

# Building Atlas of Knowledge Maps: Towards Smarter Collaboration

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**Abstract:** The paper discusses the possibilities and prospects for creating corporate atlas of knowledge maps – a visual guide of diagrams describing the intellectual assets of the enterprise. The discussed case is based on the university business school. Mapping or visualization provides information transparency of communications in universities making collaboration smart and effective. The walls of universities are opaque, and visualization provide a higher level of teaching, research, consulting and administration. The paper presents the preliminary results of the project “Methodology and technology for developing digital knowledge maps for education and research teams” and proposes and describes specific features of a systematic repository of diagrams, that is called an atlas of knowledge maps. We developed a set of diagrams to describe knowledge, created an ontology of the properties of such maps and suggested considering the most popular ones as a kind of atlas from which decision makers can select relevant maps for their work. The survey is preceded by the use of ontologies - conceptual models of areas of knowledge and professional activities of the teacher. In general, the approach can be adapted to business companies and government organizations if they are interested in disclosing their intellectual capital.

## 1 INTRODUCTION


Business and academic work require cooperation. Learning includes access to influencers and experts. It can be difficult to find colleagues and potential partners in an overloaded world of redundant and contradictory information.


But companies and universities are in no hurry to share their intellectual assets, and often companies themselves do not know about their "treasures". Acquisition and systematization of such information resources are useful primarily for the companies themselves, in addition, they are invaluable in the market. The paper discusses the possibilities and prospects for creating the atlas of corporate knowledge maps - visual guide to the intellectual assets of the enterprise based on the case of a university business school.


Visual knowledge maps are a powerful tool for enhancing understanding and fostering collaboration in a company setting. These maps can be used to

visually represent information, ideas, and relationships in a clear and concise manner, making it easier for faculty and students to grasp complex concepts and share knowledge with their colleagues.

Visualization allows to present complex data and identify patterns, trends, and structures, which facilitates deeper exploration of the data. Diagrams allow all the employees and newcomers to expand less cognitive energy deciphering the meaning of the text they are reading, which means they will have more cognitive energy available for the critically important tasks of understanding, assessment and reflection (Miller 2023, Moody 2007). The main benefits of knowledge visualization are related to: stakeholder engagement, flexibility, knowledge transfer, signalling role, agility and interactivity (Troise, 2022). Using knowledge representation and mapping help to organize the smarter collaboration. The term was coined by H. Gardner (Gardner, 2017) when she described the need for highly-specialised experts to come together in order to tackle more complicated issues than any of them could do on their own.

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The paper discusses some preliminary results of the METAKARTA project (Methodology and Technology for developing digital Knowledge mAs for education and Research TeAms) where we developed the methodology visualizing teaching and research activity of the faculty members.

The paper structure is as follows: the current section 1 provides the motivation for creating a new approach, section 2 presents a brief literature review and highlights the existing research gap, the atlas' attributive ontology design is described in section 3, while section 4 provides a demonstration of this approach in a decision-making process.

## 2 KNOWLEDGE MAPPING

Knowledge maps are powerful information visualization techniques that allow describing knowledge assets, connecting experts, accessing knowledge over time, existing knowledge resources and knowledge gaps (Faisal et al., 2019). The main tools that are widely used in knowledge mapping, require the participation of both experts and analysts who develop visual diagrams reflecting

- Sources of knowledge;
- Location of knowledge elements;
- Owners of knowledge elements;
- Links and relations between them, etc.

Knowledge maps are closely related to competency maps and employee competency management, which are denoted as skills and competencies in corporate decisions (Anthony, 2021). Such maps turn enterprise data into valuable and insightful information. Knowledge maps are one of the tools used in knowledge engineering for organizing and presenting knowledge, forming a graphical framework and landscape in visualizing complex concepts, decision support, knowledge sharing, etc. (Balaid et al., 2016).

However little attention is paid to the development of a well-structured set of visual representations of key concepts, relationships, knowledge owners of a knowledge domain of the organization encouraging the employees to see the big picture, promote collaboration, and improve organization and focus.

The development of knowledge maps starts with the definition of goals and stakeholders. For each level, a basic atlas (visual set) of types of knowledge maps was created.

