Academic thinking in science Logistics

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DOI: http://dx.doi.org/10.25673/103477

Abstract
The scientific discipline of logistics has existed at universities and colleges for about 45 years and trains young academics for the industry and for logistics tasks in all other areas (e.g., trade, transport, hospital, administration, military. hazardous goods logistics, disaster logistics). Subtly and yet noticeably, logisticians are characterized by a special way of thinking. The task is to make this academic logistical thinking explicit, but not retrospectively, declaratively, but on the state of the year 2023.
This work is intended to contribute to basic research and academic teaching in logistics.
The authors characterize logistical thinking and then provide some guidance accordingly, that can be used, for example, in the analysis, design, optimization, improvement and planning of logistical solutions and have a high degree of general validity.

The research is based on the authors' many years of expertise in the field of Supply Chain Management, Logistics and Material Handling combined with a comprehensive German literature review and the evaluation of current academic education, research projects and trends.

1. Introduction: Logistics - Definitions: Status 2023
The authors propose following definition for logistics, based on [1]:

Logistics is the holistic analysis, planning, management, coordination, implementation, control and improvement of all flows of information, people, goods, finance and energy. In addition to flows, business models, logistical objects, logistical systems and logistical infrastructures are also considered individually and in their interaction.
Supply chain and demand management, the intelligent configuration, planning and control of logistics and value creation networks are an important sub-area of logistics.

In June 2010, the BVL Scientific Advisory Board developed a basic understanding of logistics as a scientific discipline in the form of a position paper [2]. As of 2023, the following recommendations result for updating based on [2]:

- Basic definition of logistics (see above)
- The primary scientific issues of logistics relate to the analysis, configuration, organization, control or regulation and improvement of these networks and flows with the claim of enabling progress in the balanced fulfilment of economic, ecological and social objectives (sustainability). The fulfilment of customer needs sets the objective and dynamic standard. In addition, safety becoming increasingly important.
- In addition to flows, business models, logistical objects, logistical systems and logistical infrastructures are also considered individually and in context.

In addition to this basic understanding of logistics, innovations (e.g., digitalization and networking) and social framework conditions (e.g., Supply Chain Act) have a decisive influence on logistics goals, options for action and solutions. Ten Hompel characterizes, for example, with regard to the trend "digitalization": "Logistics is on the threshold of the Silicon Economy. The complete digitalization of our supply chains and infrastructures with the help of artificial intelligence is without alternative in order to make the mobility of people and goods sustainable and to achieve our climate goals." [3] In [4], exemplary research questions are raised in relation to Logistics 4.0. In [5], the effects of current trends on logistics are listed and characterized.

2. Characterizing logistics as a science

Note: This paper cannot and does not refer in detail to the philosophy of science. (Cf. e.g. [6] for more details).
First of all, the term "science" is defined by Bendel [7] as follows: "Science aims at gaining knowledge (research) and imparting knowledge (teaching), using recognized and valid methods and publishing or incorporating results. In a certain sense, it is unconditional and open-ended."
For the establishment of logistics as an applied science, the examination of relevant characteristics is necessary. (Cf. [2] [8] [9] [10] [11])
Sciences are primarily distinguished by their object of knowledge. The goals of knowledge and the use of recognized research methods are also frequently mentioned. (Cf. [12])

1. Objects of knowledge in logistics are:

- Flows in networks [2]
- Logistical business models
- Design of the life cycle of logistical objects
- Design of the life cycle of logistics systems including networks as MTO systems
- Design of the life cycle of logistics infrastructures
- Linking the design objects to logistics solutions
- Academic qualification and training of logisticians

2. The knowledge goals of logistics are the discovery and formulation of model solutions, laws, rules, theories and hypotheses concerning the objects of knowledge.
3. Important research activities and research methods in logistics are in extension of the logistics definitions (Cf. [13]):

Perceive, inform, describe, invent, analyze, model, plan, optimize, improve, explain, perform, evaluate, reflect, recognize and decide.

In addition, there are a number of other indicators (e.g., social, economic and ecological relevance, specialist language, own scientific community and career structures, own scientific teaching at universities and colleges, number and quality of doctorates and habilitations as well as recognized academic publications and media) that prove the existence of a science, which cannot and should not be discussed in depth here.

