Revising the Intellectual Bandwidth Model and Exploring its use by a Corporate Management Team

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Abstract

Organizations exist to create value that members could not create individually. They create value by harnessing the intellectual resources of their members to provide goods and services tailored to the needs of their clients. This paper investigates the tenets of the Intellectual Bandwidth (IB) model by exploring its use by a team of corporate managers. The results provide insight into the key concepts underlying the model and enable it to be revised. The analysis of the results suggest IB has definite boundaries. While further research is required to devise reliable measures of IB constructs, this paper's contribution is in the "treasure map" that enables future research to focus on uncovering the relationships between value creation and Intellectual Bandwidth.

1.Introduction

Organizations exist to create value that members could not create individually. Value is anything that people consider useful, important, or desirable [7]. Value is often measured in monetary terms, but value can manifest in many dimensions. Cognitive value may be derived by reducing demands on limited attention resources. Social value may manifest as improved relationships. Physical value may appear as improvements in comfort, and health. Emotional value may manifest as one of the many variations of happiness, and political value may emerge as increased power. There is increasing recognition that corporate performance is affected by a plethora of intangiable assets that work together to create value. Alan Greenspan [2] noted that, particularly during the past two decades, an ever increasing share of GDP has reflected the value of ideas more than material substance or manual labor input. Quinn [9] even suggests that organizations' success will be determined by the extent to which the knowledge, and expertise of its members can be used to provide customized goods and services. It seems that value is created by harnessing intellectual capital.

In order to create value, people must go through a *value creation process* where they become informed, reason together, make a plan, and take action [7]. Value is important because regardless of the kind of value an organization seeks to create for its stakeholders, it must be able to bring its intellectual capital (IC) to bear on its tasks. An organization's intellectual capital is embodied in its repeatable processes, in the understandings of its members, and in its physical repositories of knowledge. In an effort to better understand how organizations deploy their intellectual capital, and how such deployment could be made more effectively and efficiently, researchers have begun to explore the concept of Intellectual Bandwidth [7,8,11, and refer to special issue of JMIS on Intellectual Bandwidth, vol 17 no 3.]. An organization's Intellectual Bandwidth (IB) is its ability to bring its intellectual capital to bear on the tasks at hand [7]. The higher is an organization's intellectual bandwidth, the higher would be its potential to create value.

In relation to knowledge creation, organizational learning or creating value from intellectual capital is often seen as an emergent, wholistic process of sense making through the creation of mental models [12,15] or dynamic spirals and inter-relations [5,14,]. Huber [5] suggests that learning occurs when increasingly varied interpretations of a phenomenon are developed. Models of intellectual bandwidth posit that an organization's ability to create value is bounded by what its members know or can learn, and by its ability to bring together multiple minds for joint action to achieve a goal. Thus, intellectual bandwidth has at least two dimensions: ability to know, and ability to collaborate.

An understanding of Intellectual Bandwidth might provide insight into how organizations create more value by leveraging existing intellectual assets. It might provide a basis for making useful choices about where and how to deploy information technology to improve learning and collaboration. Such understanding might assist in overcoming some of the problems associated with current knowledge management efforts. Hibbard and Carrillo [3] suggest that problems which stem from traditional business environments that hoard knowledge is an obstacle which is preventing knowledge management efforts being a complete success. Vance [16] suggests that the reason information and knowledge may not be easily transferred from the holder to the person needing it may be because much of it is tacit, and therefore inarticulable by the holder. Intellectual Bandwidth harnesses the tacit dimension of knowledge through collaboration. It might suggest ways to leverage currently separate knowledge management initiatives and collaborative technology initiatives in ways that substantially increase an organization's ability to create value.

This is paper offers a refinement of an earlier model of Intellectual Bandwidth, and reports an exploration of the intellectual bandwidth requirements for the management team of a multinational accounting firm. It then suggests approaches for developing rigorous measures of Intellectual Bandwidth requirements and use.

2. A Revised Model of Intellectual Bandwidth

Early models of Intellectual bandwidth posit IB as having at least two independent dimensions: Information Assimilation, and Collaboration. (Figure 1, [7]).

