Agility and Semantic Structures to Scaffold Modern Academic Education

Supporting the Digital Transformation in Higher Education Institutions – Part I: Introduction

Prof. (FH) Karsten Böhm, Workshop at the “CloudEarth Innovation”-Project, 22th November 2022

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Some words about myself

German born European ▪ Computer Scientist ▪ (Research) Professor ▪ (used to be) Director of Studies

Agenda

- 14.00 – 14.45h Introduction on the current situation in HEI & current developments

+15" Break

- 15.00 – 15.30h Interactive session: Warmup by reflecting the situation of the participants
- 15.30 – 16.15h Introduction of Pre-built information spaces for learning environments

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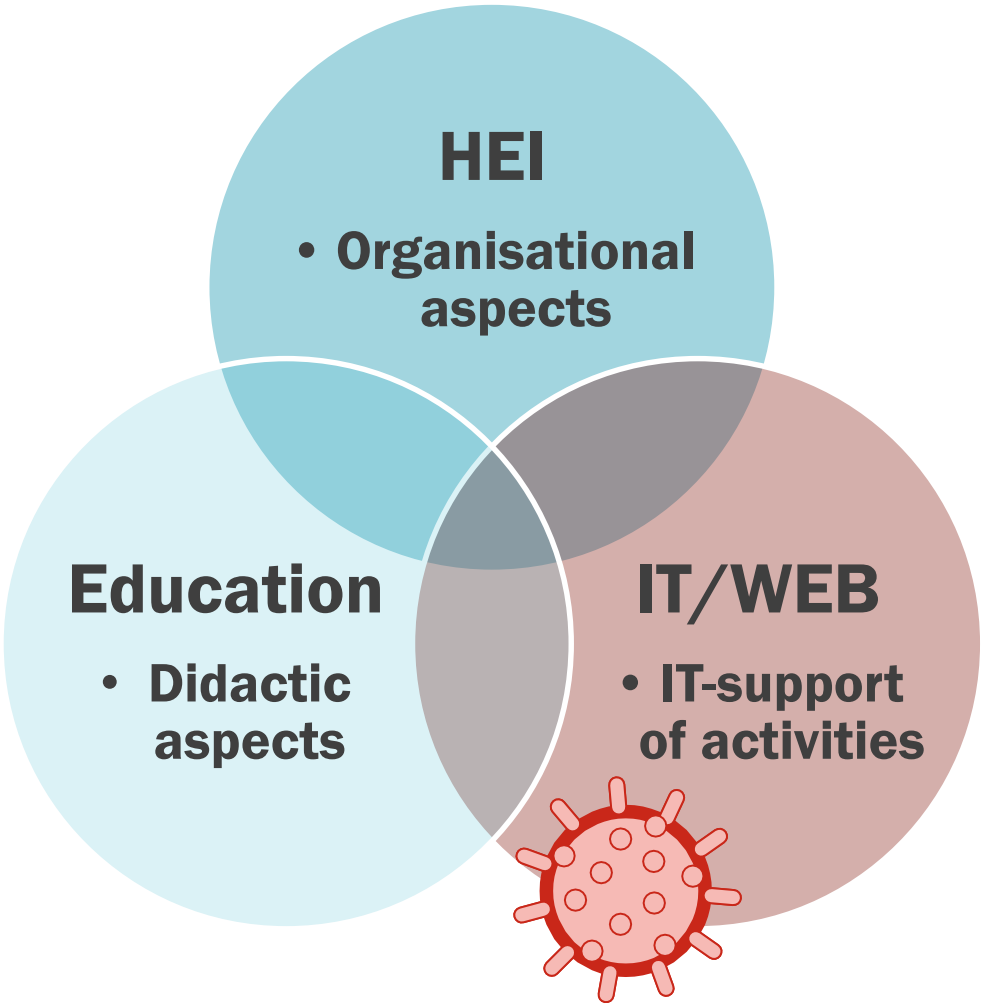
- 17:00 – 17:30h Summary, Reflection and Wrap up, Take Away and preparations for the spring-session in 2023

