Employing the Intellectual Bandwidth Model to Measure Value Creation in Collaborative Environments

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Abstract

Nunamaker et al. [1] introduced the intellectual bandwidth (IB) model as a research tool to help decision makers to better understand value creation. Bach et al. [2] used the IB model to map value creation attributes of an information system in a conceptual real-world business case involving the diagnosis and treatment of HIV patients. This paper describes a methodological approach that enables practitioners to use the IB model to identify potential areas of value creation. It presents a pragmatic way of employing the IB model for the HIV information system and discusses possible ways to conceptualize, operationalize, and ultimately measure value creation in collaborative environments, such as those encountered in worldwide networked research environments.

Technical and human aspects are inseparable factors for value creation in organizations. The technological aspects include the application of technology as well as organization concepts such as strategy. Human aspects include collaboration and the collaborative interplay between humans employing technology. With the IB model it is possible to emphasize the importance of both dimensions. This model makes pragmatic data analysis possible without requiring practitioners to deal with complicated statistical analyses. In this way research that is useful for theory and practice is possible.

1. Introduction

Nunamaker et al. [1] introduced the intellectual bandwidth (IB) model as a research tool to help organizations understand the nature of value creation. Unfortunately, they did not propose a means of measuring the two dimensions that comprise this potentially useful model. In this paper we present a pragmatic means of helping practitioners identify areas of value creation in their organization. We emphasize the role of the practitioner since he/she is in the best position to identify the most important business problem or decision. Practitioners have access to data and information that academic researchers seldom have, and they often have a better understanding of the actual business context. To help these managers better understand the business situation and to communicate significant insights we propose teaching them how to properly “reflect” on important organizational issues. While managers naturally engage in reflective behavior, they are often not aware of it; they need a systematic approach that will enable them to become aware of their reflective behavior so that they will be able to document and communicate their knowledge.

The literature is replete with examples of reflective behavior. Quinn [3] gives numerous examples of reflective behavior in corporations and describes how in complex and dynamic real-world situations, managers reflect on emerging situations embedded in specific business contexts. Nonaka and Takeuchi’s [4] discussion of knowledge creation -- for example, in the following: “a spiral emerges when the interaction between tacit and explicit knowledge is elevated dynamically from a lower ontological level to higher levels” -- is in essence an example of reflective behavior. Unfortunately, it is too complex to be understood and employed by most practitioners. Hansen et al. [5] present empirical evidence of reflective behavior in their discussion of the role of consultants when they conclude, “consultants collectively arrive at deeper insights by going back and forth on problems they need to solve.” Their stories support the notion of reflective behavior as well as the idea of vertical research that will be discussed in a later section. Checkland [6] uses action research to explain his soft systems methodology (SSM) that can be thought of as reflective in nature. In general, all major research methods, such as action research, case study research, grounded theory, and ethnography on which the above references are based, are reflective in nature. The aim here is to describe the underlying mechanics of reflection and define the essential terms shared by all research methods.

However, any method designed for practitioners should not be overly theoretical or involve long and elaborate steps since practitioners are less likely to have the time and patience to struggle with such constructs. They want a method that is easy to use and understand [7], [8], [9], [10]. To help in this regard we refer to the work of Schön [9] in developing our approach.
Reflective Practitioner

Schön describes reflective practitioners as professionals in practice who hold a reflective conversation with the situation. They must construct reality from the materials of situations that are puzzling, troubling, and uncertain. They must make sense of an uncertain, usually complex and ill-defined, situation that initially makes no sense (p. 40). This process of making sense is reflective behavior that needs to be approached in a systematic way employing the IB model. Explaining the mechanics of expressing reflective insights through the IB model by using the reflective research approach is the objective of this paper.

This paper presents a conceptual way for conceptualizing, operationalizing, and measuring value creation in collaborative environments such as the ones envisioned in the IB model. Bach et al. [2] used the IB model to map the value creation attributes of an information system in a conceptual real-world business case involving the diagnosis and treatment of HIV patients. In this paper, quantitative and qualitative measures are introduced as a way of operationalizing the model. A systematic approach is presented by means of which assessments of the two IB dimensions, collaboration and information assimilation, can be quantified. The approach presented here is predicated on the implicit notion that the person in the best position to correctly assess these dimensions is the reflective practitioner. The next section introduces the notion of reflective research and that of the reflective practitioner.