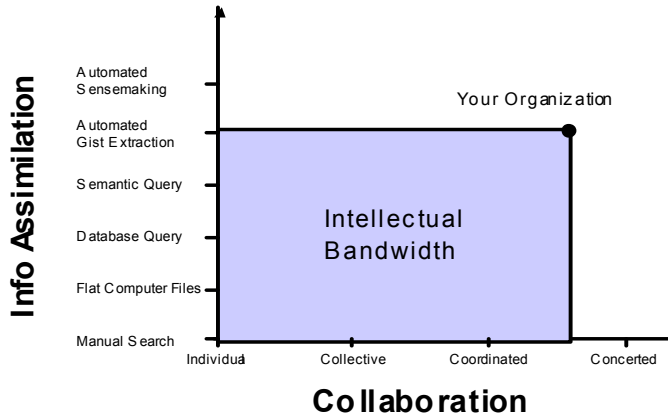

Figure 1. A model of Intellectual Bandwidth *(Source: Nunamaker et. al. 2001)*

The concept of Information Assimilation embodied a hierarchy of technologies. All these technologies could help the members of an organization assimilate information. The model posited that technologies near the top of the hierarchy would help members assimilate more information of higher sophistication and abstraction more quickly than would technologies near the bottom of the hierarchy. The closer to the top was an organizations infrastructure, the more intellectual bandwidth an organization could have.

The concept of collaborative work mode embodied a hierarchy work modes ranging from individual work to concerted work. Work modes range from collective, to coordinated, to concerted. People who create value independent of the efforts of others are said to be working in the individual mode. People who make individual efforts, and then add up the products of their efforts are said to be working in Collective Mode. Team members are said to be working in Coordinated Mode if they create value through individual effort, but team members must coordinate the timing of their deliverables because the outputs from one person become the inputs for other people's efforts. People are said to be working in Concerted Mode when all members must contribute to the creation of a joint deliverable. Organizational teams often move seamlessly among the work modes, depending on the nature and phase of their tasks.

The original IB model posited that a given organization's intellectual bandwidth was the product of its ability to assimilate information, and its ability to collaborate. In its initial form, the model appeared to be useful for understanding how organizations use technology to leverage their intellectual capital to create value. However, the original form of the model did not articulate the principles underlying its dimensions, which limited its usefulness.

3. Refinements to the Vertical Axis

The vertical axis on the original model, Information Assimilation, made reference to a hierarchy of technologies that help people *know*, but it did not explicitly articulate the differences in the support each level might provide. Further, the model was likely become obsolete as the technologies in its hierarchy became obsolete. The original model would need to be updated continuously, as technologies came and went. However, the hierarchy of technology in the model does suggest there may be some underlying principle that is independent of the technologies that support it. Holsapple and Whinston [4] suggest that as organizations will be

increasingly regarded as joint human-computer knowledge processing systems, they will be viewed as a societies of knowledge workers who are interconnected by computerized infrastructures. This means that underlying the hierarchy of computer technologies, there appears to be a hierarchy of understanding [8].

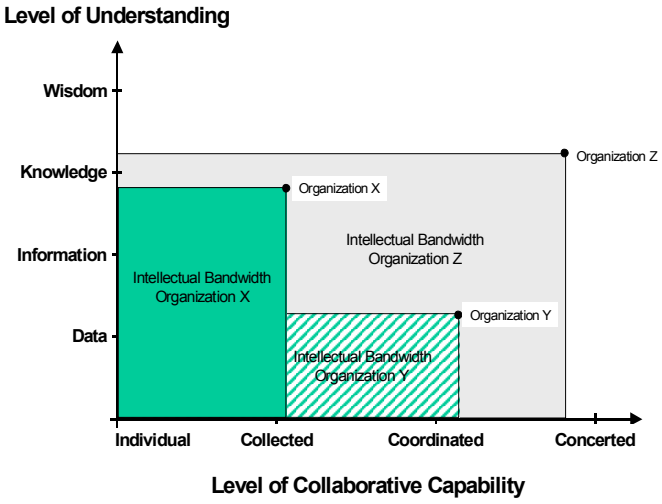

Figure 2. *The Information Assimilation dimension of Intellectual Bandwidth was by a Level of Understanding dimension. Each kind of technology in the original model helped people achieve some level of understanding – data, information, knowledge, and wisdom. Levels of understanding will remain constant even as technologies come and go. Source: Nunamaker et al (2002)*

Nunamaker *et. al.* [8] defined a hierarchy of understanding that built on the often-proposed hierarchy of information: data, information, knowledge, and wisdom. For each level of the model, the authors defined *what* was to be understood, and the *context* in which it could be understood, as follows:

Data: Understanding of Symbols. In understanding data, one understands the meaning of *symbols* in the context in which they were *collected*. Data have no meaning outside the context in which they were collected. For example, the symbols, '4' and '7' can be perceived, but alone cannot be understood. Are they arranged alphabetically? Are they a two-digit decimal integer? What, if anything, do they quantify?

