Allow Knowledge to Prevail: All-scientists Sustainable Contributions to Multi-disciplinary Scientific Insight, from Prehistory to Future

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Research

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Senior Scientist and Senior Lecturer Information Science, Security, and Computing at Leibniz Univ. Hannover; IARIA Fellow.
This talk addresses theoretical and practical aspects of systematical and methodological views on knowledge in science and academic contexts.

The goal is a base for a fundamental understanding of knowledge and its complements for sustainable employment by all scientists and domains, gaining multi-disciplinary insight, targeting even complex multi-disciplinary scenarios like knowledge integration and coherent conceptual contextualisation.

This talk provides essential information about the fundamental knowledge complements and component frameworks and delivers references to publications and created implementations and realisations.

Examples integrate many disciplines and domains, e.g., information science, natural sciences, geology and geophysics, prehistory, archaeology, social sciences, humanities, geography, and geoinformatics.

Future research will address the continued creation and further development of aforementioned reference implementations and component frameworks.
Introduction and Motivation

- **Advances:**
  Very little advances in ... computing, data related disciplines, documentation and reuse of experience, using classification and related methods, ...

- **Common Views:**
  Very loosely coupled perspectives, synonymously used terms and concepts, little holistic understanding.

- **Awareness and Practice:**
  Who is currently really practicing or considering all best practice, standards, holistic views, and approaches together in an integrated way?
Questions

Content First.

But:

- How comes that everything is said to be “content”?  
- If “data” is used as synonym for “content”, what does that mean?  
- Considering the statement “If you torture the data long enough it will eventually confess.” (Ronald Harry Coase), what can you do that “data” cooperates and supports you on a voluntary, constructive base?
- In what way do data, information, knowledge . . . contribute?
- Why are data and content isolated from context, methods, . . .?
- In what way does the startup view contribute to sustainability?
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Entities

Entities in use

- **Data:**
  Big data, research data, information, ...

- **Classification:**
  Universal Decimal Classification (UDC), Library of Congress Classification, ...

- **Computing:**
  Distributed Computing, High End Computing, High-Performance Computing, Supercomputing, programming ...-solution, Unified Modelling Language (UML), ...

- **Experience:**
  Documentation, recommendation, learning processes, education, cognition, competence, ...

  (Subjective impression: At first, implemented entities alone do not help a lot for understanding the essence of knowledge?)
Public Understanding

Knowledge today (Source: Merriam Webster Dictionary)

1. a (1): the fact or condition of knowing something with familiarity gained through experience or association
   (2): acquaintance with or understanding of a science, art, or technique

b (1): the fact or condition of being aware of something
   (2): the range of one’s information or understanding answered to the best of my knowledge

c: the circumstance or condition of apprehending truth or fact through reasoning

d: cognition: the fact or condition of having information or of being learned a person of unusual knowledge

2. a: the sum of what is known: the body of truth, information, and principles acquired by humankind

b: archaic: a branch of learning
Definition

Defining knowledge \[1\] (Delegates and other contributors)

“Knowledge is created from a subjective combination of different attainments as there are intuition, experience, information, education, decision, power of persuasion and so on, which are selected, compared and balanced against each other, which are transformed, interpreted, and used in reasoning, also to infer further knowledge. Therefore, not all the knowledge can be explicitly formalised. Knowledge and content are multi- and inter-disciplinary long-term targets and values. In practice, powerful and secure information technology can support knowledge-based works and values.”


Delegates and contributors: Claus-Peter Rückemann, Friedrich Hülsmann, Birgit Gersbeck-Schierholz, Knowledge in Motion / Unabhängiges Deutsches Institut für Multi-disziplinäre Forschung (DIMF), Germany; Przemysław Skurowski, Michał Staniszewski, Silesian University of Technology, Gliwice, Poland; International EULISP post-graduate participants, ISSC, European Legal Informatics Study Programme, Leibniz Universität Hannover, Germany
<table>
<thead>
<tr>
<th><strong>Factual Knowledge</strong></th>
<th>(\Leftrightarrow)</th>
<th><strong>Numerical data, data ...</strong></th>
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<td><strong>Experience ...</strong></td>
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### Systematical view on knowledge (complements and examples) [2]:

<table>
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<tr>
<th>Knowledge Type</th>
<th>Examples</th>
</tr>
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Systematical view on knowledge (complements and examples) [2]:

- **Factual Knowledge** ⇔ Numerical data, data …
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Systematical view on knowledge (complements and examples) [2]:

- Factual Knowledge ⇔ Numerical data, data …
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- Procedural Knowledge ⇔ Workflow, computing …
- Metacognitive Knowledge ⇔ Experience …
- Structural Knowledge ⇔ Standard hybrid formats …
- …
Systematical View on Knowledge: FCPM Complements

Systematical view on knowledge (complements and examples) [2]:

- **Factual Knowledge** ⇔ Numerical data, data ...
- **Conceptual Knowledge** ⇔ Classification ...
- **Procedural Knowledge** ⇔ Workflow, computing ...
- **Metacognitive Knowledge** ⇔ Experience ...
- **Structural Knowledge** ⇔ Standard hybrid formats ...
- ...

Factual Knowledge Example: Data / Information [10], [2]

<table>
<thead>
<tr>
<th>Vesuvius [Volcanology, Geology, Archaeology]:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(lat.) Mons Vesuvius.</td>
</tr>
<tr>
<td>(ital.) Vesuvio.</td>
</tr>
<tr>
<td>Volcano, Gulf of Naples, Italy.</td>
</tr>
<tr>
<td>Complex volcano (compound volcano).</td>
</tr>
<tr>
<td>Stratovolcano, large cone (Gran Cono).</td>
</tr>
<tr>
<td>Volcano Type: Somma volcano,</td>
</tr>
<tr>
<td>VNUM: 0101-02=,</td>
</tr>
<tr>
<td>Summit Elevation: 1281\UD{m}. ...</td>
</tr>
</tbody>
</table>

... Syn.: Vesaevus, Vesevus, Vesbius, Vesvius  
s. volcano, super volcano, compound volcano  
s. also Pompeji, Herculaneum, seismology  
... compare La Soufrière, Mt. Scenery, Soufriere

<table>
<thead>
<tr>
<th>%%IML: UDC: [911.2+55]:[57+930.85]:[902]&quot;63&quot;(4+37+23+24)</th>
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| %%IML: GoogleMapsLocation: http://maps.google.de/maps?hl=  |
| de&gl=de&vpsrc=0&ie=UTF8&ll=40.821961,14.428868&spn    |
| =0.018804,0.028238&t=h&z=15 |
**Conceptual Knowledge Example: Universal Decimal Classification, [2]**

The Universal Decimal Classification (UDC) is a general plan for the knowledge classification. UDC is a hierarchical decimal classification system that divides the main knowledge fields into 10 main categories (numbered from 0 to 9). Each field is in turn divided into 10 subfields, each subfield is in turn divided into 10 subsubfields, and so on. A more extensive classification code in general describes a more specific subject. “Facetted” and “multi-disciplinary” is synonym to the UDC, [http://www.udcc.org](http://www.udcc.org).

**UDC Standard Operation / Symbols** (besides place, time, nationality, language, form, and characteristics)

- Addition: “+”
- Subgrouping: “[]”
- Consecutive extension: “/”
- Non-UDC notation: “*”
- Relation: “:”
- Alphabetic extension: “A-Z”

**Simple UDC Examples** – consistent due to UDC releases / editions

1. (0.02/.08) Special auxiliary subdivision for document form
2. =1/=8 Natural languages
3. =9/=93 Artificial languages
4. 59+636 Zoology and animal breeding
5. (7):(4) Europe referring to America
6. 311:[622+669](485) Statistics of mining and metallurgy in Sweden

Here, all small unsorted excerpts of the knowledge resources objects only refer to main UDC-based classes, which for this part of the publication are taken from the Multilingual Universal Decimal Classification Summary (UDCC Publication No. 088) [11, 12] released by the UDC Consortium under the Creative Commons Attribution Share Alike 3.0 license [13] (first release 2009, subsequent update 2012).
Program / Workflow Code (© CPR / LX / GEXI) [14]
Carousel links, calculated via non-explicit references of comparable objects (red) from knowledge resources within trees. Starting topics are identified by large golden bullets. The two fitting lines within the object carousels are \text{Historical City: Roman: Pompeji: Napoli: Architecture: Volcanic stone} and \text{Environment: Volcanology: Catastrophe: Volcanic stone}. Fitting object term for historical city and environment is \text{Volcanic stone}. Excerpt of associated multi-disciplinary branch level objects: \text{Limestone, Impact feature, Climate change.}
Metacognitive Knowledge

**Metacognitive Knowledge Example: Experience / Documentation [2]**

- **Metacognitive knowledge:**
  Metacognitive knowledge can relate to any of factual, conceptual, and procedural knowledge.

- **Cognition:**
  cognitio(-), from cognoscere (Latin) :: get to know. The mental action or process of acquiring knowledge and understanding through thought, experience, and the senses (Source: Oxford dictionary).

- **Analogy:**
  ἀναλογία, analogia (Greek) :: proportion. A cognitive process of transferring information or meaning from a particular subject (the analogue or source) to another (the target).

- ...
Examples of categories . . . [2]

**material structures** are **natural objects** such as biological organisms, minerals, and chemicals and **man-made** objects such as architectural buildings and machinery.

**abstract structures** are any (knowledge/information/data) structures in information science, used in theory and practice.

**structure types** are hierarchies or lattices.

Example from discipline’s view . . .

**Logic, philosophy:** Structure is essential in logic, e.g., structure of arguments. An argument consists of one or more premises from which a conclusion is inferred. Basic inferences are deduction and induction.

...
Methodological implementation and realisation

- Methodological implementation and realisation are based on the **Conceptual Knowledge Reference Implementation (CKRI)** [16] and respective contextualisation.

- Components outside the core scope of this knowledge focussed geoscientific, prehistoric, and archaeological research are employed and can be extended via the **Component Reference Implementations (CRI)** frame [17]. Both provide sustainable fundamentals for highest levels of reproducibility and standardisation.

- Universally consistent multi-disciplinary conceptual knowledge is based on the Conceptual Knowledge Reference Implementation (CKRI) [16] and implemented via UDC code references.

- CKRI is provided in development stage editions, prehistory-protohistory and archaeology E.0.4.6, natural sciences E.0.2.8).
Example: Resulting symbolic representation of features groups [18, 19] [20, 21, 22] [23, 24]

(a) Generated symbolic representation of country ident. contexts.

(b) Generated symbolic representation of object AoI contexts.

Figure: Resulting symbolic representation of a volcanological features group (maars) based on the coherent conceptual knowledge integration (excerpt). Sequence of procedural steps for larger scale and smaller scale contextualisation, including country identification contexts (a) and AoI contexts (b). Generated representations include integrated CKRI references, projection of topographic and bathymetric results, and further knowledge for respective areas.
Benefits and Drawbacks

- Knowledge is supported on a **more holistic base**.
- **Experience**: All scientists and domains have (themselves) shown of being able to contribute on all knowledge complements.
- **Natural complexity** of knowledge can contribute to solutions.
- **Tasks** (creation, provisioning, consumption etc.) can be served on non-technical data-centric level.
- **Systematic application** of methods.
- **Long-term use** is supported.
- **Multi- and interdisciplinary** creation and work are supported. . . .
- **Further telic and atelic efforts** (e.g., reference implementations from disciplines) required and enabled.
- **Education and learning** processes required.
- **Appropriate (best) practice** required.
- **Continuous, ongoing, further development** required. . . .
Allow Knowledge to Prevail in most cases means...

- Knowledge is made up from the **complements of computing, data, experience, classification, ...**
- The complements should be **preserved** (e.g., with long-term resources and research data management).
- Preserved knowledge should be prepared to be continuously scientifically **revisited, revaluated, recontextualised**.
- The holistic knowledge view should be **trained**.
- The holistic knowledge view should be **fostered**.
- The holistic knowledge view should be ‘**funded’**.
- Believe in tools and technology without working on ‘knowledge’ and ‘data’ is rarely a great achievement.
- (In general, **quality** (of data) is hermetic and has to be defined, always, for any case.)
Lessons Learned and Conclusions

- Beware of knowledge/science/disciplines/... cargo cult practice.
- All scientists should educate themselves regarding knowledge complements.
- Any ‘knowledge’ can be handled in an appropriate way.
- Systematical view enables options for priorities/integration.
- Targets: Sustainable Reference Implementations, Research Knowledge ((Data)) Management and long-term projects.
- Long-term documentation (which does not necessarily mean textual papers only) is required.
- Long-term funding (of endeavouring scientists) is ‘reasonable’.

What we should epitomise, practice and ‘walk the talk’, means:

Not being restricted to do what (technical) tools can do but being able to do what is scientifically possible!

Knowledge First!
Thank you for your attention!
Reference section containing all the cited and used references and publications on further reading.


[6] C.-P. Rückemann, R. Pavani, L. Schubert, B. Gersbeck-Schierholz, F. Hülsmann, O. Lau, and M. Hofmeister, *Best Practice and Definitions of Data Value*. Post-Summit Results, Delegates' Summit: Best Practice and Definitions of Data Value, September 13, 2018, The Eighth Symposium on Advanced Computation and Information in Natural and Applied Sciences (SACINAS), The 16th International Conference of Numerical Analysis and Applied Mathematics (ICNAAM), September 13–18, 2018, Rhodes, Greece, 2018, delegates and other contributors: Claus-Peter Rückemann, Westfälische Wilhelms-Universität Münster (WWU) / Knowledge in Motion, Unabhängiges Deutsches Institut für Multi-disziplinäre Forschung (DIMF) / Leibniz Universität Hannover / North-German Supercomputing Alliance (HLRN), Germany; Raffaella Pavani, Department of Mathematics, Politecnico di Milano, Italy; Lutz Schubert, IOMI, University of Ulm, Germany; Birgit Gersbeck-Schierholz, Knowledge in Motion, Unabhängiges Deutsches Institut für Multi-disziplinäre Forschung (DIMF), Germany; Friedrich Hülsmann, Knowledge in Motion, Unabhängiges Deutsches Institut für Multi-disziplinäre Forschung (DIMF), Germany; Lau, Olaf, Knowledge in Motion, Unabhängiges Deutsches Institut für Multi-disziplinäre Forschung (DIMF), Germany; Hofmeister, Martin, Knowledge in Motion, Unabhängiges Deutsches Institut für Multi-disziplinäre Forschung (DIMF), Germany; DOI: 10.15488/3639, URL: http://history.icnaam.org/icnaam_2018/icnaam.org/sites/default/files/Preliminary%20Program%20of%20ICNAAM%202018_Web_version_70.pdf, URL: http://icnaam.org/sites/default/files/Preliminary%20Program%20of%


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