2. Reflective Research

As noted above, the intellectual bandwidth model [1] was built as a tool to help organizations understand the nature of value creation. This model is based on two dimensions that determine an organization’s ability to solve problems effectively. The first dimension focuses on people’s understanding of the problem and presents a hierarchy based on the assumption that our understanding increases as data are transformed into information, which is then transformed into knowledge and ultimately wisdom. The second dimension of the model focuses on the level of collaboration among individuals or units in the decision-making process, recognizing that people can work together at many different levels [11]. By juxtaposing the two dimensions, an organization can examine its actual intellectual bandwidth, i.e., the degree to which it is effective in doing meaningful work (creating value) through its members, as well as its potential intellectual bandwidth, i.e., the degree to which it could be more effective in doing meaningful work (creating value) through its members. This gap between the actual and potential bandwidth provides a measure of potential value creation.

In order for organizations to determine their potential for value creation with the help of the intellectual bandwidth model, they must be able to analyze organizational processes. While practitioners are constantly analyzing their environment and trying to make sense of their world, they do not always do so in a systematic way. On the other hand, academic researchers analyze problems in a systematic way, but they do not always study the problems of interest to practitioners. There is an abundance of literature that discusses this practitioner-academic gap e.g., [12], [13], [14], [15], [16]. This literature acknowledges the inability of academic researchers to fully understand critical data/information needed to correctly assess a specific business situation. It also recognizes that two individuals or groups with different experiences and perspectives, and hence different mental models, may find it difficult to communicate [17], [5]. To correct for these deficiencies, Schön [9] recommends that practitioners be instructed in a method that helps them reflect on critically important instances, i.e., that they become reflective practitioners and approach problems in a systematic way that allows them to make comparisons across different problems and settings.

Reflective research is an open research methodology that can be flexibly employed by practitioners in highly specific real-world situations. It is designed to enable practitioners to cope with the high levels of complexity, change, uncertainty, and instability that accompany dynamic real-world situations. In general, reflective research allows practitioners to (1) identify categories and concepts that emerge from observations of the real world, (2) link the observational findings into strategies and systems that can be implemented, and (3) construct organizational theories, models, and hypotheses for subsequent research projects. The specific approach we present here integrates Nunamaker et al.’s [1] notion of intellectual bandwidth with Schön’s [9] concept of the reflective practitioner as one way of bridging the problematic practitioner-academic gap [18].

It should be noted that reflective research is embedded in and can be executed with many established research methods. For example, most action research approaches involve reflective cycles. Similarly, the grounded theory approach used to analyze ethnographic data requires the researcher to engage in cycles of reflection in order to make sense of the data. Likewise, the seven stages of soft systems methodology all require reflective behavior and the cycles between real world (stages 1, 2, 5, 6, 7) and conceptual modeling (stages 3 and 4) are reflective.
Our goal here, however, is not to simply present the notion of reflective research and to show it compares with or can be used in conjunction with other approaches; rather, it is to present a specific reflective research methodology and to define its essential steps. While practitioners naturally perform reflective behavior without being aware of it, the reflective research methodology described in this paper tries to make practitioners aware of their natural reflective behavior and conceptualizes a means for practitioners to communicate and document their knowledge in order to create value along the dimensions defined by the intellectual bandwidth model.

In the following section we present the essential mechanics of the reflective research approach. The approach consists of a multi-phase process, comprising conceptualization, operationalization, and measurement phases that allow for constant verification of personal knowledge, decisions, organizational behavior, strategies, theories, etc. in ongoing reflective cycles. The process is flexible and allows reflective practitioners to work simultaneously on several stages to capture real-world phenomena. Due to its flexibility, openness, and comprehensiveness, the reflective approach avoids oversimplification and the reduction of reality to isolated variables of the academic, etic research approach.

2.1 Toward a Theory of Research

The theory of research commences with the notion that we can classify research as being either horizontal or vertical or both (see figure 1). The vertical pillars in figure 1 represent single real-world situations (or cases) that we can look at from one perspective and that communicate “one lesson to be learned.” Alternatively, academic research usually employs the horizontal research approach. Surveys and interviews are used to gather uniform data from a large number of people. This research approach is applicable for questions that fit many people and normally involve general subject matters for research. For example, how much butter do you eat every day? Approximately one tenth of accessible information is useful for horizontal research; that is, it can be researched by asking the same questions of different people with different reference frames, i.e., living in different contexts and environments. The answers to these questions are likely to produce a useful, but not necessarily complex, result. The first horizontal bar from the bottom indicates such direct horizontal research.

