THE ROLE OF EMERGING TECHNOLOGIES FOR KNOWLEDGE MOBILIZATION, DISSEMINATION, AND USE IN EDUCATION

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Evidence on isolated exemplary practices in education suggests that new models of teaching and learning have the power to improve educational outcomes dramatically. As a result, many people are asking how to scale-up scattered, successful "islands of innovation" into universal improvements in schooling (Dede 1998). Undertaking "systemic reform" (sustained, large-scale, simultaneous innovation in curriculum, pedagogy, assessment, professional development, administration, incentives, and partnerships for learning among schools, businesses, homes, and community settings) requires policies and practices different from fostering pilot projects for small-scale educational improvement (Means 1994). For example, systemic reform involves moving from relying on special, external resources to reconfiguring existing budgets in order to free up money for innovation. Also, strategies for change that are effective when pioneered by leaders in educational innovation must be modified so that typical educators can implement them.

As one way of making the widespread implementation of innovations possible, new information technologies are reshaping the nature of knowledge mobilization, dissemination, and use in many fields, including education. This paper elaborates three ideas about using information technology to aid in adapting exemplary educational projects from their initial sites to others:

- ***Emerging information technologies enable a shift from the transfer and assimilation of information to the creation, sharing, and mastery of knowledge.*** Active collaboration among educators in developing insights about an innovation is more powerful in fostering effective implementation than simply receiving data about what someone else has done. This shift from assimilation to sharing about best practices potentially increases both the speed and the effectiveness of generalizing and applying educational innovations. Knowledge mobilization and use must itself mirror the types of shifts desired in educational practice, moving from passive assimilation of information to active construction of knowledge, so that the process is consistent with its content.
- ***Dissemination efforts must include all the information necessary for successful implementation of an exemplary practice, imparting a set of related innovations that mutually reinforce overall systemic change.*** For example, dissemination of a promising technology-based learning environment would ideally include information

about the learning environment itself, professional development strategies, necessary shifts in organizational policies and practices, and the requisite technological infrastructure and associated support services. It would also include evaluative data about the program's effectiveness and costs, alternative strategies for generating resources to meet those costs, ways to involve the community in the innovation, and approaches for ensuring a positive impact on equity.[1] New interactive media offer powerful ways of communicating this level of informational detail.

- ***A major challenge in generalizing and scaling up an educational innovation is helping practitioners "unlearn" the beliefs, values, assumptions, and culture underlying their organization's standard operating practices.*** Altering deeply ingrained and strongly reinforced professional rituals takes more than an informational interchange of the kind typical in conferences and most professional development. Emerging interactive media can enable virtual communities that provide affective and social support, which may lead to deeper behavioral changes in educational practices. In knowledge mobilization and dissemination, using both synchronous and asynchronous media for interaction is important in helping all involved participate fully in this unlearning process.

These ideas support the notion that, in contrast to conventional wisdom, dissemination should foster adaptation of an educational innovation, not just adoption. New interactive media offer great promise for supporting widespread communities that reflect on and adapt best practices as they emerge. However, simply using emerging information technologies to deliver large quantities of innovation-related data quickly can, at best, marginally improve education reform efforts and, at worst, overwhelm reformers. Thus, reconceptualizing the historic role of information technology in knowledge mobilization and use is central to its future effectiveness.

A. EMERGING TECHNOLOGIES FOR THE CREATION, SHARING, AND MASTERY OF KNOWLEDGE

Educational systems greatly benefit from learning about the failures, as well as the successes, of the attempted innovations of others. Deep understanding arises from deliberation about specific evidence and its interpretive transformation for local contexts and cultures (Cohen 1996). Expanding use of best practices, then, requires developing a vibrant learning community

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[1] The U.S. Department of Education s Expert Panel on Technology is tak in developing criteria for designating exemplary and promising practice

of practitioners; the community must be built not only by distributing descriptions of innovations, but also by fostering rich dialogue about their evolution and implementation.