The thesis is put forward that logistics as a science is characterized by a specific type of thinking by which it can also be designated, other examples being e.g., mathematical thinking or economic thinking. In addition to a variety of general types of thinking that are available to all disciplines as a repertoire, some types of thinking and models of thinking are particularly required and promoted by an individual scientific discipline. In addition, individual models of thinking are developed and used to solve typical thinking tasks. The research gap is to make this logistics thinking explicit.
Following John H. Flavell [14], this is called metacognition, "thinking about thinking itself" and is applied to the science of logistics. "This ability to control, monitor and organize one's own thinking, or to correctly classify memories, perceptions and decisions, and to reflect on and evaluate them, can help people make better decisions, formulate achievable goals, but also clearly recognize strengths and weaknesses." [15]
The concrete research questions are:

1. How does/should an academic logistician think?
2. What are important models of academic thinking in logistics?
3. How should academic thinking be trained in logistics?

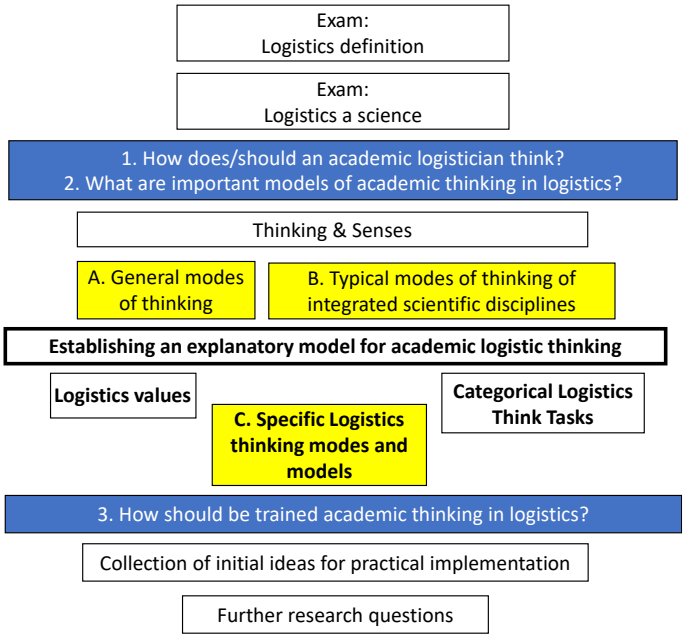

Figure 1: Systematic approach to research

3. Methods

The research is based on the authors' many years of expertise in the relevant scientific field combined with a comprehensive literature review, the evaluation of current academic education, research projects and trends.

A systematic approach with focal points was formulated. (Fig. 1) The starting point is first to look at the concept of "logistics" and "logistics as a science" (cf. bullet points 1 and 2 and Fig. 1). Subsequently, the term "thinking" is defined.
In order to characterize the types of thinking, three approaches are to be applied (marked in yellow):

A. General ways of thinking that are available to all people.
B. Typical thinking of other sciences used in Logistics. (Types of thinking that are primarily used by logistics as an interdisciplinary science. Here the limitation should be on typical ways of thinking, a logistician would call them "A ways" of thinking.)
C. Special "logistics maps". This raises the question of the special nature of logistics.

As an aid, an explanatory model for logistical thinking is to be described and categorically filled with reference to logistics. These thinking aids are to be designed openly and can be used as a kind of checklist.

Once the explanatory model has been used to qualitatively describe logistic thinking, the task is to derive ideas and approaches for academic education and training.
Open questions are derived from the documented state of knowledge, which can and should be addressed through further research.

The chosen, systematic approach (Figure 1) is methodically underpinned in the following:
Preparation of own expert knowledge (thinking, questioning, documentation)
Analysis of existing publications on:

1. Thinking and senses (literature analysis)
2. General ways of thinking (literature analysis)
3. Typical ways of thinking of other scientific disciplines relevant to logistics
   (Thinking, expert survey, documentation)
4. Explicit research on logistic thinking (thinking, literature analysis, expert knowledge)

The literature analysis carried out can be characterized as follows:
Language: German
Search Terms:
Denken; Sinne; Denkart;
Denkart + Wissenschaftsdisziplin;
Logistikdenken, Logistisch* Denken,
Denken in der Logistik, Denkmodelle der Logistik
Period: 1990 - 2023
Search locations: Google Scholar, SpringerLink, ResearchGate

Explanatory model: Conceptual research work
Ideas for training senses and logistic thinking: creative research work
In terms of novelty, this research builds on existing knowledge. The intended added value is to reflect logistic thinking at the level of 2023 and to provide guidance for targeted academic training.

4. Results and Discussion

4.1. Status: Thinking and sense

"Thinking is the processing in the brain of information perceived by our body and its sense organs." [16]
It can be roughly divided into three phases:
Sensory impressions that initiate and accompany thinking processes, the actual thinking processes and the thinking results.
Thinking processes are thus initiated by one and/or more sensory perception(s).