The second bar depicts reflective horizontal research, which represents an increase in our understanding of the real-world situation, but it is never carried out exclusively. As our desire to understand the complexity increases, questions become more specific, and fewer people are able to answer them. Thus, reflective horizontal research must be preceded by vertical research. First, a sufficient number of real-world cases must be collected and similar cases identified before questions can be developed that are applicable to different people in different yet similar contexts.

In vertical research, questions are asked that only one or a few people are able to answer. In-depth knowledge about a real-world situation is needed to answer these questions. Those who have such knowledge are normally the only ones able to formulate the questions likely to accurately capture phenomena in real-world situations. The ideal research situation involves a combination of both research approaches. Here, the research practitioner is able to document and communicate vertical research findings to practitioner colleagues and academics. In the following sections we develop the notion of a reflective research methodology.

2.2 Toward a Reflective Research Approach

The reflective research methodology basically consists of an integrated multi-phase / multi-stage process. The number of phases and stages varies depending on the complexity and kind of real-world situation.

2.2.1 Toward a Multi-Phase Reflective Research Approach

The reflective research methodology basically consists of the following three phases: (1) conceptualization, (2) operationalization, and (3) measurement. These three phases do not necessarily have to be employed in a single research cycle; rather, different phases can be communicated in separate papers. For example, here we focus on an
application of the reflective research approach for the purpose of developing an organizational approach to creating value within the intellectual bandwidth model. While Bach et al. [2] presented a conceptual business case involving the implementation of an information system for the diagnosis and treatment of HIV patients, that is, a product of the conceptualization phase, this paper uses the same case, but it focuses primarily on the operationalization phase as a step toward the measurement phase.

Our approach shows how an organization can use the reflective research methodology to predict potential value creation in the first phase, identify variables for the measurement tools in the second phase, and measure actual value creation in the third phase after a new system has been implemented. Subsequently, additional phases can be added to evaluate the improvements of the implemented information system.

The first phase involved the development of a detailed description of an implementable information system [2]. The potential bandwidth of the organization was defined by a qualitative description of the potential value-creating properties of an information system and its anticipated value-creating impact on the organization [2]. This research step is usually employed during the development phase.

The second phase consists of a quantitative assessment of the anticipated value-creating properties of the information system. A reflective questionnaire is employed to quantify the potential and actual values of the bandwidth. This phase involves the development of measurement tools and a procedure for measuring and calculating the values for the coordinates of the IB model. This research step can be performed before and after the information system has been implemented.

The third phase consists of the actual measurement and calculation of values for the coordinates of the IB model that have been identified and described in the second phase. A baseline measurement is performed before the information system is put into practice. Examples of variables that can be measured include the time end-users need to handle a certain amount of information, the amount of data a system is able to process, the size of the network that can be established, the cost of adding a new participant to the network, the time required for the network to share data, the time network participants spend sharing knowledge, and so on. The IB model is used to show improvement of actual bandwidth over time if certain steps are taken by management and implemented into organizational processes. This research step can be performed only after the information system has been implemented.

2.2.2 Toward a Multi-Stage Research Methodology

Figure 2 shows the multiple stages that are part of the reflective research methodology. The stages describe the underlying mechanics of reflection-in-action in each phase; they are shared by all research approaches. For example, Basili’s GQM paradigm [19], which could be considered a reflective goal-question-metrics process, does not define how to arrive at a validated goal. Basili states that planning begins with well-defined and validated goals that should be chosen and worded in such a way that they are verifiable. He does not define the specific mechanics of how this can be accomplished. The reflective multi-stage mechanics describes the essential stages commencing with the observation of real-world reality. Real-world reality consists of three essential observational areas: real-world situations, organizations, and management instruments (technology, strategy, finance) that are vital to manage reality. Based on unstructured and unsystematic observations, practitioners are able to describe goals that can be verified. In contrast to Basili’s paradigm, which commences with a validated goal, the aim of reflective research is to document and understand real-world reality before systematic research can begin.