Lacking the context in which they were collected, one cannot accurately understand the symbols, even if one recognizes them. If one can only understand the symbols if one knows they were collected for example, as the month and day of somebody's birthday.

Information: Understanding Relationships Among Symbols. In understanding Information, one understands relationships between data items in the context in which they are presented. Information is useful when it is presented to emphasize relationships. For example, a pie graph may represent age brackets as population percentages.

Knowledge: Understanding Patterns. To understand knowledge one must understand the patterns in the context from which they emerge. Patterns are not information (relationships among data). Rather they exist separately from information, as archetypes or standards to which emerging information can be compared, so that one may draw inferences and take action. Relationships that emerge repeatedly imply underlying principals of cause and effect, and therefore may become the basis for standard operating procedures to either mitigate or enhance effects. The contexts from which patterns emerge suggest which standard operating procedures might apply.

Wisdom: Understanding Principles. Wisdom entails understanding the causes and consequences underlying patterns, and the context in which they obtain. Wise people understand which knowledge applies to the current context. Collections of knowledge are not wisdom, but causes and consequences may be inferred by recognizing useful principles that emerge as one considers patterns within knowledge.

With a hierarchy of understanding as its vertical axis, the model becomes a means for explaining what kind of contribution a given technology might make to the understanding of people working to create value. The technologies come and go, the model can remain constant. The model may become a guide for deciding what kind of technologies should be created, and how they should be deployed.

4. Refinements to the Horizontal Axis

The horizontal axis of the Intellectual Bandwidth model, offers a hierarchy of collaborative work modes, but does not yet explain the principle underlying the hierarchy. We argue that the underlying principal is a hierarchy of Interdependency. It is a *continuum of understanding* in which understanding evolves to give new meaning to data [14]. It is the degree to which the efforts of team members must be interdependent in order for the team to succeed.

Individual Work Mode People who do not work in teams, but create value through efforts independent of all others can be said to be working in individual mode. Authors and poets typically do much of their work in individual mode.

Collective Work Mode. People must work in collected mode when individual efforts will not produce sufficient volume to achieve a goal. No coordination among members is required for the individuals to be productive. Team productivity is the simple sum of individual performances. The only interdependency among team members is the joint goal. Data entry clerks and sprinters at a track meet work in this mode.

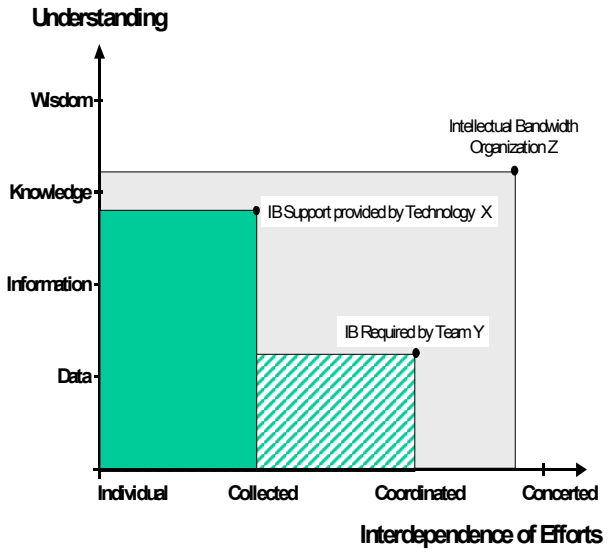

Figure 3. A Revised Model of Intellectual Bandwidth. *The vertical axis represents a continuum of understanding. The horizontal axis represents a continuum of the interdependence of efforts required for a team to succeed. Notice that the model can be used to represent the potential contribution to IB made by a certain technology, IB used by or needed by a team, and the IB of an organization, which represents a boundary on its ability to create value.*

Coordinated Work Mode. Coordinated work involves managing interdependencies between individual activities [6]. Team members working in this mode still make individual efforts, but the success of some members depends on the timely receipt of the deliverables produced by other members. Therefore, the success of the team depends on their ability to coordinate the timing of their efforts and the quality of their deliverables. Synergy is possible as team members apply their unique skills and talents to the parts of the task where they are most needed. Much of the effort in many organizations takes place at this level.