While in other scientific disciplines, e.g. the sense of smell (chemistry), the sense of touch (medicine) and the sense of taste (food technology) also play a role in academic education, the sense of sight (perception of the scene, environment, images, photos, animations, videos, reading) and the sense of hearing (spoken word, sounds, tones) are particularly relevant for academic logistics of the five basic senses.
For further information in this area, we refer to the explanations on mechanisms of perception on [17].
Accompanying the thinking process, communication and further information gathering can take place. Individual personality types and thinking styles are not considered in this publication.
As a finding, the following tasks arise:

- to learn to see logistically
- to listen logistically with the best possible understanding, and
- to communicate with others.

4.2. Stand: common thinking models

The following Table 1 is the compilation of an open list of general features to characterize thinking. They are referred to as types of thinking, whereby actually every thinking process has several of these characteristics. In this sense, the characteristics are more descriptive than delimiting or classifying.

Table 1: State of knowledge on logistics-relevant, general types of thinking [18] [19] [20} [21]

Aspect	Examples
Conscious-ness	conscious, ~~preconscious~~, ~~unconscious~~
Logic	logical, dialogical, causal-logical, final-logical analogical ~~paralogical, counterfactual~~, lateral
Thought process step	discursive (in steps of thinking), argumentative, ~~intuitive (by leaps and bounds)~~
Reference	narrative, pictorial, analogue, associative
Abstract--ness	abstract, concrete
Science reference	~~psychological, theological~~ technological, ecological, biological, sustainable **logistical,** technical, economic, informatic, mathematical, legal, sociological academic, non-academic, pragmatic, empirical, heuristic Interdisciplinary, monodisciplinary, transdisciplinary
Cultural circle / Region	occidental, western, ~~eastern~~ global, regional
Belief	~~ideological, christian, jewish, islamic, atheistic~~
Time reference	operational, tactical, strategic, visionary retrospective, present-orientated, forward-looking Life cycle (idea, development, construction, commissioning, use, dismantling/disposal)
Emotio-nality	~~emotional~~, ~~intuitiv~~
Complete-ness	holistic, incomplete
Rationa-lity	rational, irrational
Structure	linear, causal, networked, control loop-based (cybernetic), case-by-case, complex
Direction	analytical, synthetic inductive, deductive, discursive vertical, lateral
Quality	quantitative, qualitative reproductive, productive
Basic setting	idealistic, optimistic, pessimistic, realistic
Practical relevance	theoretical, practical
Gender reference	~~male, female, diverse, gender-independent~~
Flexibility	flexible mindset, changing mindset, inflexible mindset
Criticism	critical thinking ~~uncritical thinking~~

In Table 1, the types of thinking that are not relevant to the academic training of logisticians have been marked with a cross out.

In the following, a literature source will be presented and discussed as an example. This is not done in full in order not to go beyond the scope of the paper. The International Center for Studies in Creativity distinguishes seven types of thinking in relation to creativity [22]:

- Visionary thinking (ideal state)
- Strategic thinking (concrete direction)
- Tactical thinking (concrete action)
- Contextual thinking (environment, supporters & threats)
- Diagnostic thinking (facts & open questions)
- Thinking in ideas (4 principal options [22])
- Evaluative thinking (assessing quality and feasibility).

After evaluation and classification, the following statements emerge:

1. Visionary, strategic and tactical thinking: These types of thinking have already been listed under the general "types of thinking under time reference".
2. Analytical (diagnostic) thinking also belongs to the general types of thinking.
3. A contextual reference must be established in every thinking process and is thus fundamental and not specific.
4. Thinking in ideas is generally called creative thinking. This is what is actually specific.
5. Every thinking process should reflectively evaluate the thinking and the thinking results. This is also more general.

From Table 3, it can be deduced that these general types of thinking are available as broad thinking options alone or in almost any combination. They thus form the general basis of the logistician's thinking. In order to generate a broad repertoire, many types of thinking should be required and made conscious in the training of logisticians.

4.3. Status: Sciences relevant to logistics and their typical way(s) of thinking

Logistics is characterized as an interdisciplinary scientific discipline. This means that it synergistically uses different perspectives from other scientific disciplines. Table 4 names scientific disciplines that are important for logistics. Exemplarily, the respective, salient, science-specific thinking is characterized. This is based on expert knowledge from the authors' point of view. These properties are referred to as characterizing properties because they are characteristic of the individual scientific disciplines, which does not mean that all the other types of thinking listed in Table 1 are not also (frequently) used.