- All timing in CET

Introduction on the current situation in HEI

Introduction & context of my research

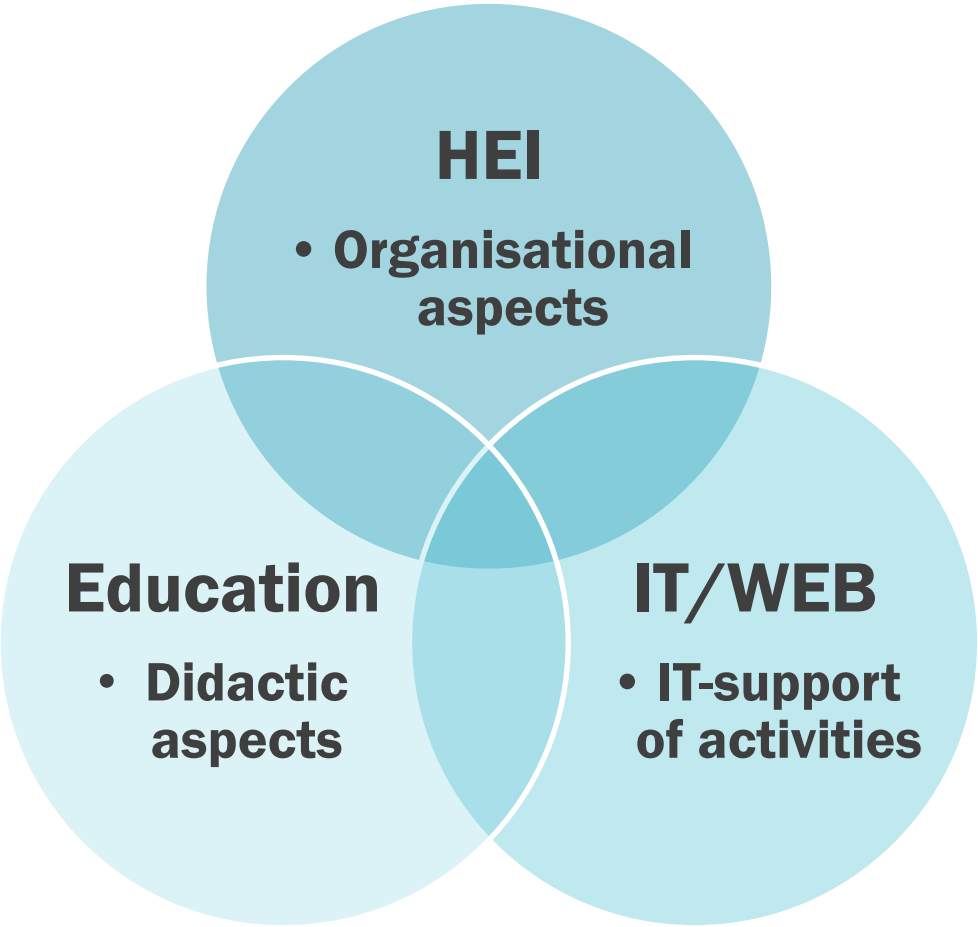
- Coming from the context of a lecturer, program designer and researcher in the field of IT-based KM
- During 2020 as a result of the COVID-19 pandemic the importance of IT-supported teaching became SUDENTLY prominent & mission critical
- Challenges and problems became MUCH MORE evident.
- Question arose how to support HEIs in a better way by IT-supported Knowledge Management (in the future).
- Traditional HEI practises were being challenged and they still are ("post-pandemic")



Source of COVID-Icon: https://commons.wikimedia.org/wiki/File:Coronavirus_icon.svg

Current impressions on “Post-COVID” times (in the DACH region)

- Interestingly – and much to my surprise – developments in HEI did not continue at the same pace
  - 2022 felt like a “back to the old normal” rather that establishing the “new normal” from 2020/21
  - importance of IT-supported teaching is being kept at the current level or even reduced
  - Lessons learnt are in danger to be forgotten
  - Critical aspects (“Zoom fatigue”, “social impacts”) are getting attention – and are used as an excuse
- Challenges and problems are still there
- Traditional HEI practises are back and dominating (again)



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VUCA as a way to describe the world

- VUCA as the abbreviation for Volatility – Uncertainty – Complexity – Ambiguity
- Used to describe the dynamics of our current world/economy/society
- Does also affect the sector of Higher Education Institutions (HEI), but is not perceived that way
  - We “talk about” VUCA but we’re not really able to “act quick enough” for VUCA
  - We assume “life-long-learning” for the societies, but still stick to the barriers of schools and HEI
  - We’re not addressing the aspect of ‘alternative pathways to [practical] knowledge’ seriously enough

VUCA as a way to describe the world

Volatility – Uncertainty – Complexity – Ambiguity

- (V) – Volatility in HEI
  - changing topics that are concerned relevant and/or interesting by stakeholders (students, companies),
  - volatile group sizes with diverse backgrounds
  - programs are designed and funded in the long run – adaptations are difficult

- (U) – Uncertainty in HEI
  - external drivers like the digital transformation, the lasting effects of the COVID pandemic
  - changing expectations of future generation of students, working students, lifelong learning
  - topics and education profiles are changing and new job profiles are emerging
  - development and financing phases is not designed for such an uncertain environment

VUCA as a way to describe the world (continued)

Volatility – Uncertainty – Complexity – Ambiguity

- (C) – Complexity in HEI
  - In most engineering programs increasing complexity of the fields in terms of subjects becoming broader
  - subjects having a deeper level of knowledge that is needed to master it.
  - educating students becomes a challenge, as the time for education remains the same. Lecturers need to select and curate content and moderate the learning process more carefully.