Concerted Work Mode. Concerted work requires the highest level of interdependency among team member efforts. In this mode, all members of a team do not coordinate the exchange deliverables, but rather produce a joint deliverable. The timely and effective contributions of all team members are required for the goal to be achieved. Imagine what might happen if, for example, the lead actor in a play decided to show up and deliver her lines on a different night than the rest of the company. Or, imagine what might happen if various key stakeholders in a Fortune 500 company tried to write separate components of a strategic plan without first working in concert to conceive a strategy. For such tasks, collective or coordinated work would yield nothing of value. Only a concerted effort can produce a result.

A hierarchy of work modes gives the impression of discrete levels with identifiable boundaries between them. However, a hierarchy of effort-interdependence suggests a continuum from fully independent effort to fully concerted effort. The work modes become useful markers along that continuum, rather than separate levels in a hierarchy. Figure 3 illustrates a revised model of Intellectual bandwidth based on the principles underlying the dimensions of the earlier models.

The revised model of intellectual bandwidth can be the basis for several kinds of analysis. It can be for assessing the intellectual bandwidth of an organization. It can also be used for assessing the IB required by or used by a particular team. It can now also be used as a basis for assessing the contribution that a particular technology might make to intellectual bandwidth. Thus, the model may be useful for discovering IB gaps, and for deciding what technologies to deploy to improve a team's ability to create value. It may also be useful as the basis for assessing gaps between available IB, and the IB being used by a team.

In order to assess gaps between required (or used) IB and available IB, it must be possible to measure both a team's use of IB and an organization's available IB. An organization's IB may be measured in terms of the expertise of its employees, the productivity of its repeatable processes, the richness of its stored knowledge, and its technical infrastructure for knowledge management and collaboration. A team's requirements would be measured in terms of the degree to which they must bring that which they know to bear, and the degree to which they must collaborate in order to succeed. The

latter view must drive the former, because one cannot effectively deploy resources until one knows what one needs to accomplish with them. The next section of this paper presents the first exploration of the IB needs of an existing management team.

5. Research Methods

The Team. A large multinational accounting firm brought members of its management team to a European university for training workshops on change management. The university designed a change management game and ran this as role-playing scenarios where participants adopted conflicting roles in a hypothetical organization that was undertaking a large information systems related change management project. Participants were to play out their role based conflicts, and eventually negotiate agreements on a way to move the project forward to completion. As a precondition for participating in the workshop, participants agreed to answer questions about their use of IB in their workplace. The questionnaire also helped the researcher designing the game to further sharpen the role descriptions of the change management game.

Ninety-one people participated in six sessions of about under twenty participants per session. They all responded to the questions posed about IB. One participant did not report a job title, and four reported that they were not part of the management team. Data from those five participants were excluded from subsequent analysis. Table 1 shows a breakdown of remaining eighty-six people by job title.

Table 1. Study Participants	
Job Title	Count
Assistant Manager	17
Manager	43
Senior Manager	15
Director	4
Partner	7
Total	86

The Exploratory Questions. The purpose of this exploratory study of IB use by a management team was to describe the phenomenon, to support theory building and to point the way toward future development of rigorous metrics. The theory of IB is not yet sufficiently mature to allow the rigorous derivation and testing of hypotheses, nor the development of rigorous metrics. Drawing on the definitions of the two axes of the revised IB model, we developed several questions about each construct.

Preceding the questions about Levels of Understanding, the participants received the written instruction, "Circle the number under the statements that best describes aspects of your personal work situation" Preceding the questions about Interdependence of Effort, participants received the written instruction, "Circle the number under the statements that best describes the ways you work with others." Participants could respond to all questions on a five-point scale.

The ends of the scale were anchored with the phrases "Not at all," and, "Always." The middle of the scale was anchored with, "Sometimes." Tables 2 and 3 present the text of the questions to which the participants responded.

6. Results

This study was exploratory, not a rigorous empirical test of hypotheses. As such its results should be considered indicative and suggestive, not definitive and conclusive. Table 4 presents the mean responses to each question, broken out by job title and aggregated across job titles. It also presents a one-sample, 2-tailed t-test for each question testing whether the aggregate mean response to the question was statistically significantly different than neutral.

The t-tests suggest that the respondents may have had definite opinions on all questions, because the tests showed that the mean response to all questions was statistically significantly different than neutral. Exploratory ANOVAs found no difference in the responses to any question by job title.

The Data Level. The managers reported that they did "observe the world and collect data about it" (Data1). This is in keeping with their professions as accountants. However, they had not received a rigorous definition of the word, "Data" before responding to the question. When asked questions based on the definition of the concept, they reported that they did not prefer facts to summaries (Data2), they did not collect and use underlying details (Data3), and they did not deal in particulars instead of abstractions (Data4). It might be useful in future studies to learn the nature of the "data" that these manages do observe and collect, and to see how it fits into the hierarchy of understanding. It may be important when developing metrics for the data level to be explicit about the meaning of the word, "data," or to avoid its use altogether. It appears that this group of managers did not require understanding at the data level, despite their positive response to Question Data1.