Table 2: Sciences relevant to logistics and their typical way / ways of thinking

Science	Typical thinking
Mathematics Statistics, Stochastic, Logic	analytical logical infer
Physics **Mechanics**	dynamic movement & flow-oriented
Science	**Typical thinking**
Economics	economic model-based time-related (visionary, strategic, tactical, operational life cycle)
Engineering (general) Construction Production engineering Traffic engineering Material flow technology Electrical engineering Electronics Systems Engineering Automation Technology Environmental Technology Energy Technology Safety Engineering Maintenance Materials technology	creative analytical critical systemic systematic reflective flexible practical
Labour Science **Ergonomics**	human-centered ergonomic
Cybernetics	control loop based
Informatics	algorithmic
Law	contextual evaluative
Organizational Sciences	structural process-oriented
Social science	dialogical communicative
Artificial intelligence	artificial mechanical

4.4. Explanatory model: Logistical thinking

An explanatory model of logistical thinking was developed from the experiential knowledge of the logistics experts involved, supplemented by the results of the initial literature studies (Figure 2). It will be explained in the following:

Figure 2 sets up a triangular framework of thinking that includes:

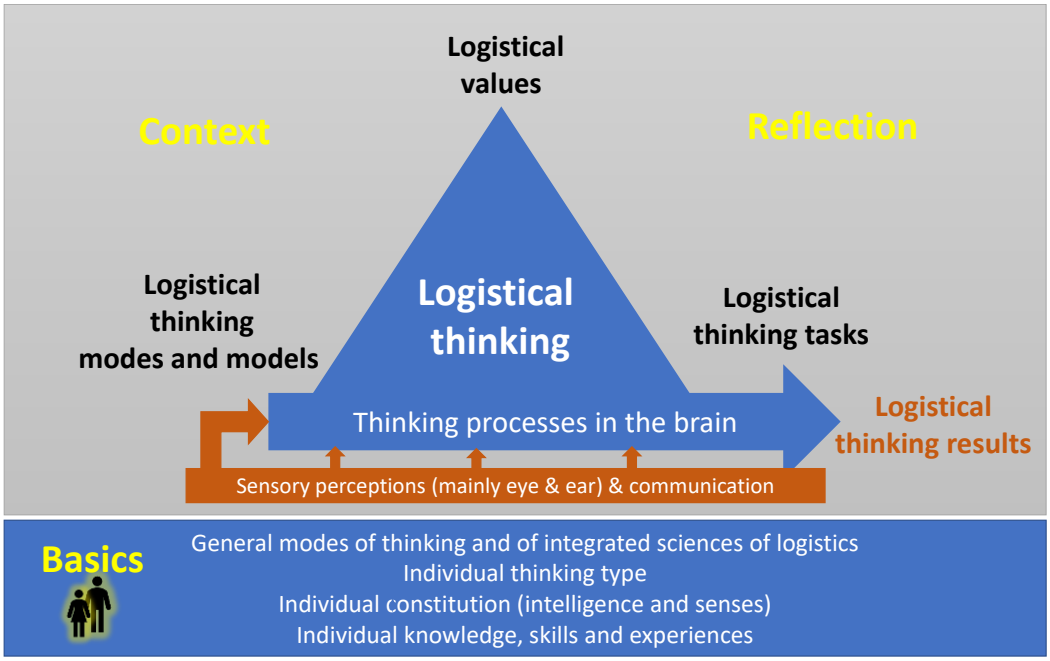

Figure 2: Explanatory model of academic logistical thinking

1. the quality criteria (value measure)
2. the appropriate logistics thinking maps, which are due to interdisciplinarity, are supplemented by types of thinking and thinking models of relevant scientific disciplines and
3. the application reference in the form of typical logistics problems & tasks.

This results in a network of possible thoughts and thought processes. Logistical thinking always establishes contexts. This concerns e.g. allocations, obstacles and promoters. These contexts concern both the values, the tasks and the appropriate thought models, as well as the solutions worked out through the thinking process. This in turn indicates that the same thinking constellations can and will lead to different solutions in different contexts. Reflection is equally important for the evaluation of the thinking process and results.

4.5. Results of the literature review on logistic thinking

At all colleges and universities that train and educate logisticians, the question of how academic, logistical thinking can be taught and trained is addressed consciously or unconsciously. A rough review of German-language logistics literature revealed that many academics look to the past and explain the logistical thinking of past decades. This view of the past is deliberately not taken here. From the authors' point of view, it is more important to deal with the logistics of the present 2023 and the near future (until 2030) and beyond.