The National Science Foundation (NSF) is currently exploring the idea of learning communities. Two years ago, NSF instituted a new multidisciplinary funding program to examine the potential of emerging information technologies in fostering "Knowledge and Distributed Intelligence" (KDI). This initiative [http://www.ehr.nsf.gov/kdi/ default.htm] was prompted by fundamental shifts that new interactive media are creating in the process of science. Scientists are moving away from an investigative process based on reading others' research results in journal publications as a means of informing and guiding one's own scholarship. Instead, scientists are engaged in virtual communities for creating, sharing, and mastering knowledge: exchanging real-time data, deliberating alternative interpretations of that information, using "groupware" tools to discuss the meaning of findings, and collectively evolving new conceptual frameworks.

NSF calls this process "knowledge networking" and is funding a series of KDI investigations to study these virtual communities both in the context of science and as a generalizable process that could enhance many forms of reflective human activity. Through knowledge networking, an emergent intelligence appears in which the virtual community develops a communal memory and wisdom that surpasses the individual contributions of each participant. NSF is supporting studies of this process through its "Learning and Intelligent Systems" (LIS) initiative within KDI.[2] Both knowledge networking and emergent intelligence

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[2] For example, Marcia Linn at the University of California-Berkele SCOPE: Science Controversies On-line: Partnerships in Education [htt bin/showaward?award=9873180]. This project promotes knowledge net scientists and learners exploring current scientific controversies that (such as evidence of life on Mars). The project s research combines ex pedagogy, technology, and classroom instruction from the University of University of Washington, and the American Association for the Advan Sciencemagazine. There are both national and international school part are creating new media as needed and using powerful existing applicati Knowledge Integration Environment [KIE] [http://www.kie.berkeley.edu/KIE/software/descriptions.html]).

are important new capabilities that can transform knowledge mobilization, dissemination, and use in education.

Knowledge networking involves creating a community of mind. Through sharing disparate data and diverse perspectives, a group develops an evolving understanding of a complex topic. Over time, the group's conception of the issues continually expands and deepens, at times broadening the range of fields and experiences seen as relevant. During these times, the membership of a networking community grows to include participants who bring new perspectives and backgrounds. Thus, a network is in longitudinal flux as an ever larger cast of members redefines how to conceptualize the topic; this involves a constant collective acculturation into new ways of thinking and knowing. For example, in the context of educational reform, the participants in a knowledge network might be teachers, administrators, parents, taxpayers, politicians, teacher trainers, researchers, school board members, and other policymakers--each bringing differing perspectives and knowledge across multiple educational settings. Communal learning is at the core of the networking process.

This collective learning mirrors the complex initial acculturation process that people who wish to join a knowledge networking community must undergo to become effective participants. This acculturation involves:

- Mastering a common language and a generally accepted set of theories and mental models (to provide a framework for communication)
- Inculcating communally defined processes of collecting and analyzing data (to enable sharing reliable information)
- Developing proficiency in design, reasoning, and argumentation (to facilitate the evolution of ideas)
- Accepting a common set of values, such as respect for others' perspectives (to encourage wide participation)

Currently, the absence of these types of acculturation undercuts opportunities for sustained educational reform. For example, the war between proponents of phonics and advocates of whole language illustrates the dysfunctional dynamics that can occur without mutual acculturation processes to enable reflective dialogue. Through tools for representation,

collaboration, and community building, new interactive media can create a framework within which constructive interaction can occur. Advances in information technology aid knowledge networking through providing rich sources of data, rapid information exchange, sophisticated analytic tools, and the collective intellectual capacity to tackle the complex problems that underlie educational innovation.

For some time, NSF has funded research on acculturating new participants to function effectively in knowledge networks (such as involving students in scientific communities).[3]

U.S. Department of Education knowledge mobilization, dissemination, and use initiatives could expand key dimensions of knowledge networking. New initiatives could create educational "testbeds" to explore networking design for a class of social knowledge communities that have properties different from those of virtual scientific research networks. Transfer of knowledge among members of such educational communities--in ways that enable them to adapt solutions to their own contexts--is not simply exchange of superficial information about successful innovations. It requires engagement in rich, artifact-focused dialogue that provides detail about the nature and processes of education reform. For example, educators can undertake collaborative annotation of video-based case studies of educational practice that include ancillary information such as student products and teacher reflections (Jacobs et al. 1997). Knowledge networking technologies represent a new and powerful strategy for enhancing innovation sharing and adaptation, since teachers find direct knowledge about each others' practices much more convincing than conventional forms of research evidence.