Table 2 Questions on The Understanding Dimensions of Intellectual Bandwidth	
Data	
Data1	In my work I must observe the world and capture data about it.
Data2	Summaries and analyses won't do for me. I need the original facts.
Data3	I am the one who collects or uses the underlying details.
Data4	I deal in the particulars, not in generalizations, abstractions, or inferences.
Info	
Info1	The facts are less useful to me than the relationships they indicate.
Info2	I organize and make sense out of data.
Info3	A summary or analysis is more useful to me than the underlying details.
Knowledge	
Know1	I watch for patterns in the information and I have a procedure for dealing with the patterns when they emerge.
Know2	It is more important for me to understand how to do things than to understand why we do them.
Know3	I need the practical knowledge and not the reasons behind it to get my work done.
Know4	I draw on standard operating procedures in order to carry out my work.
Wisdom	
Wisdom1	Sometimes, as a part of my job, I am expected to abandon standard policies and procedures because, in my judgment, they just don't apply to the situation at hand.
Wisdom2	In my work, it is important that I understand the principles behind the way we do things.
Wisdom3	I must understand the causes and consequences of my work, and I must decide which principles apply to the situations in which I operate.
Wisdom4	In my work, it's not enough to know how things are to be done, I must also understand why they are done that way.
Wisdom5	I must understand not only the rules, but also when it is important to break the rules.

Table 3. Questions about the Effort Interdependency Dimension of IB	
Collective	
Collec1	We each do our own work. Someone collects our results and our task is done. (Like counting ballots after an election).
Collec2	We all produce something. We add up what each has produced to know what we've accomplished. (Like filling sandbags for a leaky dike)
Collec3	My productivity depends on my efforts alone. It doesn't depend on what the people around me are doing.
Coordinated	
Coord1	We each do our own work, but if people don't deliver their results to me on time on time, my work suffers.
Coord2	Mostly we make individual efforts, but I often need to coordinate carefully because either I need their results to accomplish my work, or they need my results to accomplish their work.
Coord3	I need my colleagues to hand over in a timely, accurate and complete format so that I can do my part (like agents, insurers and actuaries preparing and insurance policy).
Concerted	
Concrt1	There isn't "my deliverable" and "his deliverable" and "her deliverable." We all have to work together to produce a joint deliverable.
Concr2	We don't hand things off to each other; we all have to work on the same thing at the same time. (Like a play – all actors on the stage must act in concert to deliver the play. If one actor decides to show up and deliver his lines the following night, the whole play fails.)
Concr3	Our efforts must be simultaneous and continuously coordinated in order for us to succeed.