### 2.1 Definition of Goals

In the field of management, the following goals may be solved using the developed knowledge maps:

- optimization and activation of resources, including the formation of project teams or working groups taking into account the principle of complementarity, ensuring the transfer of knowledge from experts to employees who have gaps (Liebowitz, 2005) (in this case, an employee development plan is formed based on such tools as coaching and mentoring) and strategic planning for the development of assets (Zack, McKeen, Singh, 2009) (based on the analysis of the map for various areas of knowledge, a decision is made to close gaps or change the focus of activity);
- identification of the hidden potential of employees. The principle of completeness, implemented in the construction of ontologies of subject areas, provides a comprehensive analysis and allows for the formalization of those areas of knowledge that were previously not in the field of view when assessing employees. By discovering previously unknown competencies and publications of subordinates, a manager can make a more informed (and therefore less risky) decision about developing new areas of activity (Butt et al. 2021).

### 2.2 A Stakeholder Analysis

Before the knowledge mapping study, a stakeholder analysis was conducted. Stakeholders who influence academic and research teams and benefit in one way or another from access to the knowledge map data may include both external and internal users and can be divided into three categories: managers (administrators), experts, and ordinary employees, including newcomers (Pereira et al., 2023). The METAKARTA project expanded the traditional classification and identified another category: external experts. In modern universities, the roles described above are represented by internal stakeholders: administration (managers), research and teaching staff, including young scientists and postgraduates (experts and ordinary employees). Based on the fundamental differences between these three groups of knowledge map recipients, a classification was proposed at three levels: general, focused, and detailed, as described in previous publications. These three levels in the described case correspond to:

- institution level,
- department level,
- individual level.

The next two figures illustrate school and department levels for shaping the research activity by mapping the bibliometric data extracted from Google Scholar.

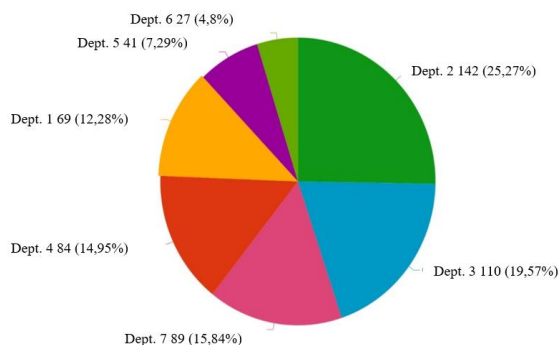


Figure 1: Distribution of all the publications among the school departments.



Figure 2: Portrait of department X.

Figure 1 shows the general level distribution of all the publications listed in the database among the university school departments. Here the information on the percentage of the total amount of publications of the university school departments is stated. That helps to evaluate the more and less active departments in terms of publications.

Figure 2 shows focused and detailed levels of generalization describing a portrait of the faculty from department X and gives the information on the number of publications for each of the faculty members, their H-index, the number of citations of each of the teacher.

### 3 DATA COLLECTION METHODOLOGY

The METAKARTA Project results include visual representations of two information landscapes – teaching and research. The essential part of the project was devoted to data collection.

Bibliometric data was acquired from Google Scholar, while teaching information needs two data processing stages. Two surveys with self-assessment questions were conducted where the faculty assess their teaching competences and expertise. Initially a set of secondary data was used from 2019-2020 larger project initiated as part of the internal self-assessment of the targeted school full-time faculty.

Organization of the data was as follows: each respondent answered a series of binary questions whether they consider themselves as an expert in a particular area of knowledge from the predefined set of ontologies. In case of a positive answer for a particular area a set of questions regarding teaching, research and applied consulting experience followed. Consequently, the dataset was organized in a “matrix” logic – the assessment of experience in each type of activity was carried out for each area of knowledge noted by the employee.

The analysis of results of the first survey helps to prepare the second updated one.