While a detailed description of the mechanics (the mechanics of the stages can be refined endlessly) of the multi-stage methodology is the subject of a subsequent paper, here we briefly describe the approach.

### Multi-Stage Reflective Research Methodology: Stages

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>Observation of Real-World Reality that consists of Real-World Situations, Organizations, and Management Instruments (Technology, Strategy) that are Vital to Manage Reality</td>
</tr>
<tr>
<td>Stage 2</td>
<td>Reflection on Acquired Information and Proposition of Action</td>
</tr>
<tr>
<td>Stage 3</td>
<td>Reflection on Proposed Actions and Development of an Understanding of Dynamics of Real-World Situation</td>
</tr>
<tr>
<td>Stage 4</td>
<td>Formulation of Intellectual Bandwidth Model and of Concrete Actions to Close Gap between Actual and Potential Bandwidths</td>
</tr>
<tr>
<td>Stage 5</td>
<td>Implementation of Actions and Reflection on Impact on Real-World Situation</td>
</tr>
<tr>
<td>Stage 6</td>
<td>Reflections on Impact on Gap between Actual and Potential Bandwidth</td>
</tr>
<tr>
<td>Stage 7</td>
<td>Reflection on Stages 1-6 and Proposition for Action Plan as well as Future Research Projects</td>
</tr>
</tbody>
</table>

**Figure 2:** Stages of the reflective research methodology

The primary purpose of the methodology is to enable reflective practitioners to do vertical case-specific research. The goal is to document and communicate observations and findings practitioners encounter at work. Practitioners possess knowledge and
experience and have access to information that is inaccessible to academics. As a result, they are the only information sources able to communicate real-world cases. When academics work with research practitioners using the reflective methodology, academics can build their own research of real-world cases; this research is more likely to produce accurate results that are relevant for practice as well as more likely to create better theories and hypotheses for academia [20].

Indeed, when applying the first multi-stage cycle, the outcome of the first phase (conceptualization) of the reflective research methodology is a conceptual description of the actual and potential intellectual bandwidths [2]. By identifying and conceptualizing the gap between the actual and the potential bandwidths (value creation vector), practitioners as well as academics can think about innovative ways to close the gap. Further reflection on the gap might result in the formulation of concrete action plans, e.g., the development and implementation of an end-user information system.

Each stage consists of research steps that are appropriate and applicable to a particular real-world situation. The reflective practitioner (preferable together with academics) decides which steps in which phase and stage are appropriate. Depending on the requirements determined by the real-world situation, reflective practitioners have to develop the multi-stage procedure most appropriate for their specific kind of research. Here we present flexible guidelines to help reflective practitioners develop questionnaires that will enable them to conceptualize, operationalize, and measure phenomena in specific real-world situations and cases.

### 2.2.3 Toward a Theory of Reflective Questionnaire Design

Although Labaw [21] attempted to introduce a general theory of questionnaires, a coherent theory of questionnaire design remains elusive (e.g., [22], [23]). Nonetheless, Gendall [22] presented three general principles useful for horizontal research that can be helpful in formulating a theory of reflective questionnaires for real-world (vertical) research.

These principles are: “Find out what is in the respondent’s mind”; “Let the respondent tell you what he or she means and do not impose your values, perceptions, or language on the respondent”; and “Deal first with the questionnaire’s objectives.” That is, to develop the wording for the questionnaire one must first know what is to be achieved with the questions. Gendall also presented three specific principles concerning (1) the questions, (2) the words, and (3) the format. Gendall concluded that “all questionnaires reflect their designer’s view of the world, no matter how objective the researcher has attempted to be [22].”

Building on Gendall’s principles, we propose an approach for developing a reflective questionnaire that can be used with vertical research. This approach requires a dialogue between the reflective practitioner and the real-world situation and is less concerned with what is in the mind of a respondent. In this instance, the questionnaire focuses on value creation...
in collaborative environments and includes three general and four specific principles.