- (A) – Ambiguity in HEI
  - fast-evolving knowledge domain in many [new] subjects.
  - [new] Concepts like Digital Transformation, Artificial Intelligence and the Cloud technologies with multiple meanings and require different levels of knowledge to become actionable.
  - Understanding those concepts and applying them in real-life scenarios if often the requirement

VUCA as a solution space

Vision – Understanding – Clarity – Agility

- (V) – vision to address volatility in HEI
  - guidance as USP is needed to navigate through changing topics
  - important to develop applicable knowledge, or to employ a guiding attitude to the education
  - vision needs to be employed in practice – need to become a cultural value in the HEI.

- (U) – understanding to address uncertainty in HEI
  - active and ongoing reflection process on the requirements of the application domain
  - Understanding expectations and requirements of the current and next generations of students
  - interplay and a communication of values between different generations: lecturers (“older generations”) and students (“newer generations”).
  - in a VUCA world this process is being accelerated and in the sense of a dialogue becoming more important

VUCA as a solution space (continued)

Vision – Understanding – Clarity – Agility

- (C) – clarity to address complexity in HEI
  - by building on existing knowledge and by employing scientific methods
  - objective view of the world help students to provide orientation in a complex and changing world
  - convey important tool-sets to navigate in that world at topics that they are faced later in their life

- (A) – agility to address ambiguity in HEI
  - important on the strategic level (for the development and adaptation of programs)
  - Important at operational level (the execution of programs).
  - tailored to the specified group of students and even towards the individual using learning analytics and digitization of learning environments to provide additional or alternative learning paths.

VU – at strategy level // CA – at operational level

- The VUCA solution space resembles a modern education in my opinion
- Vision and understanding in the solution space are aspects that target the organization as whole and can be considered as goals at the strategy level

- Clarity and Agility are aspects that target the operational behavior of the organization and can be considered as goals at the operational level
  - This work(shop) focusses on CA as a primary objective
  - CA should be aspects of education programs / lectures / qualification profiles
  - CA is our ultimate goal as lecturers
  - CA is what (engaged & motivated) students (implicitly) expect

CA might be contradictions – balancing of the aspects is critical

Clarity

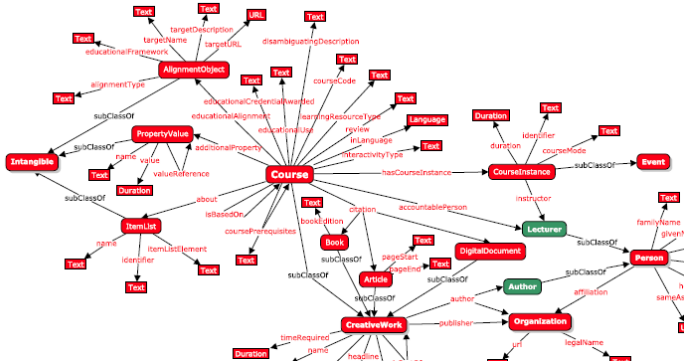
- More clarity might be imposed by more structure
- Creating rigidity that affects agility