The following summarized findings regarding current logistical thinking emerge from the literature review (selection):

Basic understanding of logistical thinking:

"Logistical thinking and action are in demand today in all industrial, commercial and service companies and state institutions and authorities." [32]

What is needed is ... "a new way of thinking about logistics, a paradigm shift away from reduced thinking about transport, transshipment and warehousing to an approach of holistic consideration and shaping the future - not only in relation to the logistics industry, but to the economy and society as a whole.

Competitiveness and quality of life in many areas are largely dependent on the performance of logistics. Logistics can and must therefore assume even greater responsibility in the future than it has in the past - in an economic, ecological and social sense." [29]

Important ways of thinking and characteristics of logistical thinking are:

- **Flow-oriented** (flow principle and flow perspective); "Structure follows Process [30] [31] [33] [37] [38] [40] [42] [43] [46]
- **Value chain thinking** [27] [28] [29] [37] [45]
- **Life cycle thinking** [29] [43] [45]
- **Customer perspective, competition and service thinking** [29] [31] [33] [35] [36] [37] [40] [43] [45] [46]
- **Society orientation** (stakeholder management) [29] [45]
- **Functional optimization** (resource orientation) [31]

- **Technical-economic thinking**
  - Total cost thinking [33] [43]
- **Systems thinking** [30] [31] [38] and **networks thinking** [33] [42] [43] [49]
- **Organizational task and thinking** [30] [36], **coordination** [31]

- **Holistic** [23] [26] [30] [32] [36] [40] [44] [46]
- **Interdisciplinary** (but also monodisciplinary and transdisciplinary) [44]
- **Integrative** [30] [38]
- **Time related:**
  - **Time factor** [30] [38] [40] [46]
  - **3 Levels of time, thought and action** of the management: normative, strategic and operative [41]
  - **Future-oriented** [39]
- **Complex** [49]
- **Analytic** [36]
- **Critical** [48] includes: Changing perspectives, asking questions, contextualization, open discourse, listening, reading, writing as thinking [48]
- **International** [36]
- **AI-based, integrated** [47]

The presentation of further realized evaluations is not included here.

4.6. Ideas of logistical thinking

The following open lists of values and tasks are generated to support Figure 2.
Examples of typical logistics values are:

- Quality-oriented
- Effective
- Sustainable (efficient, ecological, social)
- Safety & secure,
- Fast
- On time
- Holistic
- Resilient
- Digital & networked
- Transparent
- Innovative
- Integrative
- Weighing
- Flexible
- Law, compliant
- Simple
- Realizable
- Adaptive
- Scalable

and many other more.
The values can be used for:

- Goals
- Options for thought and action and
- Evaluation variables for the results.

Table 3 lists categorically important thinking tasks in logistics as an open list.

Table 3: Important thinking tasks of Logistics (Ex.)

Thinking tasks	O	P	S	I
Recording and assessing the situation	x	x	x	x
Identify and describe problems & tasks	x	x	x	x
Thinking about goals	x	x	x	x
Design solution, calculate (estimate/calculate), design and plan	x	x	x	x
Practical, implementation oriented	x	x	x	x
Analytical, improving, optimizing	x	x	x	x
Generating new ideas	x	x	x	x
Generating variants	x	x	x	x
Critical thinking (cf. [48])	x	x	x	x
Reflect (cf. [31])	x	x	x	x
Developing visions	x	x	x	x
Decide	x	x	x	x

Explanation: O = Object; P = Process; S = System; I = Infrastructure

The crosses in the columns prove that all tasks actually exist.

4.7. Ideas to create and train logistical thinking

In the following, the third research question, how to develop and train logistic thinking, will be answered. Table 4 contains a first collection of ideas for training the senses.

Table 4: Training the senses for science Logistics

Sense	**Training approach**
Sense of sight	Learning to see logistically
Sense of hearing	Logistic understanding Practice listening
Reflect sensory impressions	Practice reflection

Table 5 contains initial ideas on logistical thinking.

Table 5: Developing logistical thinking

Metacognition	**Addressing and developing logistical thinking**
Explanatory model (Figure 2)	Communicate and use the explanatory model
General models of thinking (Table 1)	Design training tasks, that allow the use of a variety of thinking styles

	Reflect on the completed thinking and the quality of the thinking results together with the students
Logistical tasks	Know and recognize logistical tasks; Train assignments to thought models
Context	Make people aware of the context and practice it: Values - context Tasks - context Models of thinking - context Solutions - context
Logistical thinking models	Know and master these science-typical categorical models of thinking. (open list)
Logistical values	Know current logistical values Know or develop options for action Derive and use qualitative and quantitative valuation parameters

5. Conclusion and Limitations

What are the most important results of the research?

- The concept of logistics was modified, expanded and sharpened.
- The self-conception of logistics as a scientific discipline was briefly characterized and confirmed.
- The relevant senses as triggers of thought processes in logistics were identified.
- A selection of logistics-relevant ways of thinking (general, science-specific and logistics-specific) was made, that offers a variety of potential thinking alternatives.
- An explanatory model for academic logistical thinking was established:
  - It includes a triangle of values, task and ways of thinking.
  - In addition, context setting and reflection are very important.
  - The thinking triangle is based on individual thinking prerequisites. (Cf. Fig. 2)

To underpin the explanatory model of academic logistical thinking, exemplary lists were drawn up. Ideas were collected on how relevant senses and logistic thinking can be specifically promoted and trained in academic education and training. (Cf. Tables 4 and 5)

Methodological alternatives are:

Regarding the type of literature analysis:

- Extension of the language area
- Extension of the relevant databases
- Modification and altered combination of search terms
- Deepening the knowledge of related sciences.

As an alternative to the literature analysis and the expert knowledge of the authors, other logistics experts (national, international) could be interviewed and their views compiled, for example. In this sense, the results published initially in this paper represent a starting basis that should and must be discussed, supplemented, expanded and modified.

Although the evaluation is still pending, the research results could be evaluated against the following criteria using the following methods:

- Accuracy (verification)
  through expert consultation and scientific discussion,
- Correct setting/selection of priorities
  through expert consultation and scientific discussion,
- Sufficient completeness
  through expert consultation,
- Comprehensibility
  through survey of students
- Unambiguity
  by interviewing students
- Applicability (validation)
  by means of logistic case studies and
- Usefulness
  through interviews after application.

The limitations lie in the knowledge and experience of the authors. Opportunities exist in the publication of the results and their direct incorporation into the academic training of logisticians, thereby raising awareness and promoting logistical, systematic thinking. The explicit aim is to increase both the quality of the thinking process and the quality of the results.

What are the next steps in the research project?

Professional discussion and reception as well as processing of professional criticism.

Completion of the open lists of relevant values, problems & tasks and models of thinking.

Development of a sample table on essential criteria for contexts.

Elaboration of a list of questions for reflection on logistical thinking

Development of suitable thinking tasks for academic education and training.
Extension of the methodological approach to the various application areas
An exploitation perspective for the research (business case, product, service, technology etc.) is the following:
Inclusion of a chapter on "Logistical Thinking" in the book "Fundamentals of Logistics".
Making the paper available and publicizing it in other countries (e.g. Austria, France, Italy, Slovakia, Hungary, Ukraine, Cuba).
Share the paper at the BVL (German) and the ELA (German and English).

Examples of further research questions are:

1. How to categorize the problems and tasks of logistics?
2. How can logistical values, potential courses of action and key figures be systematically and clearly linked?
3. Theorizing logistics: what are, for example, the most important theories, laws, hypotheses of logistics?

True to the principle: "If you go with the flow, you go down the drain", this research paper wants to leave the mainstream and provide some new insights. We look forward to the critical, professional discussion!

6. Use of the findings for doctoral students

For doctoral students, in addition to the possible self-reflection of the thinking process, the following special follow-up possibilities of the results achieved are offered:

1. Conscious training of the senses "seeing" and "hearing" on the acquisition of data and information relevant for logistics.
2. Use of the compiled scientific disciplines relevant to logistics as potential evaluation aspects (checklist of table 2) of one's own research work
3. Helping to describe the scientific task & problem in terms of:
   - Values: objectives, options for action, evaluation criteria, results.
   - Categories of the task and classification of the research task (table 3)
   - Consideration of the context of research
   - Use of ways of thinking to compile a most suitable approach (potential solutions and their evaluation) by using tables 1 and 2 and the collection of logistical thinking.

7. References

[1] Bundesvereinigung für Logistik (BVL): Logistikdefinition https://www.bvl.de/service/zahlen-daten-fakten/logistikdefinitionen 16. March 2023

[2] Bundesvereinigung für Logistik (BVL): Delfmann et.al.: Positionspapier zum Grundverständnis der Logistik als wissenschaftliche Disziplin in: Flexibel – sicher – nachhaltig, Thomas Wimmer, Tino Grosche (Hrsg.): DVV Media Group GmbH, Hamburg, 2011, S. 262-274 https://www.bvl.de/positionspapier

[3] Quote Michael ten Hompel in Delfmann, W. u.v.a. (2021): Positionspapier der Bundesvereinigung Logistik 2021: Logistische Leistungen und Lösungen sind entscheidend für die Zukunft von Wirtschaft und Gesellschaft in Deutschland https://www.bvl.de/positionen

[4] Delfmann, W.; Kersten, W.; Stölzle, W.; ten Hompel, M.; Schmidt, T.: Logistik als Wissenschaft -zentrale Forschungsfragen in Zeiten der vierten industriellen Revolution Positionspapier des Wissenschaftlichen Beirats der Bundesvereinigung Logistik (BVL) https://www.bvl.de/positionspapier-logistik40

[5] Glistau, E.; Coello Machado, N.; Trojahn, S.: Logistics 4.0 - goals, trends and solutions. In: Advanced logistic systems - Miskolc: Univ., Bd. 16 (2022): 1, S. 5-18

[6] Helfrich, Hede: Wissenschaftstheorie für Betriebswirtschaftler. Wiesbaden: Springer Gabler 2016. S. 3-4)

[7] Bendel, O.: Definition: Was ist „Wissenschaft“? https://wirtschaftslexikon.gabler.de/definition/wissenschaft-100061

[8] Jobst, E. (1968): Spezifische Merkmale der technischen Wissenschaft in ihrem Wechselverhältnis zur Naturwissenschaft. Deutsche Zeitschrift für Philosophie, 16(8), 928-935.

[9] Diemer, A., & König, G. (1991): Was ist Wissenschaft? Technik und Wissenschaft, 3-28.

[10] Klaus, P. (2009): Logistics research: a 50 years’ march of ideas. Logistics Research, 1(1), 53-65.

[11] Mols, M. (2001): Politik als Wissenschaft: Zur Definition, Entwicklung und Standortbestimmung einer Disziplin. Politikwissenschaft: Eine Einführung, 3, 25-66.

[12] Thommen, J.P. Erkenntnisobjekt. Gabler Wirtschaftslexikon. https://wirtschaftslexikon.gabler.de/definition/erkenntnisobjekt-36144/version-259609

[13] Trojahn, S.; Dittrich, I.; Findik, R. (2022): Grundlagen der Logistik. Theorie und Praxis logistischer Systeme. 5., vollständig aktualisierte und erweiterte Auflage. Huss Verlag. ISBN 978-3-949994-07-4 (Buch): S. 31-34
[14] Flavell, J.H. (1979) Metacognition und cognitive monitoring: A new area of cognitive – development. inquiry American psychologist 34 (10): 906
[15] Begriff Metakognition https://lexikon.stangl.eu/4068/metakognition Online Lexikon für Psychologie & Pädagogik
[16] Hoyer, H.G.: Das Falschdenkersyndrom. Warum wir Menschen zwangsläufig falsch denken und was wir tun können, das möglichst abzustellen. Springer Sachbuch. ISBN: 978-3-658-32864-1; ISBN 978-3-658-32865-8 (eBook): https://doi.org/10.10007/978-3-658-32865-8
[17] Pinel, J. P. J., Barnes, S., Pauli, P.:(2018): Biopsychologie. 10. aktualisierte und erweiterte Auflage.Print-ISBN: 978-3-86894-343-6. E-ISBN: 978-3-86326-834-3. Seiten: 736. Sprache: Deutsch
[18] Denkarten www.zentrum-systemisches-denken.de/denkarten
[19] Denkarten: Dorsch, F.: Psychologisches Wörterbuch: Testverzeichnisse und Testerklärungen. 7. Auflage 1963, S. 69-71
[20] Denkarten www.muellerscience.com Verweis auf Paul Lorenzen 1965
[21] Harrison, A. F., Bramson, R. M. (2002): The Art of thinking. The classic Guide to increasing Brain Power. Berklay. 240 S.
[22] 7 Arten des Denkens in der Innovation. International Center for Studies in Creativity creaffective GmbH München. https://www.creaffective.de/2017/11/sieben-arten-des-denkens-innovation/ 20.03.2023
[23] Sauerbrey, G. (1991): Logistisch denken. Gabler, Wiesbaden.
[24] Müller-Steinfahrt, U. (2006): Diffusion logistischen Wissens, Denkens und Verhaltens in Großunternehmen. Kölner Wissenschaftsverlag.
[25] Fleischmann, B. (2018): Begriffliche Grundlagen der Logistik. Begriff der Logistik, logistische Systeme und Prozesse, 1-16.
[26] Lange, V. (1994): Logistische Konzepte-Großes Potential. publica.fraunhofer.de
[27] Bergmann, L., & Lacker, M. (2009): Denken in Wertschöpfung und Verschwendung. Modernisierung kleiner und mittlerer Unternehmen: Ein ganzheitliches Konzept, 161-168.
[28] Matyas, K. (2022): Instandhaltungslogistik: Qualität und Produktivität steigern. Carl Hanser Verlag GmbH Co KG.
[29] Lehmacher, W. (2013): Wie Logistik unser Leben prägt: Der Wertbeitrag logistischer Lösungen für Wirtschaft und Gesellschaft. Springer-Verlag.
[30] Bretzke, W. R. (2010): Logistische Netzwerke. Berlin: Springer
[31] Lasch, R. (2018): Strategisches und operatives Logistikmanagement: Prozesse. Wiesbaden: Springer Gabler.
[32] Wehking, K. H. (2020): Technisches Handbuch Logistik 1. Fördertechnik, Materialfluss, Intralogistik. Berlin. Heidelberg: Springer Vieweg.
[33] Engelsleben, T., & Niebuer, A. (1997): Entwicklungslinien der Logistik-Konzeptionsforschung (No. 93): Working Paper.
[34] Klaus, P. (1993): Diffusion und Implementation strategischer Logistikziele—durch „Target "-Controlling?. Logistik-Controlling: Konzepte—Instrumente—Wirtschaftlichkeit, 59-71.
[35] Heiserich, O. E. (2002): Grundlagen der Logistik. Logistik: Eine praxisorientierte Einführung, 1-24.
[36] Müller-Steinfahrt, U. (2004): Der Mensch in der Logistik. Entwicklungspfade und Meilensteine moderner Logistik. Skizzen einer Roadmap, Wiesbaden.
[37] Heinimann, H. (1999): Logistik der Holzproduktion - Stand und Entwicklungsperspektiven. Forstwissenschaftliches Centralblatt vereinigt mit Tharandter forstliches Jahrbuch, 118(1): 24-38.
[38] Bretzke, W. R.(2020): Begriff, Aufgaben und Bedeutung der Logistik. Logistische Netzwerke, 3-26.
[39] Göpfert, I. (2022) Logistik der Zukunft - Logistics for the Future. Springer Fachmedien Wiesbaden GmbH. https://doi.org/10.1007/978-3-658-37444-0_2
[40] Wegner, U., Wegner, K.,(2017): Logistik als Management-Aufgabe. Einführung in das Logistik-Management: Prozesse–Strukturen–Anwendungen, 1-15.
[41] Pfohl, H. C. (2021): Management der Logistikfunktion. Logistikmanagement: Konzeption und Funktionen, 23-48.
[42] Doborjginidze, G. (2005): Auswirkungen der Entwicklung von innovativen Logistikkonzeptionen auf die mittel- und osteuropäische Verkehrswirtschaft. Analyse der Entwicklung intermodaler Logistik-