**The general principles of real-world research**
The first general principle of real-world research is: “Gain an initial in-depth understanding of the real-world reality.” The second general principle is: “Triangulate obtained information.” In vertical research, the triangulation of information means that the reflective practitioner employs multiple methods (observation, interview, content analysis, etc.) and data sources (colleagues, customers, consultants, literature, financial data sheets, documents, etc.) to acquire useful data. During the reflective cycles, the reflective practitioner decides what information is relevant. The third general principle is: “Define a research focus for a particular context and case (project) that creates value.” The research focus directs the design of the questions. In reflective research, the questions are designed to communicate real-world context and in-depth understanding of one or a few practitioners to an audience of academics and colleagues rather than to produce an average of many people’s opinions. Therefore, reflective practitioners cannot formulate relevant research questions without understanding the particular context of the case under consideration.

**The specific principles of real-world research**
Similar to Gendall’s three general principles, our first three principles focus on the questions, wording, and format. The first specific principle is: “Questions are operationalization tools to communicate context and understanding.” As Fowler [24] noted, “a good question … produces answers that are reliable and valid measures of something we want to describe. A bad question … obscures, prohibits or distorts.” Questions need to allow practitioners to communicate context and understanding to other practitioners and academics. The second specific principle is: “Avoid unfamiliar or difficult words; many information-carrying words in one question (this may be difficult in complex scientific environments); words that sound like something else; broad concepts; a qualifying clause at the end of a question; two questions in one; suggestions or leading” In general, keep questions short, simple, and concrete [22], [25], [26], [27], [28]. The third specific principle is: “Questions should follow a logical sequence. Formatting should meet the needs of the real-world context and case first, the needs of the reflective practitioners and the audience second, and those of research methodology and data processors last.” Questionnaires should be designed to make the task of reading questions and understanding the context and case (project) as easy as possible for the audience of practitioners and academics [22]. The fourth specific principle concerns the presentation of results: “Employ the IB model.” The presentation is particularly important to motivate and guide the audience; results need to be presented in a format that is understandable to practitioner colleagues as well as to academics. The intellectual bandwidth model is especially well suited to bridge the practitioner-academic divide [18].

**The purpose of the questionnaire**
In constructing the questionnaire for vertical research, it is important to keep in mind that the intent of the reflective questionnaire is to facilitate knowledge transfer from reflective practitioners to other practitioners and academics. Because real-world (vertical) research differs from horizontal research, questionnaires are designed to report on and document real world phenomena, rather than to gather data from a large number of different people in different situations in order to acquire an average opinion. Real-world questionnaires are designed to cope with the complexity, instability, rate of change, uncertainty, deceptiveness, and incompleteness of information that is typical of real-world situations. The purpose of the reflective questionnaire is to document specific information about a specific real-world phenomenon in a specific context at a specific non-repeatable time or time frame from a specific perspective of somebody who has the most complete access, real insights, and overview concerning the real-world situation under consideration. While academic research usually begins with a description of the problem statement, research purpose, and questionnaire, real-world research recognizes that interesting findings generally result to a large extent from the messiness, complexity, uncertainty, and instability of real-world events [29]. The real-world questionnaire is designed to capture this messiness, complexity, uncertainty, and instability.

3. **Defining Conceptualization, Operationalization, and Measurement**

As noted above, reflective research differs from traditional, more linear research. In the traditional research approach, academics consult the literature, conceptualize their research project, identify an appropriate research methodology for their project, including data collection procedures (operationalization), collect the data (measurement), and perform statistical analysis from which they draw conclusions. In contrast, reflective practitioners engage in a series of conceptualization cycles (see figure 5) that allow them to triangulate and reflect on perceived observational data and to anticipate and react to the constantly changing environment. Reflective practitioners thus consult the real world and employ reflective research to identify what actions might produce the greatest value for the organization. First, they must conceptualize what they have observed. In such conceptualization cycles...
they develop the in-depth knowledge that enables them to understand the real-world situation, identify problems and/or opportunities and ideas regarding “what might be best to do.” In other words, they have identified a relevant case, i.e., a project that might lead to value creation. In order to estimate what value can be created, the reflective practitioner develops a procedure (operationalization), which includes a description of the real-world situation, the process of the project and the proposed actions, and time and resources that have to be allocated. To find out which actions are most likely to lead to the greatest level of value creation, the reflective practitioner measures variations, analyzes the results, draws conclusions, and redesigns and implements the actions. The action of the organization ought to have some measurable impact on the real-world situation, and the reflective research cycle starts again. Here we describe the three phases—conceptualization, operationalization, and measurement—in greater depth.