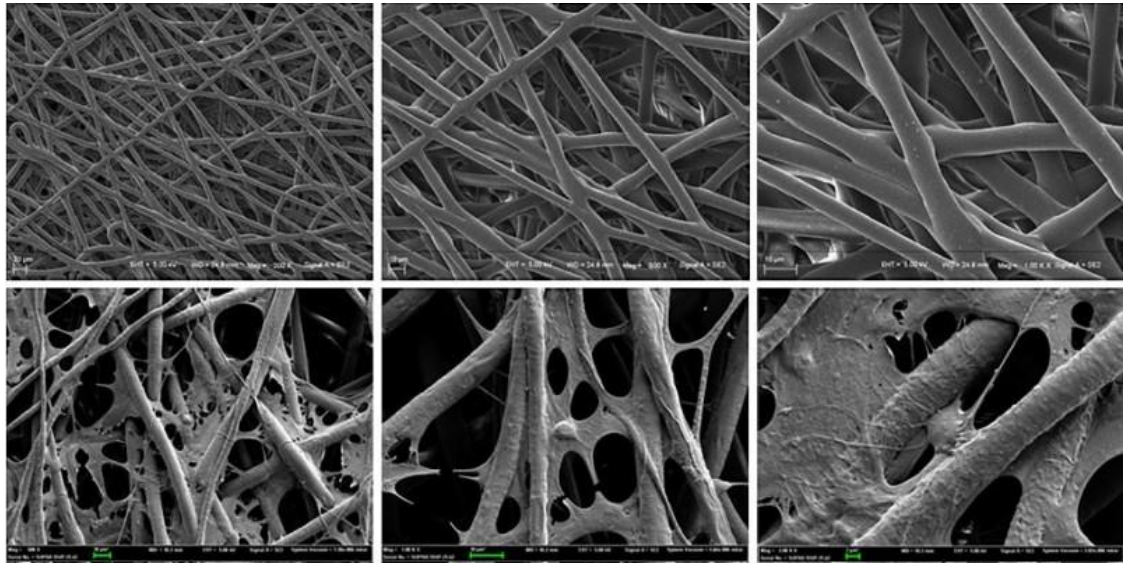
Agility

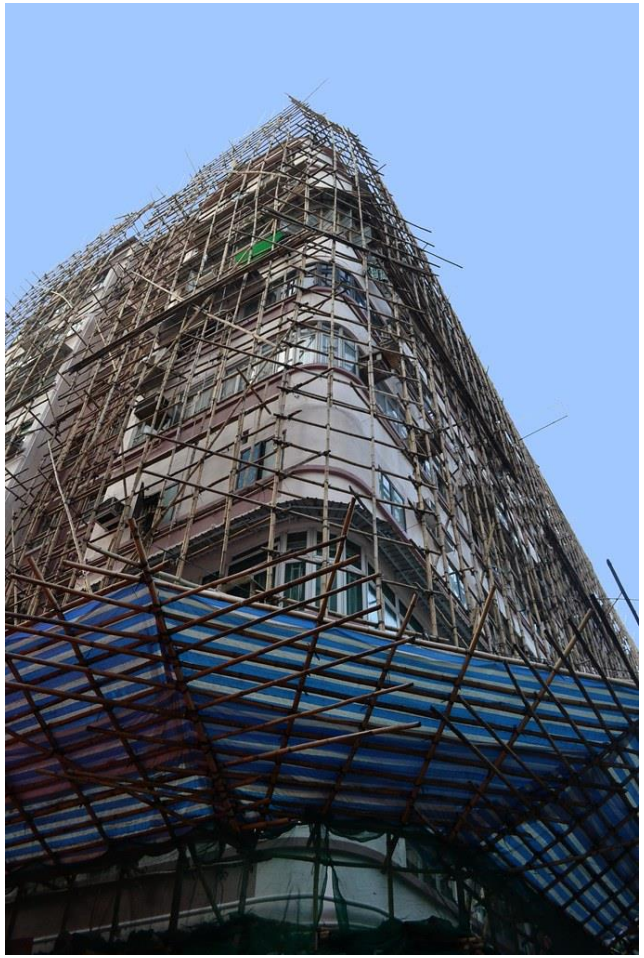
- More agility might change the process [often]
- Changes can affect the clarity of the education

The idea of a scaffolding

- In order to support modern education (CA) we need a supporting structure that helps to educate according to VUCA, but preserving the CA properties
- Currently education programs are specified by documents