Netzwerke in mittel- und osteuropäischen Ländern, 150-154.
[43] Pfohl, H. C. (2018): Charakterisierung der Logistikkonzeption. Logistiksysteme: Betriebswirtschaftliche Grundlagen, 23-50.
[44] Fleischmann, B. (2018): 1.1 Logistikbegriff. Begriff der Logistik, logistische Systeme und Prozesse, 1. Books.google.com
[45] Lehmacher, W. (2013): Die Welt der Logistik. Wie Logistik unser Leben prägt: Der Wertbeitrag logistischer Lösungen für Wirtschaft und Gesellschaft, 1-38.
[46] Lasch, R. (2021): Grundlagen der Logistik. Strategisches und operatives Logistikmanagement: Prozesse, 1-28.
[47] Gethmann, C. F., Buxmann, P., Distelrath, J., Humm, B. G., Lingner, S., Nitsch, V. & Spiecker genannt Döhmann, I. (2022): Künstliche Intelligenz in der Forschung: neue Möglichkeiten und Herausforderungen für die Wissenschaft (p. 179): Springer Nature.
[48] Graf, S.; Wieser, A., Buff Keller; E. Überfachliche Kompetenz: Kritisches Denken. Unterlagen entwickelt im Zuge der Studiengangsinitiative Raumbezogene Ingenieurwissenschaften. ETH Zürich, Departement Bau, Umwelt und Geomatik. https://doi.org/10.3929/ethz-b-000458785
[49] VDI Verein Deutscher Ingenieure 2019: Analytisches Denken, Systematisches Denken, VDI Verlag GmbH. Online: https://www.ingenieur.de/karriere/schluesselqualifikationen/analytisches-denken-systematisches-denken/ [29. Juli 2019]

Further reading recommendation:
Spitzer, M.; Herschkowitz, N. (2020): Wie wir denken und lernen. Ein faszinierender Einblick in das Gehirn von Erwachsenen. mvg Verlag.
1. Auflage