3.2. Operationalization

Operationalization involves the development of a set of rules and operations that define what to measure and how to measure it (definition of variables and concrete description of real-world setting). It includes decisions about the development of data collection techniques and procedures (e.g., questionnaire) and which representation and communication tools (e.g., intellectual bandwidth model) are to be used. During the operationalization phase, real world events or phenomena that have been selected as relevant are further assessed and rated using various data collection methods in a consecutive reflective cycle. Here reflective practitioners employ quantitative approaches (see Section 4 below) and also triangulate their findings with different data sources (e.g., opinions of customers and colleagues).

3.3. Measurement

Measurement is the act of assigning a value to the object of study during data collection that can also be used in the chosen presentation tool based on rules established in the operationalization process. Measurement allows for the testing of previously defined endpoints of hypotheses and theories, but it does not generally provide reflective practitioners with a new understanding of the events or phenomena under study. In this case, measurement results in absolute or relative quantitative values of the intellectual bandwidth model, which can be used in conjunction with qualitative descriptions. Absolute quantitative values are quantitative measures of actual events or phenomena that are produced by the static reference frame of a mechanical instrument (e.g., stop watch, megabyte of Word file, etc.). Relative quantitative values reflect measurements of actual events or phenomena that are produced by the dynamic reference frame of the human mind (e.g., responses to questionnaires and interviews). These relative quantitative values actually create a qualitative result, because the result is based on the opinion of human subjects [30].

4. A Conceptual Real-World Case Study

In a previous paper, Bach et al. [2] discussed an “end-user information system” (EUIS) that is employed to facilitate value creation. The value creation potential of the EUIS has been conceptualized in the intellectual bandwidth model (IBM). That paper described the EUIS in sufficient detail so that it can be programmed and implemented in practice.

In this paper we focus on the academic side. First, we will discuss features of the IB model; then we will present the case study.
4.1 The Intellectual Bandwidth Model

A description of the IB model has been given in Section 2.2.2 and can be found in Nunamaker et al. [1], [11], Qureshi et al. [31], [32], and Bach et al. [2]. Here we focus on issues concerning the importance of the IB model. The usefulness of the IB model lies in its ability to provide the means to conceptualize and operationalize value creation and to communicate this to others. Whereas technology can significantly improve the volume and speed of information assimilation, collaboration is critical to value creation. Without the human capability to analyze and utilize collected information, value cannot be created. For value creation in complex real-world environments, the development of a collaborative environment and the design of information systems that facilitate collaboration and increase effectiveness of information assimilation systems are essential. The gap between the actual and potential intellectual bandwidth helps reflective practitioners make sense of the IB concept and helps them to conceptualize the possibilities for value creation. The research that can be done with the IB concept juxtaposes two variables in one bandwidth model. While in the IB model the two variables, “collaboration” and “information assimilation,” are juxtaposed, in reflective research, practitioners can combine any two variables. The IB model is essentially a presentation and communication tool, and we can expect that more applications will be developed in the field of reflective research. Measurement in the IB model can be accomplished by employing the reflective research methodology developed in this paper.

4.2 Data collection

This paper presents an exploratory approach that employs reflective research methodology. At this stage of our research we are less concerned with absolute values of measurement and more concerned with the relative value of organizational value creation operationalized in the IB model. In the conceptualization phase information is gathered and reflected on, and the result is conceptualized in the IB model. In the operationalization phase procedures are developed, and results are presented as bandwidth gap (vector) in the IB model. Further discussion on the gap should result in action. In the measurement phase, the value of the gap can be determined.

Data collection techniques employed include participant observation and informal interviews in the pharmaceutical industry. The case study took place over a period of forty-two months. Fifty-nine diagnostic laboratories were visited and one hundred twenty individuals were interviewed. The reflective practitioner was in close contact with five laboratories and fourteen individuals who worked with the HIV EUIS described in Bach et al. [2]. Important data were obtained from discussions with colleagues from various business units and in the research and development department. Information about available technologies was obtained from benchmarking.