		Table 4. Mean Responses By Job Title (n)						One-Sample Two-Tailed T-Test Test Value = 3			
Question	**Question key-words**	**Ass Mgr (17)**	**Mgr (43)**	**S. Mgr (15)**	**Director (4)**	**Partner (7)**	**Total (86)**	**Mean Diff**	**t**	df	**Sig.**
Data1	Observe/capture data	3.82	3.67	4.17	3.75	4.57	**3.87**	0.87	7.69	85.00	0.00
Data2	Need Original facts	2.29	2.71	2.93	2.75	2.86	**2.68**	-0.32	-3.61	85.00	0.00
Data3	Collects Detail	2.35	2.74	2.60	2.25	2.29	**2.58**	-0.42	-4.92	85.00	0.00
Data4	Particulars	2.53	2.81	3.20	2.75	2.71	**2.81**	-0.19	-2.11	84.00	0.04
Info1	Relationships, not facts	3.06	3.30	3.47	3.00	3.71	**3.30**	0.30	3.23	85.00	0.00
Info2	Organize and make sense	3.76	3.91	3.93	3.25	3.57	**3.83**	0.83	9.08	85.00	0.00
Info3	Summarize or analyze	3.94	3.78	4.00	3.75	4.00	**3.87**	0.87	11.90	85.00	0.00
Know1	Patterns and procedures	3.76	3.95	3.80	3.75	3.71	**3.86**	0.86	11.05	85.00	0.00
Know2	How NOT why	2.12	2.02	2.67	2.25	1.71	**2.14**	-0.86	-8.65	85.00	0.00
Know3	Practical, not reasons behind	2.47	2.33	2.20	2.25	2.00	**2.30**	-0.70	-7.57	85.00	0.00
Know4	Use SOPs	2.50	2.40	2.07	1.75	2.57	**2.34**	-0.66	-7.01	85.00	0.00
Wisdom1	Abandon SOPs	3.53	3.51	3.67	3.50	3.71	**3.56**	0.56	7.14	85.00	0.00
Wisdom2	Understand principles	4.35	4.23	4.40	4.25	4.29	**4.29**	1.29	18.46	85.00	0.00
Wisdom3	Causes and Consequences	4.35	4.21	4.33	5.00	4.29	**4.30**	1.30	20.28	85.00	0.00
Wisdom4	How AND Why	4.24	4.16	4.47	4.25	4.14	**4.23**	1.23	20.15	85.00	0.00
Wisdom5	Rules and when to break	3.88	3.72	4.07	4.00	3.00	**3.77**	0.77	8.12	85.00	0.00
Collec1	Own work, collected results	1.65	1.90	2.00	2.00	1.29	**1.82**	-1.18	-13.18	84.00	0.00
Collec2	Add up products	2.41	2.81	3.00	2.25	2.86	**2.74**	-0.26	-2.12	85.00	0.04
Collec3	Productivity depends on me	1.94	1.79	1.87	1.75	1.43	**1.80**	-1.20	-13.49	85.00	0.00
Coord1	Suffer without others results	3.35	3.37	3.67	3.00	3.86	**3.44**	0.44	4.19	85.00	0.00
Coord2	Coordinate carefully	3.14	3.26	4.13	2.25	3.71	**3.38**	0.38	3.56	85.00	0.00
Coord3	Need timely handover	3.32	3.28	3.60	2.25	3.71	**3.33**	0.33	3.08	85.00	0.00
Concert1	Our Deliverable	3.65	4.08	4.07	4.25	4.43	**4.03**	1.03	11.95	85.00	0.00
Concert2	All at same time	3.47	3.00	3.40	3.75	3.00	**3.20**	0.20	2.00	85.00	0.05
Concert3	Simultaneously coordinated	3.88	3.69	4.33	4.00	4.00	**3.88**	0.88	10.03	85.00	0.00

The information Level. The managers responded positively to all the questions about the information level. They reported that they did find facts less useful than the relationships (Info1), that they did organize and make sense out of data (Info2), and that they found a summary or analysis more useful than the underlying details (Info3). The response to Question Info2 suggests that the managers may work with data to convert it into information, while the responses to Questions Info1 and Info3 suggest that they use information, rather than data to accomplish their work. Given the differential answers to Data1 and the other data questions, however, it may be that the managers understood a loose definition of the word, "data."

It might be useful to a more complete understanding of IB if future studies were to examine what kinds of data and information managers actually use. The responses did suggest that the managers may require understanding at the information level.

The Knowledge Level. The managers reported that they do watch for patterns and had procedures for dealing with them when they emerged (Know1). However, they did not find it more important to understand the "how" than the "why" (Know2), nor did they need practical knowledge rather than the reasons behind it (Know3). They reported that they drew on standard operating procedures infrequently (Know4). In retrospect, only Question Know1 is actually based on a definition of Knowledge. It may be that Questions Know2 and Know3 are better as screening questions for the Wisdom level than as measures of whether respondents require understanding at the knowledge level. It is puzzling that a group of accountants would report that they do not draw on standard operating procedures to carry out their work, given that accountants work constantly with Generally Accepted Accounting Procedures. This anomaly bears future investigation in future studies.

The Wisdom Level. The respondents said they needed to understand the principles behind what they did (Wisdom2), that they needed to understand the causes and consequences of their work (Wisdom3), and that they needed to know the "Why" as well as the "How" of their work (Wisdom4). They reported that they needed to know when to abandon standard operating procedures (Wisdom1), and when it was important to break the rules (Wisdom2). All these questions derive from the definition of wisdom given in the model, which suggests that these managers may need understanding at the Wisdom Level.

These results are consistent with the responses the participants gave to Questions Know2 and Know3 where they reported that they rarely needed to know the how of something without knowing the why.

7. Analysis

To summarize, the results suggest that these managers may not often need understanding at the Data Level, but that they might frequently need understanding at the Information Level and at the Wisdom Level. Their response to Know1 suggests they may possible need understanding at the knowledge level, but the responses to Know2, 3, and 4 may have more to do with the Wisdom Level than the Knowledge level.

Collective Work. The managers were quite firm in their reports that they did not often participate in collective work. The mans for all questions on this topic were below neutral. They reported that they rarely "each do their own work" and have someone collect the results (Collec1). They rarely "each produce something" and then add up the results to measure productivity (Collec2). They said it was rare for their productivity to depend on their efforts alone, without depending on what the people around them were doing (Collec3).

Coordinated Work. It may be that the managers engage in coordinated work more frequently than they do collective work. The means for all three questions on this construct were above neutral. The reported that frequently they each did their own work, but that they depended on timely deliverables from others (Coord1, Coord3). They also said they frequently made individual efforts, but coordinated carefully for things they needed from others and for things others needed from them (Coord2).

Concerted Work. The managers may also frequently participate in concerted efforts. They reported that they often had a common deliverable rather than individual deliverables (Concert1). They said they frequently worked on the same time (Concert2), and they said that their efforts had to be simultaneous and continuously coordinated in order that they might succeed (Concert3).

The results suggest there may be another interesting story to tell. Question Concert2 presents an extreme case of concerted effort, with its wording, "like a play…if one actor decides to show up and deliver his lines the following night, the whole play fails." Paired sample t-tests revealed that the managers engaged in this extreme form of concerted effort less frequently than they did the

more moderate phrasings of Concert1 ($t = 7.21$, $df = 85$; $p=.000$) and Concert2 ($t = 6.76$, $df = 85$; $p=.000$). This outcome hints that the Interdependence of Effort dimension may be a continuum, as suggested by the revised model of IB, rather than discrete levels as suggested in the original model.

When developing rigorous measures of IB use, it will therefore be important to create questions that take the continuum into account. Care must be taken in constructing scales, because reliability may be low if, for example, questions about extremely interdependent concerted work are mixes with questions about moderately interdependent concerted work. One might gain reliability by framing questions that where the response scale asks a participant to choose a level of interdependence rather than one that asks about how often one works at a given level. However, care must be taken to formlate clear questions. Because questions that ask for the user to choose a level of interdependence might mask the presence of multi-modal work situations.

7.1 Intellectual Bandwidth Usage by Managers.

The data suggest that the managers who participated in this study may function at the concerted and coordinated levels of collaboration more frequently than they do at the collective level. It suggests they may require understanding at the information level and the wisdom level more frequently than they the do at the data level. Figure 4 approximates an illustration of their requirements for intellectual bandwidth based on these findings.

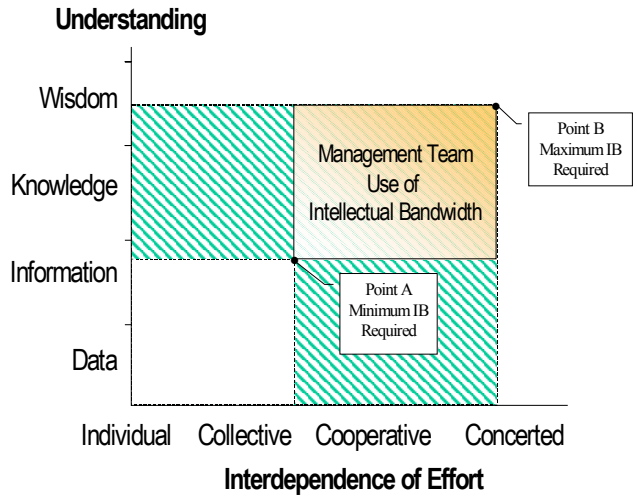

Figure 4. Intellectual Bandwidth Required by Managers. *The shaded box in the upper right quadrant approximates the intellectual bandwidth used by the managers who participated in this study. Point A indicates the minimum intellectual bandwidth they would require to accomplish their least demanding tasks. Point B indicates the maximum intellectual bandwidth they would require to accomplish their most challenging tasks.*

8. Conclusions and Future Directions

Because of the exploratory nature of this study, it would not be appropriate to draw conclusions based on any of the data presented here. Rather, it would be useful to consider the findings as a treasure map that points the way toward something valuable. The trip to the treasure still lies ahead.

Three parallel efforts are needed to develop rigorous metrics for IB. The first effort must devise reliable measures of the intellectual bandwidth required by or used by a team. The second must devise reliable metrics for an organizations intellectual bandwidth – its potential to bring its intellectual capital to bear on creating value for its stakeholders. A part of an organization's intellectual bandwidth will finding a way to quantify the contribution a given technology can make to intellectual bandwidth.