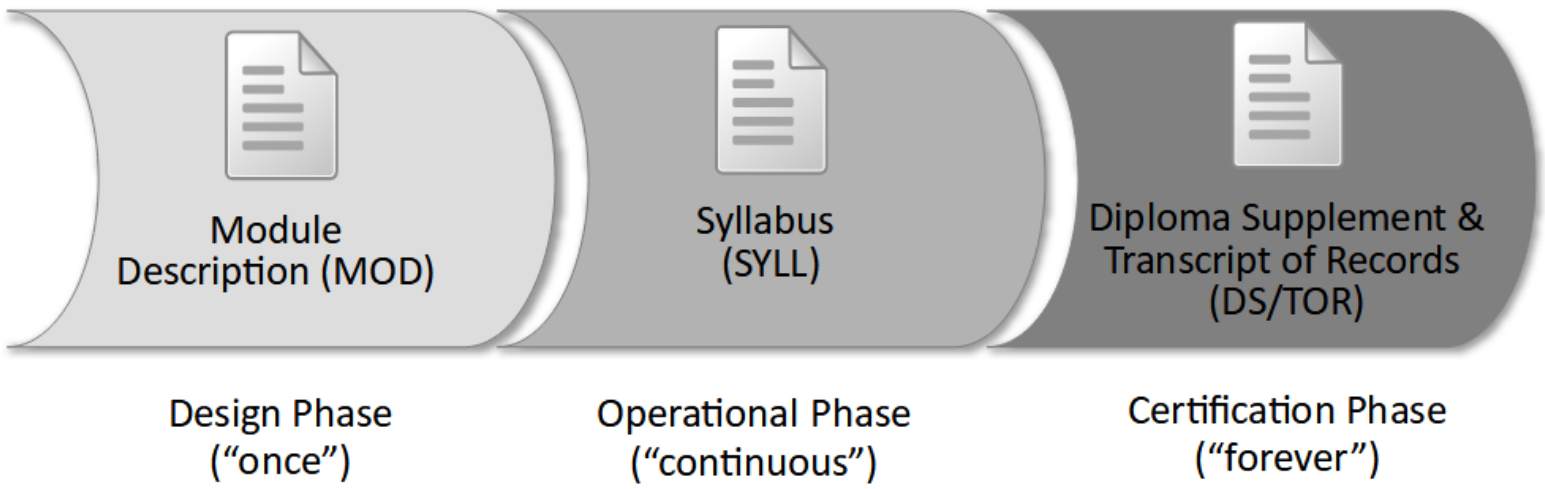


Introduction to Structural Agility

- Study programmes in Higher Education Institutions (HEI) offer qualification programs in a number of different domains
  - From a KM perspective that's Knowledge Transfer and Knowledge Sharing from the HEI to the students and Knowledge Creation by students
  - Knowledge intensive by nature and orchestrated by the study programmes
  - Defined by a bunch of defining documents (curricula, program specifications etc.) that represent externalized knowledge
- Current challenges are the increasing dynamics of the sector and the digital transformation of education
  - Different levels of abstraction in the definition – trend towards competence oriented teaching
  - Different stakeholders at design time and execution time – with often little knowledge sharing between different lectures/lecturers leading to inconsistencies
  - New support structured needed, e.g. for e-Learning courses and integrated learning analytics

Defining documents & Phases of Study Programs in HEI

- Analysis of (Austrian) study programs shows
  - A number of important specification documents and
  - Three phases that occur during the lifetime of a program



- Noteworthy to mention that all activities are document based often without any systematic structure or IT-system support
  - leading to unconnected concepts, duplicates and inconsistencies

Structural Clarity provide the base for Structural Agility

- Agility at the structural level requires structural clarity

- Should help to provide consistent and connected structures between
  - Different specification documents
  - Different stakeholders in the process
  - Different technical systems
  - Different point in time (design/execution time)

- Based on connected information models that provide structural clarity, a HEI an analyse and act consistently on the development of those structures, e.g. becoming structural agile

Agility and Learning?

- Learning is not a straight path and requires loops to reflect and learn from past experience, even failures.
- Learning‘s an individual journey.
- Learning and Teaching in Higher Education is often carried out in a one-size-fits-all manner and assumes to be a straight line from the first lecture to the final exam.

Image Source from PXHERE: https://pxhere.com/de/photo/1088522

Learning in the Technology Domain, mostly Information Technology

- Challenges and Drivers to Learning in the Technology Domain
  - Highly Dynamic – new technologies emerge all the time
  - Increasing Complexity – technologies become more powerful but also more complex (and thus hard to teach)

"Learning to learn" becomes as important as "knowing what is known today"