Data for the new questionnaire were collected in the middle of the 2023/2024 academic year from the current full-time faculty of the same school as for the first data collection (all full-time faculty members who teach at least 1 course per year were surveyed). Total sample size was 56 qualified faculty members. The retention rate of the full-time staff between the two datasets was 68.3%, which, provided that the data from the first and second surveys are brought to a single coding, makes it possible to build not only maps reflecting the development of employees, but also maps of changes by departments – a new set of maps that show the dynamics of the internal knowledge.

As a result of the two datasets comparison, we found out that:

Time spent for questionnaire fulfillment decreased by around 30-50% (depending on the number of areas of expertise – the effect was higher for employees with more areas of expertise).

The average number of knowledge areas reported by employees as areas of expertise increased from 2.5 to 3.5, thus providing a more detailed picture of knowledge in specific scientific areas (assessed across employees who participated in two data collections). A random check for deviations showed that, overall,

additional areas of expertise were supported by objective experience existing already by the time of the first data collection, which proves increased data accuracy when a sequential approach is used.

#### 4 AN ATLAS' ATTRIBUTIVE ONTOLOGY DESIGN

Based on the extensive experience in working with questionnaires in social sciences (Aithal & Aithal, 2020) a combination of primary and secondary data was used to the maximum extent possible while the development of knowledge maps for the atlas. It was found that when building knowledge maps based on primary information, there is a risk of obtaining unreliable data. In terms of completeness of information, the optimal solution is to combine primary and secondary data to build knowledge maps. In this case, different implementation scenarios are possible:

- from secondary data to primary (building an employee profile based on secondary data, then verifying this profile by the employee as part of collecting primary data with the ability to additionally collect self-assessment data);
- from primary data to secondary (primary data are verified based on available secondary data - the expertise declared by the employee is confirmed based on available objective information);
- independent assessment of the employee profile - building individual maps based on subjective assessment and secondary data with subsequent generalization on the expert profile dashboard.

Atlas systematizes the significant properties of knowledge maps bringing the connections among them. We borrowed the term from classical definition: Atlas is “a bound collection of maps often including illustrations, informative tables, or textual matter” (Merriam-Webster).

When creating an atlas of knowledge maps that describes modern diagram templates and recommendations for their use, work was carried out to generalize and structurally describe the existing diagrams. Information design in knowledge maps aims to avoid confusion by presenting data in a way that's easy to understand. Based on the study of researchers Lenger and Eppler who compiled a table similar to the periodic table, consisting of more than 100 different visualization techniques, divided by

type of use (Lengler, Eppler, 2007) we include more than 20 visual diagrams into the atlas. Also atlas systematizes the recommendations for their use, it describes modern diagram templates and structurally summarize describe the existing diagrams in a form of a table.

The conceptual representation of atlas may be defined as an attributive ontology (Fig.3).

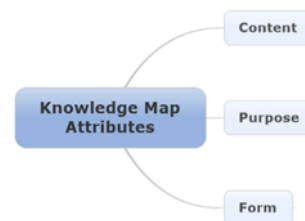


Figure 3: Structure of attriBUTive OnTology of kNnowledge maps: upper level.

The BUTTON Ontology (attriBUTive OnTology of kNnowledge maps) is a generalization and systematic description of various characteristics (attributes) of knowledge maps used to visualize the information landscape of companies and universities. This ontology summarizes many characteristics of knowledge maps into three categories:

- content;
- format; and
- purpose of map.

The format of this conference paper does not allow to show all the BUTTON ontology framework.

Using of the developed atlas create an additional advantage for all its users and the project stakeholders.

## 5 KNOWLEDGE ATLAS

The atlas of the knowledge maps presents systemic vision of possible diagrams that scaffolds the understanding of university intellectual assets from a range of perspectives. The paper tries to provide comprehensive insight into the ways in which university and faculty members visualize their bibliometric and teaching intellectual assets.

### 5.1 Classification Based on Content of Knowledge Maps

The content of knowledge maps plays a key role in determining their effectiveness and applicability in

different contexts. It includes two main aspects: the carrier and the elements of knowledge.

In the context of an educational institution, a carrier (teacher) is an entity responsible for the accumulation, transfer and acquisition of knowledge. The main feature of the attribute "carrier" is its "potential". The potential of the carrier (teacher) reflects his or her cumulative knowledge, skills and experience in certain areas and includes the depth and breadth of the teacher's expertise. The dynamics of the carrier reflect the changes in his potential over time: the teacher's self-improvement, his participation in professional training and education, as well as the continuous updating of knowledge. Relationships between carriers are a network of interactions, exchange of knowledge and experience. This includes various forms of cooperation, such as the exchange of educational materials, joint research projects, etc.

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The knowledge elements on the map include specific learning materials and information elements belonging to the carriers. Elements can be organized into different structures, have priorities, locations, and formats. By the structure of knowledge elements, we understand ways of classifying, organizing and linking individual elements of knowledge to ensure their accessibility and understanding. The structure helps to navigate in the set of knowledge, understand their interrelations and find the necessary information. Knowledge elements are prioritized subjectively by managers and reflect their understanding of the importance and relevance of knowledge components in the context of a particular area or task. Prioritization allows you to identify aspects that should be paid attention to when planning training programs, courses and human resources. The location of knowledge elements includes the geographical location of the teacher (for example, in a branch of the university), the academic unit (department, faculty) and the program.

## 5.2 Classification Based on Format of Knowledge Maps

The shape of knowledge maps is an important aspect of their visual representation, determining the way information is displayed. For knowledge maps, we

have considered graphs, tables, charts, as well as metaphor drawings as shown in Figure 4.

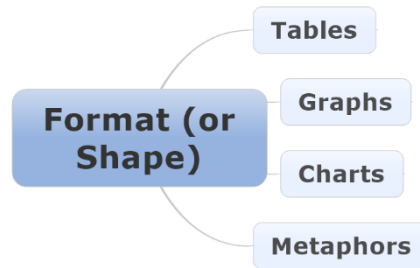


Figure 4: Possible Formats of knowledge maps in the atlas

The atlas is designed in the form of the table with a description of the difficulty level of the diagram, the preview of the pictogram, its design and the main characteristics and purpose. The maps include four major types as shown in Figure 4:

- Tables;
- Graphs;
- Charts;
- Metaphors.

Tables include one-level, multilevel and nested tables as shown in Figure 5.

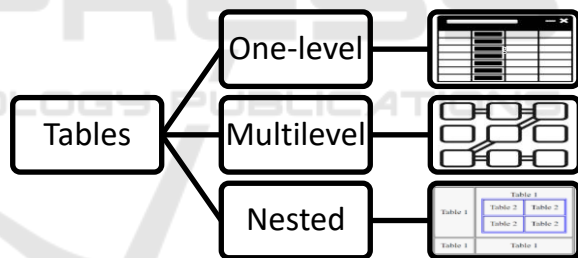


Figure 5: Types of tables in the atlas.

Heat map tables serve graphical representation of data using color and size to encode text tables for easier comparison of data values.

Field of knowledge	Employee 13	Employee 19	Employee 3	Employee 30	Employee 35	Employee 48	Employee 63	Employee 8	Total
B. International Management and International Business						3	4	7	
C. Information Systems and Information Management	4	2	3	4		3	7	5	35
D. Entrepreneurship and Innovation			1						6
E. Marketing and Sales					1		2		3
F. Organizational Behavior and Human Resource Management								1	1
G. Economics, Ecosystems, Markets, and Institutions								4	4
H. Data Analysis and Decision Making Methods				1	3		2		6
I. Urban and Regional Management and Planning				2					3
J. Strategic Management and Organizational Development				5	3				12
K. Operations Management and Project Management						4	1		5
L. Interdisciplinary and Other Fields of Knowledge	5	1	6	3				4	19
<b>Total</b>	<b>9</b>	<b>3</b>	<b>15</b>	<b>13</b>	<b>15</b>	<b>4</b>	<b>14</b>	<b>28</b>	<b>101</b>

Figure 6: A heat map table: overview of one department's knowledge.

The heat map table in Figure 6 presents an overview of the level of expertise of professors in one of the departments of the university based business

school. The collected data in the table presents the coded names of professors (columns) and the corresponding fields of knowledge (rows).

The capacity of the level of expertise of each professor is determined by the sum of spheres of competence within multiple fields of knowledge, which are presented in the corresponding cells.