4.3 Reflective Questionnaire

The reflective questionnaire was developed according to the theory discussed above. The design of the questionnaire and the answers to the questions are based on the triangulated information on which the reflective practitioner has reflected. Triangulation in this particular case is based on benchmarking and evaluation of available technology and the identification of specific IT, IS (strategy), and IM (management) needs and requirements. The HIV EUIS was developed in one laboratory in order to accommodate the specific needs of the laboratory’s IT environment and people. The in-depth knowledge and experience of a physician in the unique organizational environment and its IT capability enabled him to develop a highly customized information system that was not available on the market. At this point the answers to the questionnaire are based on the reflective triangulated evaluation of a few professionals. The outcome of this step is to concretize particular values that can be measured in a subsequent step of phase three. This should guide the design of further research efforts aimed at increasing organizational performance. The research findings of a study are limited to its particular time, location, and context. The concern of this research step is not to produce reproducible results, but to develop operationalization tools that can lead to verifiable measures.

4.4 Operationalization of a Conceptual Real-World Case Using the IB Model

In this section we operationalize in a quantitative fashion the values of the information assimilation dimension and collaboration dimension of the intellectual bandwidth model. First, the two dimensions are defined for this specific case. The second step involves the development of the reflective questionnaire (see appendix). The questionnaire serves to quantify observational data that is based on in-depth knowledge of a unique real-world situation. At the same time it establishes the context of the observed real-world environment. The third step involves the rating of the questionnaire (tables 1 and 2 in appendix), the calculation of the values (appendix) and incorporation of the numbers into the IB model (figure 6). The final step ends with an explanation of the value creation potential that is presented in the intellectual bandwidth model. This
step has been accomplished in Bach et al. [2]. The impact of possible information assimilation technologies that are seamlessly intertwined [2] and their value creation potential for laboratories of different sizes is operationalized with quantitative measures.

**Definition of the y-axis:** The values of the y-axis, the information assimilation dimension of the extended intellectual bandwidth model, resemble a hierarchy of data, information, and knowledge and are based on the definitions provided by Tuomi [33], Alavi et al. [34], and Bach et al. [30]. According to these definitions, data has no meaning, information has meaning, and knowledge is the processing of data and information in a reference frame of mind. These established definitions serve as guiding principles for defining the technology dimension, where technologies, such as hardware and software, are evaluated for their value creation potential.

The low end of the technology dimension commences with small laboratories that record genomic data on paper files and acquire data through direct communication and manually created paper files. On the next level, data are recorded and acquired in electronic form. High-end labs might add sense-making software that can automatically identify mutations and, in this way, add meaning to genomic data. They store data in local computer files. The next technological step would be a searchable database where laboratories can modify genomic data and can present the data in meaningful self-designed output forms, e.g., search for all patient samples in a particular time period. On the next level, laboratories collaborate in a network where they store genomic data in a central database to which each of them has equal access. The database contains so many samples that it is feasible to cluster identified mutations into categories of irrelevant, relevant, or newly discovered mutations. The accessibility and dissemination of a large amount of data (genomic data) that is updated online and of meaningful information (identified mutations) makes the database valuable and justifies the development of software with sense-making capabilities. Further value creation can be achieved by putting data and information into a larger medical context. Sense making can be considered as an automated reflective process where newly generated mutations are automatically classified as having or not having drug resistance properties. New and unknown mutations are sent to the research laboratories to be evaluated. The evaluation of the results is performed by putting data and information into a reference frame of mind. These calculations serve as guiding principles for defining the technology dimension, where technologies, such as hardware and software, are evaluated for their value creation potential.

All this can be facilitated by existing IT infrastructures (hardware) and product-specific information systems (software). Technology facilitates the described processes, but human input is necessary to convert these steps into a value creation process.

**Definition of the x-axis:** The creation of knowledge and its usefulness in creating value depends on collaboration. The data collected from individuals and small organizations tend to be incomplete, and small organizations do not have the financial resources needed to develop value-adding products. Coordinated and concerted effort is needed to reach the knowledge creation, utilization, and implementation levels, based on the willingness of research institutions and scientists to collaborate (sharing data, information, and knowledge), and to reach the levels between sense making and implementation to achieve maximum value creation.

The calculated values (see appendix) are entered in the IB model.

The description of the case, analysis, conclusion, and actions are described in Bach et al. [2]. The value creation vectors (VCV) symbolize the value creation potential of the HIV EUIS if laboratories of the right size implement the better (upgraded) software.