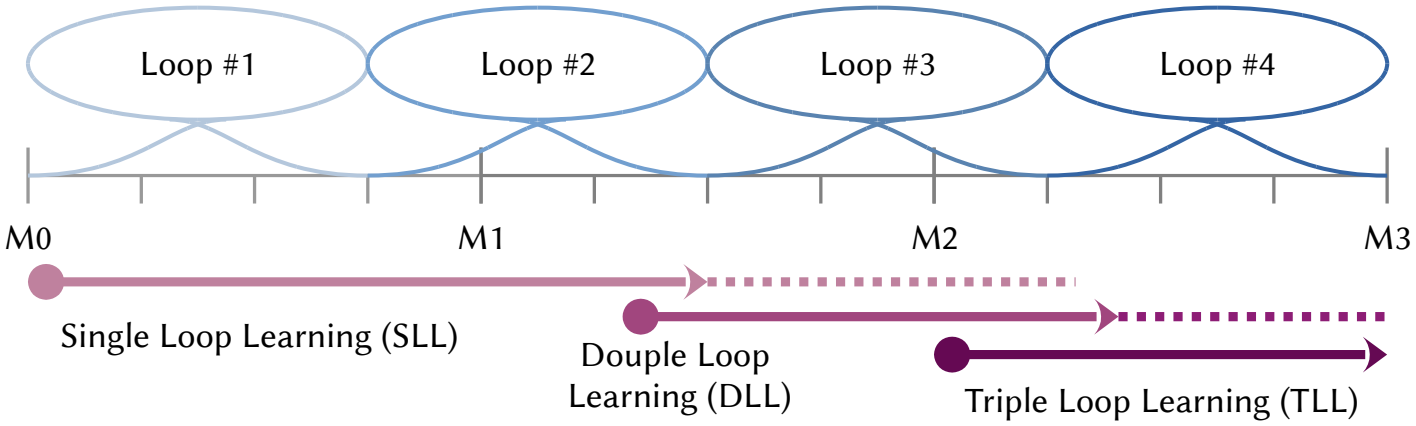
- One way of approaching those challenge is Problem Based Learning (PBL): self guided learning in which the solution of a problem is in the primary focus.


Image Source from PXHERE: https://pxhere.com/de/photo/140

Agility at execution level addresses current education requirements

- PBL leads to agile learning that becomes more individualized and “messy” from a lecturers point of view as learning paths can become highly specific.

- Clarity at execution level is needed to structure the learning in manageable ways
  - E.g. the use of agile learning loops (ALL) as a time boxing method for PBL
  - The use of IT-systems to make progress digitally visible (tasks & Kanban boards)
  - Explicit detailed competence goals for clear targets



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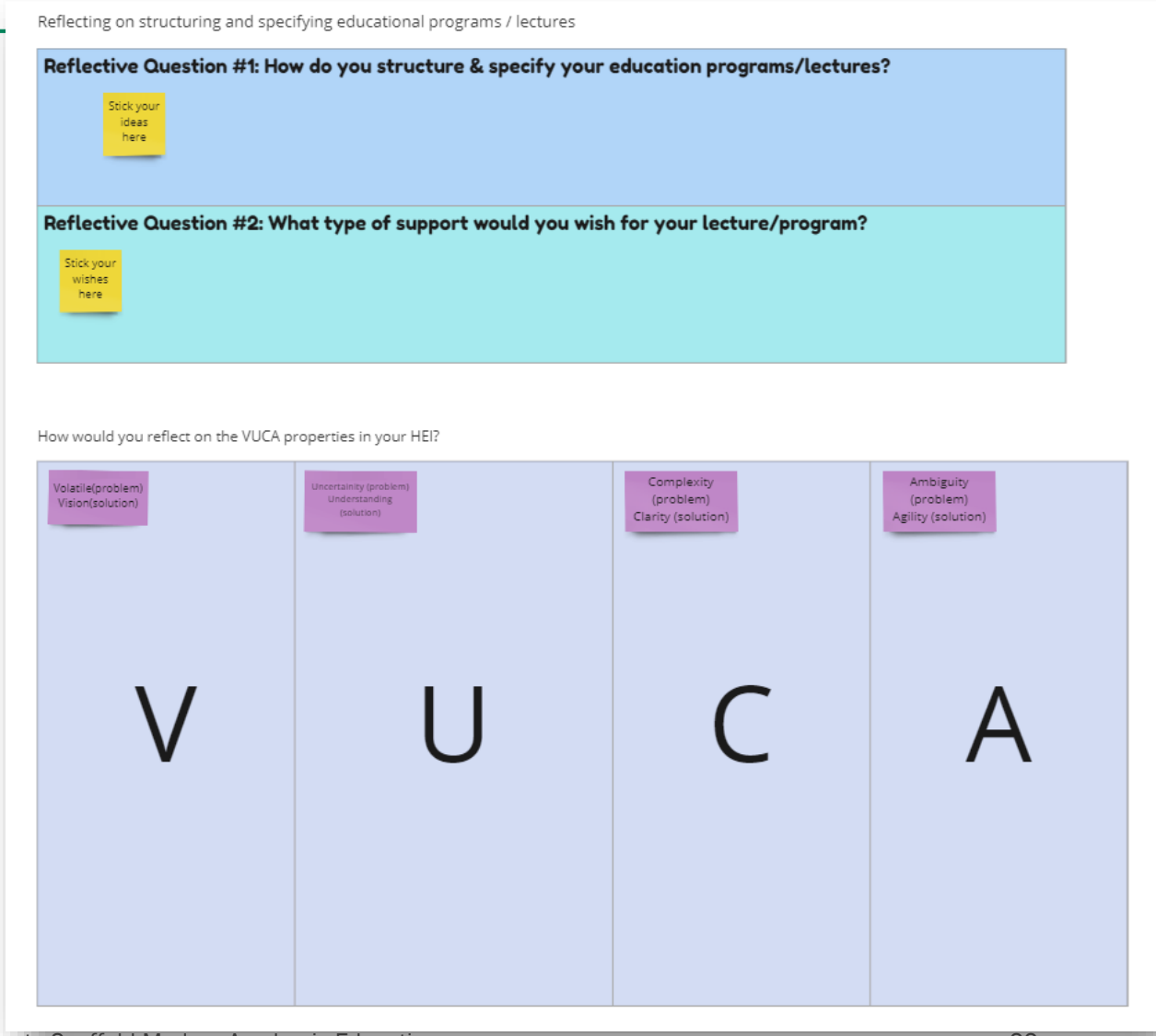
Interactive Part – Your opportunity to reflect & comment

- A Miro board has been prepared to reflect & interact on the concepts introduced:
  - Link to access the board: https://miro.com/app/board/uXjVPBBPn08=/?share_link_id=216582855888

- Your Task: Reflect on the two questions and post your comments together with the participants
- Continue in reflecting on VUCA by posting stickies in the same way.



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Pre-built information spaces for learning environments (PreBIS-LE)

Pre-Built Information Spaces

- A Pre-Built Information Space is an information collection (usually encoded in documents) that contains unstructured information (usually texts) which is structured by domain specific concepts with an explicit meaning (semantics).

- Semantic technologies are used to express such a meaning in so called knowledge representations
  - Build for purpose
  - Connection to the layer of unstructured information (linking or embedding)
  - Can be simple (in a form of meta data) or sophisticated (ontology driven)

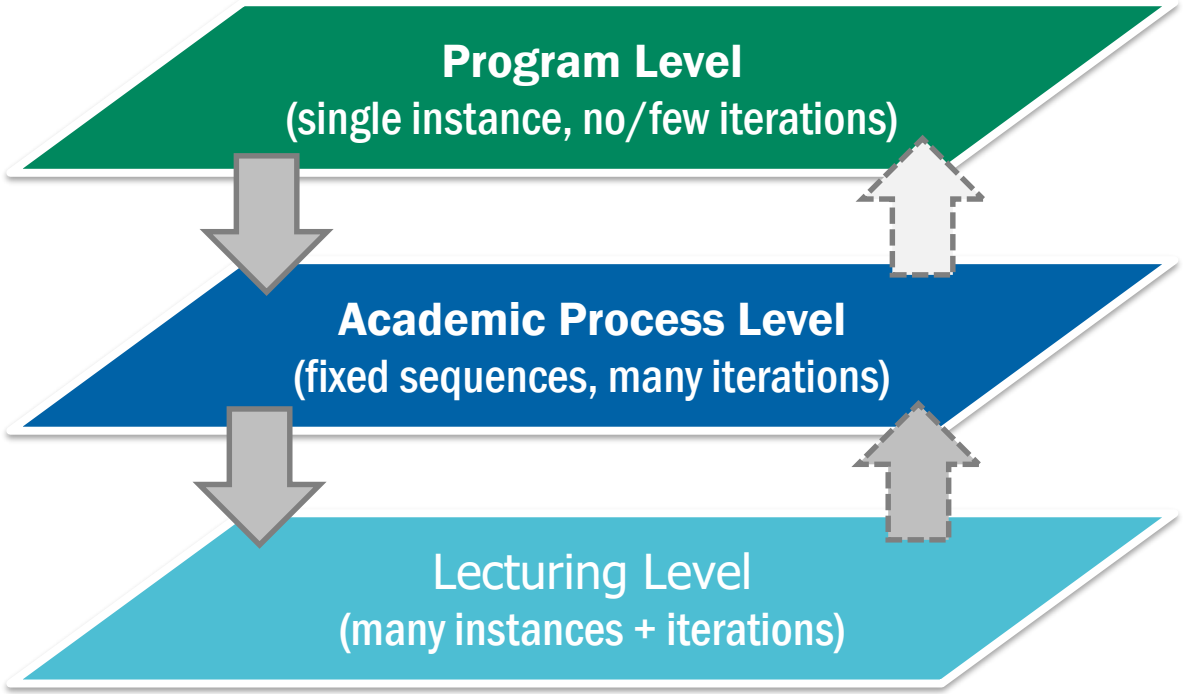
Pre-Built Information Spaces for Learning Environments

- A Pre-Built Information Space for learning environments is an information collection (usually encoded in documents) that contains unstructured descriptive information (specifications) which is structured by concepts with an explicit meaning (semantics) for competence orientation.