Because the IB model posits that IB is a boundary on value creation, it will also be important to identify or develop reliable measures of value creation that can be used to assess the degree to which changes in IB affect value created. Having achieved these means, the research community may be in a position to improve the likelihood that organizations can survive and thrive, and to diagnose and prescribe for some organizations that do not thrive.

8.1 Extending the IB Model to Community

The model of Intellectual bandwidth focuses on value creation at an organizational level, but some times organizations work together to create value that cannot be created by a single organization through its own efforts. At some time in the future, it might be useful to extend the model beyond the organization to the community or society. Communities are informal and pervasive; they may not come into explicit focus when one considers value creation [14]. The growth of special interest, entertainment, and professional discussion groups on the internet attests to the usefulness of such communities. In communities, traditional organizational, geographical, and cultural boundaries may be transcended, and new rules of behavior and social

adaptation may be created. Communities have implications for the creation and exchange of knowledge. Communities of minds may give rise to communities of practice.

Communities are comprised of individual experts, groups, and organizations that are able to access each others' valued information and resources [1]. An organization may tap into the assets of other organizations by mobilizing its own members or directors who belong to these other organizations through the community. By cultivating diversified ties to large numbers of community organizations capable of supplying resources, an organization's or a group's dependence on a single source can be significantly reduced. Collective action through communities of practice may take place by formally allocating people and resources to tasks and by providing mechanisms for their coordination [10].

The community aspects of collaboration may shed important light into how joint action among and across organizations can create value. Future research should consider the collaborative processes within communities of practice through field studies, and case studies. In particular, the forces that lead to joint action towards the creation of value should be ascertained.

9. References

[1] Eom S and C.K.Lee, "Virtual Teams: An Information Age Opportunity for Mobilizing Hidden Manpower," *SAM Advanced Management Journal*, Spring 1999, pp.12-15.

[2] Greenspan, A. Speech to the National Association for Business Economics. *New York Times*, March 28, 2001.

[3] Hibbard, J. and Carillo, K.M. Knowledge Revolution – Getting employees to share what they know is no longer a technology challenge – it's a corporate culture challenge**.** *InformationWeek*. 663. 1998.

[4] Holsapple, C.W. and A.B. Whinston. "Knowledge-based Organizations". Information Society. (2):77-89. 1987.

[5] Huber, G.P. "Organization Leaning: An examination of the Contributing Processes and the Literatures." *Organization Science*. 2. 88-115. 1991.

[6] Malone, T. and K. Crowston, "The Interdisciplinary Study of Coordination". ACM Computing Surveys. 26(1):87-119. 1994.

[7] Nunamaker, J., Briggs, R.O., and G. J. de Vreede, "From Information Technology to Value Creation Technology". In G. Dickson and G. DeSanctis. *Information technology and the New Enterprise: New Models for Managers*. Prentice Hall. 2001.

[8] Nunamaker, J., Romano, N., and R. O. Briggs, "Increasing Intellectual Bandwidth**:** Generating Value from Intellectual Capital with Information Technology". *Group Decision and Negotiation.* 2002.

[9] Quinn, J.B. *Intelligent Enterprise*. Free Press. New York.1992.

[10] Qureshi, S., and I. Zigurs. "Paradoxes and Prerogatives in Global Virtual Collaboration" *Communications of the ACM* special section on Global Applications of Groupware. 44(12). 2001.

[11] Qureshi, S., van der Vaart, A., Kaulingfreeks, G., de Vreede, G.J., Briggs, R.O. and J. Nunamaker. "What does it Mean for an Organization to be Intelligent ? Measuring Intellectual Bandwidth for Value Creation." *The Thirty Fifth Annual Hawaii International Conference on Systems Sciences*. IEEE Computer Society Press. 2002.

[12] Senge, P. M. *The Fifth Discipline: The Age and Practice of the Learning Organization*. London: Century Business. 1990.

[13] Tuomi, I. (2000) Data is More Than Knowledge: Implications of the Reversed Knowledge Hierarchy for Knowledge Management and Organizational Memory. *Journal of Management Information Systems*. 16(3), 103-117.

[14] Wenger, E. *Communities of Practice: Learning, Meaning and Identity*. Cambridge: Cambridge Oxford University Press. 1998.

[15] Weick, K.E., and F. Westley. *Organizational Learning: Affirming an Oxymoron*. S.R. Clegg et al.(ed.) Handbook of Organization Studies. London: Sage, 440-458. 1996.

[16] Vance, D. M. "Information, Knowledge and Wisdom: The Epistemic Hierarchy and Computer-Based Information System". Proceedings of the 1997 America's Conference on Information Systems. 1997.