5. Conclusion

In this paper we have attempted to conceptually demonstrate how the intellectual bandwidth model can be employed by practitioners as a practical tool for data analysis and communication. We contend that the IB model is a flexible research tool that is not limited to the two dimensions of information assimilation and collaboration. Practitioners can employ the concept of the bandwidth model and juxtapose any two dimensions that are important in their unique real-world situation. The important
feature of the IB model that is useful for practitioners is the ability to assess the gap between the actual and potential bandwidth of an organization; this provides the organization with directions on how to create value. The further development of the reflective research methodology is likely to prove not only the usefulness of the IB model but also its capability as a universal research tool to bridge the practitioner-academic gap.

Clearly, it is very difficult to communicate the different aspects of real-world research in one paper. The problem stems from the fact that the research perspective of the first practical oriented paper [2] is completely different from the academic perspective of this paper. However, combining both aspects in one paper would obscure the real-world case and might probably produce what Dyer calls “a distorted picture of reality or no picture at all [20].” We hope that the two papers together demonstrate that the IB model and this approach would equally benefit the practitioner and the academic communities.

6. References


Appendix

Questionnaire for technology dimension

Coding:

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

1.) What degree of communication technology is appropriate for the organizational situation of the lab?

2.) To what degree does the organizational situation enable the lab to utilize technology?

3.) To what degree does the dissemination of information benefit the lab?

4.) To what degree would the implementation of technology have a beneficial impact on organizational performance?

5.) To what degree would the utilization of software increase organizational productivity?

6.) To what degree would technology have a beneficial impact on organizational performance?

7.) To what degree would a data management system that can identify mutations and suggest a therapy regime (sense-making software) increase organizational productivity?

8.) To what degree would knowledge-facilitating software increase the value of the organizational database?

9.) To what degree does the lab have the financial means to implement technology?

10.) To what degree is the organization dependent on technology to handle the amount of data produced during routine operations?

Questionnaire for collaboration dimension

Coding:

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

1.) To what degree is the organization able to contribute crucial amounts of patient samples to a collaborative network?

2.) To what degree is the organization able to contribute assets to the scientific community?

3.) To what degree is the organization able to generate relevant data that supplements the database of a collaborative network?

4.) To what degree does the organization have the flexibility to free personnel to contribute to collaborative efforts?

5.) To what degree are knowledge holders in the organization able to contribute to a collaborative project?

6.) To what degree has the organization the capacity, competence, and flexibility to benefit collaborative efforts?

7.) How important is the knowledge of personnel for collaborative projects?

8.) What level of collaboration is needed by the organization for its research projects?

9.) What amount of data that the organization is likely to produce is important for collaborative research projects?

10.) What is the likelihood that the organization will create new knowledge relevant for collaborative research projects?

11.) To what extent is the organization able to add crucial information to an incomplete data set?

12.) To what extent is the organization able to institutionalize collaborative processes?

13.) To what extent is the organization a supplier of scientific information for other organizations?

14.) To what extent is the organization able to generate and grasp emerging data, dispersed data, complexity of data that is not in the hands of a single organization?

15.) To what degree is the organization through collaboration able to contribute to the completeness of a data set?

Calculation of the specific values of the dimensions

Calculation of values of technology variable (information assimilation dimension in Table 1) for y-axis results in:

<table>
<thead>
<tr>
<th>Technology value</th>
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<tbody>
<tr>
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</tr>
<tr>
<td>Tech2</td>
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<tr>
<td>Tech3</td>
</tr>
<tr>
<td>Tech4</td>
</tr>
<tr>
<td>Tech5</td>
</tr>
<tr>
<td>Tech6</td>
</tr>
</tbody>
</table>

Calculation of values for collaboration variable (human dimension in Table 2) for y-axis results in:

<table>
<thead>
<tr>
<th>Collaboration value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coll1</td>
</tr>
<tr>
<td>Coll2</td>
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<tr>
<td>Coll3</td>
</tr>
<tr>
<td>Coll4</td>
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Calculation of values of technology variable employing reflective questionnaire:

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<th>t2</th>
<th>t3</th>
<th>t4</th>
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Table 1: Values of technology variable on y-axis:

Calculation of values for collaboration variable (human dimension in Table 2) for y-axis results in:

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Table 2: Values of collaboration variable on x-axis: