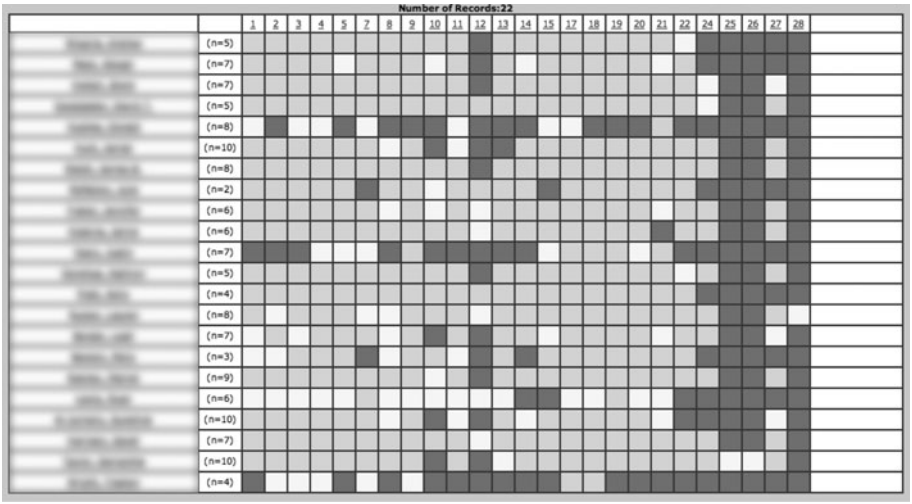

Fig. 3 An interface that compiles classroom observations across multiple teachers

learning communities or other professional development mechanism. Just as Daniel in the vignette above used the tool as a launching point for improving his own individual practice, school leadership can use the data to improve school practice. By changing the variable upon which the aggregation focused (done through a drop-down menu), the same display can be generated with the rows representing department, academic year or observer as well as other possible criteria deemed pertinent within an organization.

The tools made it possible for these activities to occur as part of the normal cycle of activity in the school without the addition of personnel to manage these processes. This is a critical feature as schools rarely have the time or personnel to dedicate to elaborate and time-consuming approaches to feedback and appraisal. Upon hiring, all teachers were introduced to the curricular aspects of the school through the use of the PGT system. A study conducted over a two and a half year period showed that use of the curriculum design templates within the system covaried with the integrity with which instruction was implemented. The study employed 578 fifty-minute structured classroom observations using the protocols defined in the component building stage (Bain and Parkes 2006b). An additional benefit was improved collaboration between faculty and students and creation of a legitimate career trajectory based upon ongoing use of the tools (Bain 2007).

Conclusion

All school reforms place complex demands on teachers to alter their practice. Feedback is critical if those reforms are to take hold. The lack of sophisticated feedback systems in school reform explains in part why so few of those efforts seem to gain traction over time (Berends et al. 2002). To be deemed legitimate by teachers, any feedback system must meet the challenge of providing accurate, multi-sourced and multi-method feedback in an ongoing and timely manner for use at multiple levels in the school. Such feedback should be emergent (Bain 2007), generating a constant flow of real-time, essential information that emerges from the core teaching and learning activity of a school. This process occurs

continuously, ever ready to be "interrupted" at a given point in time to generate reports for formative or summative purposes.

Newmann et al. (2000) describe five elements of school capacity; (1) Knowledge, skills and dispositions of individuals; (2) Professional community; (3) Program coherence; (4) Technical resources; and (5) Principal leadership. Newmann et al. (2001) extend this framework and argue that coherence should guide school improvement efforts, using their examination of elementary schools in Chicago to illustrate the positive relationship between school coherence and student achievement. The problem in school reform is not that schools do not try to do anything; rather it is that they try to do too many things. The result is often a collection of interventions that do not interface well and are often jettisoned for another program before any can be implemented in a robust manner. Those authors recommend that school leaders "focus their improvement plans, professional development, and acquisition of instructional materials on a few core educational goals pursued through a common instructional framework (p. 315)" and that "teacher hiring and evaluation could emphasize skillful use of the framework (p. 315)."

In previous sections of this article, we laid out a rationale for linkage between feedback, Organizational Learning and Knowledge Management. We see the process outlined in this article as a way for school leadership to engage in creation and deployment of tools that support the use of those frameworks. Knowledge Management can be viewed as the "creation, capture, and use of records, databases, and other information to achieve organizational objectives" (Klinger and Sabat 2005, p. 201). In the case of school reform, we see the use of technology as the medium to enact knowledge management processes in order to create program coherence through systematic and systemic feedback. The examples taken from the software described here illustrate the importance of having conducted concept mapping and component building in the design process. The PGT system assisted the school in maintaining its focus on reforms to which it had committed by supporting every teacher to grow through a process of comprehensive constructive feedback.

Serban and Luan (2002) aptly note, "Emphasis on technology alone will achieve little progress toward knowledge management, but even the strongest commitment to knowledge management that is not supported by robust technology will not succeed" (p. 2). KM Systems are a blend of both technical and social mechanisms that enable the effective creation and transmission of knowledge assets to take place. The technical component seeks to "capture, package, and distribute tangible, documented products", while the social side "enables collaboration, connection, and reflection among system users" (Marshall and Rossett 2000, p. 26). In the KM cycle, individuals and organizations transition within and between tacit and explicit forms of knowledge. If the technical mechanisms do not enable the social aspects of the KM process learning, organizational improvement will not be optimized. Organizational learning will only be realized in settings where there is alignment between the instructional culture of the school and data collected by the system.

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