The resulting table provides an efficient and easy-to-read presentation of the level of expertise of each professor according to their self-assessment.

The table can be used to identify areas of strengths and weaknesses among professors, and to allocate resources more effectively based on each professor's expertise. Further research could explore the relationship between the level of expertise of professors and the quality of their teaching and research outcomes.

There are two types of graphs as shown in Figure 7:

- Hierarchical
- Network undirected.
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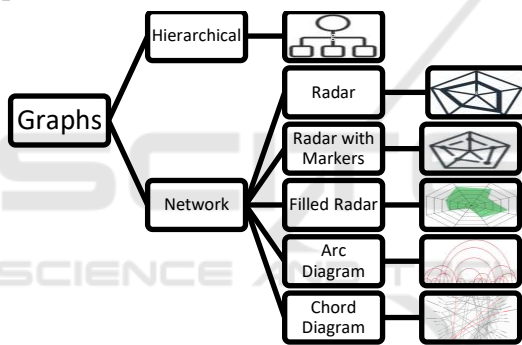


Figure 7: Types of graphs in the atlas.

Hierarchical tree is a graphical representation of hierarchically organized data in the form of a tree.

Network maps include five types:

- Radar - a graphical representation of data in the form of petals, typically used to compare different categories or aspects.
- Radar with Markers - a radar chart where in addition to the petals, markers are also displayed to indicate values.
- Filled Radar – a radar chart in which the areas between the petals are filled with color for better visualization.
- Arc diagram is useful to reveal the overlap of data.
- Chord diagram reveals the relationship between the objects inside the organization.

Charts include one-, two- and three-dimensional ones. Metaphors include images that are used as

universal metaphors to visually organize the information (physical landscape, pyramid, fishbone, etc.)

### 5.3 Classification Based on Purpose

The characteristics of a purpose include

- purpose itself,
- focus,
- stakeholders,
- level of generalization.

The purpose of knowledge maps plays a key role in their creation and can be considered in different contexts, e.g. - decision-making / market positioning / raising general awareness within the company.

"Focus" refers to the main focus of using a knowledge map. Within the framework of the study of the experience of teachers in three areas, the following types of focus can be distinguished: academic work / research / consulting and projects.

Stakeholders in our study include external and internal users. External ones include applicants, business partners and customers who can use knowledge maps to obtain information about the educational institution, projects and employees. Internal users are administration, teachers, researchers and students.

The level of generalization of knowledge maps, which is determined by the purpose and task of mapping, is also important. It can be either universal or specialized. Universal knowledge maps are applicable in various fields of knowledge and disciplines, showing the general picture of what is happening (for example, a faculty science citation map). Specialized knowledge maps can be focused on specific areas or levels, such as faculty, graduate school, department, or individual faculty.

## 6 CONCLUSION

The information space of organizations is overloaded, there is a need to find convenient assistants that facilitate the processing of information for users. The most difficult and labour-intensive part of working with information is associated with its search, structuring, and compression. The visual approach is one of the possible ways to scaffold the information flow.

The paper discusses the developing of the prototype of an atlas of knowledge maps describing the intellectual assets of the university business school. This prototype of the atlas includes invariant

representations of knowledge maps of educational, scientific and consulting activities, depending on the stakeholder, the task itself, the selected level of generalization for mapping (institute/department/individual).

One of the key benefits of using this atlas is that the maps from it help students, faculty and administration see the big picture of the academic life. By mapping out key concepts and their interconnections, employees can gain a better understanding of how different pieces of information fit together, who are the experts and how they contribute to the overall goals of the university unit in teaching and research. This can help employees make more informed decisions and work more effectively towards shared objectives and smarter collaboration.

Systematic analysis of corporate, administrative and scientific knowledge creates the potential to significantly improve the quality of information support, creating knowledge management systems for more effective interaction between various groups of organization employees and external users and stakeholders.

Ultimately, using visual knowledge maps can lead to smarter decision-making, more innovative solutions, and a more efficient and effective company. It is a step to visual organization (Bell, Warren, & Schroeder, 2014).

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