Typically, when islands of innovation in education emerge, they do not scale-up or transfer, and they eventually wither away. Evolving small-scale innovations into widespread shifts in

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[3] An example of an initiative that has developed knowledge networking based learning environments is the NSF-funded Learning Through Collabo (CoVis) project [http://www.covis.nwu.edu]. The investigators have network of meteorologists and students collecting and analyzing weathe aid learners in this process include the CoVis Visualizer and the C students also engage in telementoring relationships (Edelson et al. 19 from this project generalize across a wide range of knowledge creatio settings related to education.

standard operating practices necessitates changes in organizational structures, individual beliefs and values, and community commitment. By building bridges from reflective innovation to standard practice, testbed knowledge networks provide an excellent venue for exploring scalability and sustainability in educational innovation. However, this requires reconceptualizing traditional strategies for linearly transferring innovations from research to practice. Instead, researchers become intermediaries among practitioners, and practitioners become co-developers of innovative models.

B. INCLUDING ALL THE INFORMATION NECESSARY FOR SUCCESSFUL IMPLEMENTATION

Studies of educational change processes (Fullan 1993) document the importance of systemic relationships in determining whether the implementation of an improvement strategy succeeds or fails in reaching its educational objectives. The broad understanding that can generate solutions to local problems does not flow solely from research reports, systems analyses, or other documents. Thorough comprehension also requires participation in a knowledge community that allows members to collaboratively view, explore, and discuss concrete evidence of practice, materials, and effects, permitting them to grasp how such evidence interacts with specific contexts and cultural features. Transforming information into knowledge that is useful to education reform in different places requires understanding of an interlinked and mutually reinforcing cluster of innovations, not simply the appropriation of recipes for isolated shifts in practice and policy.

Interlinked dimensions of comprehensive educational reform include:

- Innovations in curriculum, pedagogy, and assessment
- Professional development strategies
- Necessary shifts in organizational policies and practices (for example, flexible scheduling to enable project-based learning)
- Any requisite technological infrastructure and associated support services
- Alternative strategies for generating resources to meet the initial and continuing costs of the innovation
- Ways to inculcate community support and “ownership”

- Strategies for enhancing equity rather than increasing current disparities among subgroups

To facilitate coherent, sustainable, and scalable educational reform, studies of how these dimensions of innovation can provide mutual reinforcement are vital. As has been recently suggested by the President's Committee of Advisors in Science and Technology (1997), if America's ultimate goal is long-term, pervasive, quality-centered educational improvement, our society must find ways to invest a critical mass of funds and human resources in "clinical" research to accomplish this. One important dimension of this research is developing virtual knowledge-sharing networks capable of sustaining rich, interpretive dialogue about systemic interactions in reform policies and practices.[4]

An innovative virtual venue within which such reflective interactions could take place is the Tapped In MUVE (multi-user virtual environment), a research project funded by NSF to aid in teacher professional development [http://www.tappedin.org]. Tapped In is a text-based virtual conference center, with many of the capabilities for knowledge sharing that physical conference facilities have. Participants in this MUVE can work in laboratories, libraries, and other types of specialized meeting rooms; write on and read whiteboards; take notes and display them to others; project web sites for shared discussion; and record transcripts of meetings for future reflection--all of which lead to thoughtful dialogues among geographically dispersed educators (Schlager and Schank 1997). Provided with a set of virtual artifacts from innovative districts, such a synchronous forum for collaboration and reflection could enhance participants' knowledge networking to adapt best practices.

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[4] Union City, New Jersey is an example of a school district that has im effective series of educational reforms, reshaping its curriculum, technology usage, and links to the community [http://www.union-city.k student learning are very positive and impressive, especially since t base and many challenges associated with a diverse population. Other learn from this district s successes, which have been studied in dept challenge is to create a reflective discussion around this research articles documenting these reforms. Knowledge networking tools app research settings could greatly enhance the adaptation of their insight

Sabelli and Dede [http://www.virtual.gmu.edu/integrating.html] argue that clinical, applied research on adapting exemplary innovations should involve reflective interplay between basic research and practice, a bidirectional process that helps both sides evolve toward increasingly sophisticated objectives. In such a relationship, implementation is not the blind adoption of recipes and materials for innovation developed by others, but instead the reflective adaptation of a process that enabled a similar group to succeed in improvements actualized somewhere else. Focusing on the implementation process as well as on reform outcomes makes it possible for practitioners to start with objectives consistent with their current problems and worldview and to develop more powerful goals as they reflectively adapt innovations.

In particular, effective educational innovation and evolution requires the following:

- Not only must strategies for implementation evolve--the goals of innovation must also shift as educators learn. If frozen in time, the initial objectives sought will become inconsequential, eschewed, or co-opted.
- Any sustainable change must at some point be "owned" by an individual, school, or district rather than imposed by some external mandate.
- Scaling-up necessitates experimentation to determine the contextual conditions that promote a similar innovation process; engineers know well that a design improves incrementally based on analyzing previous failed efforts.
- Productive experimentation requires a research mentality (the formation of testable hypotheses, the habit of reflection), supported by appropriate resources and embedded in the cultural self-image of educational institutions as learning organizations.

To succeed, knowledge mobilization, dissemination, and use initiatives must foster such evolving strategies, ownership, experimental tailoring to contextual conditions, and research mentalities. This cannot be accomplished via one-way transmission of best practices, but instead requires reflective, interpretive dialogue in a knowledge-building community.[5] For example,

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[5] To explore such a strategy for innovation, an NSF-funded Center for
in Urban Schools has been recently created with four partners: the De
Chicago Public Schools, the University of Michigan, and Northwe
[http://www.letus. nwu.edu]. The focus of the center is on develo
strategies for embedding learning technologies in the middle school sc
technologies provide the critical support students need to engage i
inquiry central to new national and state curriculum standards. The

traditional models of curricular dissemination presuppose that reform curricula can be "delivered" to school communities. Contrary to this model, growing evidence suggests that all curricula-- especially new reform curricula--require significant adaptation during implementation. For successful adaptation, educators must become codesigners, since curricula never serve simply as scripts for transforming practice (Gomez, unpublished). Enactment of a reform becomes an occasion to redesign and tailor practice to meet local circumstances, encouraging educators to reflect upon practice, consider new ideas, construct new understandings about practice, and reconstruct their own practice (Ball and Cohen 1996). Such tailoring is challenging and is highly dependent on local capacity, which is differentially distributed across school systems.

As Gomez writes,

> This treatment of implementation as design contrasts sharply with earlier models of implementation, which portray it as a straightforward process of transmitting policymakers' prescriptions for action to local educators to follow. Successful implementation involves a process of "mutual adaptation" in which external innovations are adapted to fit local conditions and local conditions are adapted to fit the innovations (McLaughlin 1990). But what distinguishes "mutual adaptation" from what Brown and Campione (1996) have called "lethal mutations" in evolved implementations? Why is it and how it is that, in the process of adapting reform to local conditions, the spirit of reform is frequently lost and the result is practice as usual?

One important reason for this shortfall is that not enough dialogue to enable reflective adaptation takes place between those attempting to implement an exemplary practice and the original innovators. The Center for Learning Technologies in Urban Schools is developing a "Living Curriculum" collaborative relationship between developers and teachers, initially through face-to- face interaction, but increasingly through new interactive media and the

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partners provides a unique opportunity to study how to support the s
integration into urban classrooms, using the Living Curriculum framew

formation of virtual communities for innovation. This evolution into knowledge networking is crucial for the widespread scaling-up of best practices.

C. BEYOND LEARNING: A NEW MODEL TO UNLEARNING STANDARD OPERATING PRACTICES

Most educators who implement innovative pedagogies and curricula are "pioneers": people who see continuous change and growth as an integral part of their profession and who are willing to swim against the tide of conventional operating procedures--often at considerable personal cost (Dede 1998). However, to achieve large-scale shifts in standard educational practices, a much larger group of teachers must alter their pedagogical approaches, and schools' management, institutional structure, and relationship to the community must change in fundamental ways. This requires that educational "settlers" (teachers and administrators who appreciate stability and do not want heroic efforts to become an everyday requirement) must be convinced to make the leap to a different mode of professional activity--with the understanding that, once they have mastered these new approaches, their daily work will be sustainable without extraordinary exertion.

In other words, a major challenge in generalizing and scaling an educational innovation beyond its initial implementation is not only helping others to learn the new model, but also aiding them in unlearning the beliefs, values, assumptions, and culture underlying their organization's standard operating practices. Public health professionals have learned that facilitating an individual's shift to a healthier lifestyle (altering eating and exercise habits) requires more support than simply giving that person access to data on wellness and mortality. Similarly, changing deeply ingrained and strongly reinforced professional rituals necessitates more than transferring information.

Emerging interactive media not only can communicate data across barriers of distance and time, but also can enable virtual communities with affective and social supports that foster deeper shifts in educational practices. New media enable an extraordinary range of cognitive, affective, and social "affordances" (enhancements of human capabilities) of great power for professional development-- while also potentially limiting expression and communication (Dede and Kremer 1999).

For example, the author teaches a graduate distance education course whose instructional goals are to:

1. Give participants hands-on experiences with the range of interactive media now readily available for learning across barriers of distance and time
2. Develop an understanding of how each medium shapes the cognitive, affective, and social interactions of learners
1. Model and discuss effective instructional design in the use of each interactive medium

The class uses six interactive media [http://www.virtual.gmu.edu/EDIT611/syllabus.htm]: (1) face-to-face interaction; (2) videoconferencing; (3) synchronous interactions in a text-based virtual world, "Tapped In" (discussed earlier); (4) "groupware" that incorporates a shared design-space (using Microsoft NetMeeting [http://www.microsoft.com/msdownload/ieplatform/netmeeting/06000.htm]); (5) asynchronous discussions [http://townhall.gmu.edu]; and (6) web sites structured around an ongoing interaction or experience. The first four of these interactive media are synchronous, the next is asynchronous, and the last is a mixture of both. This wide range of media incorporates the complementary strengths of face-to-face instruction, virtual synchronous interaction, and asynchronous expression and communication. Participants are able to contrast the amount of effort required to master the rhetoric of each medium, the instructional design strategies effective in each, and the ways each shape individual cognitive and affective experiences, as well as group interactions.

Much study is needed to develop the new kinds of rhetoric necessary to make emerging learning technologies effective, as well as to design learning environments appropriate for specific kinds of participants, particular types of knowledge, and various objectives. While a great deal is known about instructional design in classroom settings that can facilitate affective and social interactions, many emerging media are so new that little is understood about the emotional and collaborative affordances they provide--and lack--in knowledge networking contexts. My course provides an informal case study of the potential and limits of emerging interactive media.

My students typically have years or decades of professional experience in various aspects of education and training (for example, public school teachers, instructional designers for industry, training managers for government, college faculty and administrators). Many have no experience with several of the media used in the course; however, as majors in instructional technology, they become literate in each medium rapidly. While this group is not representative of most learners, my students are typical of professionals seeking in-service development to further their career goals, so their experiences can generalize to many educators working to adapt best practices.

Two sets of findings from my case-based research have implications for knowledge networking on educational innovations.

1. More Participants Found a "Voice"

Class participants exhibit very different preference patterns for the six media utilized. Lively debates ensue among those who like--or hate--particular instructional media and find their rhetoric either intuitive or cumbersome. Furthermore, even though all agree the class meetings on campus are valuable, a substantial proportion of students rate face-to-face interaction below some of the virtual means of communication. Beyond convenient access, the reasons these students give for preferring virtual interaction suggest that they find this type of expression more fulfilling as a medium for learning.

An outcome striking to me as an instructor is how some participants find their "voices" in one of the virtual media. Even the best classroom instructor, expert in facilitating discussion, knows that a substantial percentage of students will "lurk" in face-to-face interactions. These learners are awake and listening, but do not become actively involved unless forced to do so--and then relapse into silent observation. Such students may be shy, prefer time to reflect before answering, or feel at a disadvantage because of gender, race, physical appearance, disabilities, or a lack of linguistic fluency. In my course, some of these "passive" participants come alive in the groupware, some in the text-based virtual world, some in asynchronous discussions--but almost all are active and fluent in at least one of the six virtual media. At the same time, those students

adept at face-to-face interaction often report their expressive and communicative abilities diminish in at least one virtual medium--they feel disenfranchised and "lurk" when forced to use that type of rhetoric. All the participants are surprised by this outcome and often are unable to predict which media they personally would find empowering or which they would find disabling.

Because the vast majority of class participants find their voice in at least one of the media provided, each student is able to make a full contribution, thus increasing the overall learning experience for everyone. Also, those students who feel hampered by a particular medium can watch others model effective expression and communication. As a result, everyone's fluency and comfort in all the media improves over time, although distinct preferences remain.

2. Beyond "No Significant Differences" Findings to More Powerful Learning Outcomes

In addition to each learner finding a "voice," students in my course find that their learning is richer and more profound than in comparable conventional classes because:

- They can readily communicate with each other to share resources for learning, without all interactions facilitated by the instructor in a limited-time classroom setting or occurring in difficult-to-arrange face-to-face small group meetings.
- Extensive, deep discussions are enabled by asynchronous interaction.

Some students spend many hours communicating asynchronously, having a much richer dialogue than could have been possible through the best face-to-face facilitation.

Despite these observations, an extensive research literature has repeatedly documented "no significant differences" between various instructional media (e.g., videoconferencing vs. face-to-face instruction).[6] However, all these studies are limited in that the average performance of a group is compared for one single mode of delivery versus another. This research does not recognize that, for each medium utilized, some students are empowered, others disenfranchised, and the net impact may average out the differences.

In contrast, well-designed learning experiences using several instructional media with differing characteristics (for example, synchronous versus asynchronous, high-bandwidth versus low-bandwidth, contextualized versus decontextualized) enable all students to utilize their most

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6 For details, see [http://tenb.mta.ca/phenom/phenom.html].

effective ways of learning. For example, a text-based virtual world provides a low-bandwidth, contextualized setting, while videoconferencing enables high-bandwidth, decontextualized interaction. Mixed-media courses potentially enable better learning outcomes for every participant than comparable courses taught through any single medium--including solely face-to-face instruction. While six interactive media are likely overkill for most types of educational situations, I believe every extended learning experience should use at least one synchronous virtual and one asynchronous medium, in addition to (if possible) face-to-face interaction.

Both of these findings have implications for the design of knowledge networks to facilitate mastering best practices and adapting innovations. To ensure that all participants feel empowered to interact fully, knowledge mobilization and dissemination should utilize a mixture of media and include at a minimum one form each of synchronous and asynchronous communication. In this manner, the educators seeking to implement an innovation can receive enough intellectual, emotional, and social support to facilitate their unlearning current organizational rituals, policies, practices, and cultures.

D. CONCLUSION: FROM ADOPTING TO ADAPTING

Gomez argues that, for various reasons, recent instructional reforms are even more dependent upon local capacity than previous reforms (Elmore and Fuhrman 1994). First, the reforms lack elaborate images of the instruction they are designed to promote, because they are still being worked out by scholars (Ball and Wilson 1997). Second, the reform pedagogies that advocates propose are likely to remain weakly defined, because they call for teaching and learning practices that cannot be precisely specified by external agents. In fact, some proponents (Meier 1995) argue that it is only through ownership of the reform that powerful ideas about use emerge. The design of less well-defined materials that leave enactors room to construct their own understanding of reforms is entirely consistent with the constructivist approach to student learning that underlies most of those instructional reforms.

To meet this challenge, conventional strategies for knowledge mobilization, dissemination, and use must evolve toward facilitating the adaptation rather than the adoption of reform-based

innovations. Through empowering rich forms of knowledge networking and emergent intelligence that provide intellectual, emotional, and social support, new interactive media can greatly aid this process of adaptation. Parallel to exemplary practices with learning technologies in classrooms, the real power of these media comes not from automating information transmission, but from enabling students' collaborative, guided construction of meaning. Information technology is the only practical means we have of making such rich human experiences affordable and scaleable across the full population of educators.

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