- Semantic technologies are used to express the desired competences of course programs in a knowledge representation
  - Aligned to existing competence models (learning objectives)
  - With simple representations that are easy to understand
  - Linking different layers of specifications and
  - Using the aspect of self-similarity at the different levels

Overview on the Potential of Semantic Web Technologies in HEI

- Important: Most documents in HEI are semi-structured and suitable for the support with Semantic Web representations, but this potential is NOT used widely
- HEI world from a more abstract view:



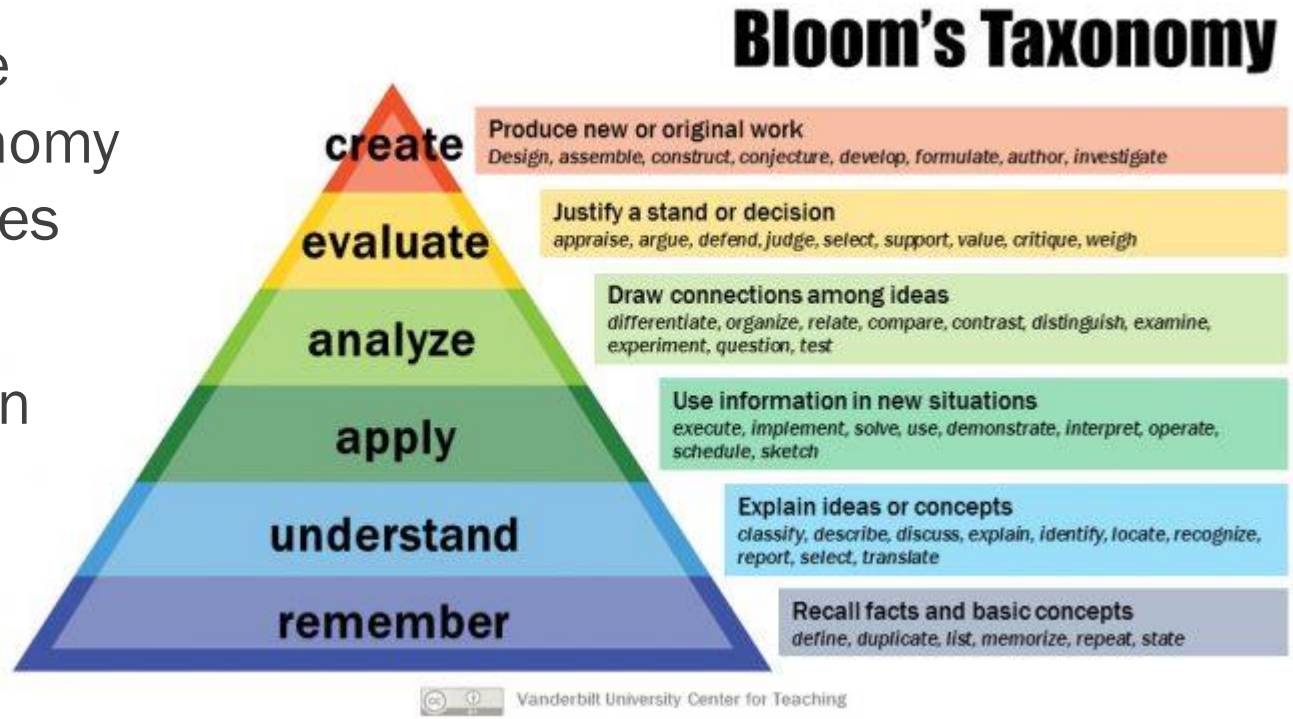
<u>Design-Time</u> (Scope: Academic program): focussing on competences, learning objectives, market requirements – the "Big Picture"
Output: [unstructured] Documents/Web-Pages

<u>Planning-Time</u>/Scope: Semester: focussing on timing & resources (persons, rooms, tools)
Output: artefacts in different systems (appointments, mails campus systems, …)

<u>Execution-Time</u>/Scope: Individual lecture: focussing on content, assessment, didactic methods
Output: wide range of digital and often unconnected digital artefacts (e.g. learning materials, grades, video-resources)

Bloom's taxonomy

- A well known framework to categorize learning goals or outcomes in a taxonomy developed by Bloom and his colleagues
- Learning outcomes that are built upon each other
- Codified with a label and a textual description



Source: https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/

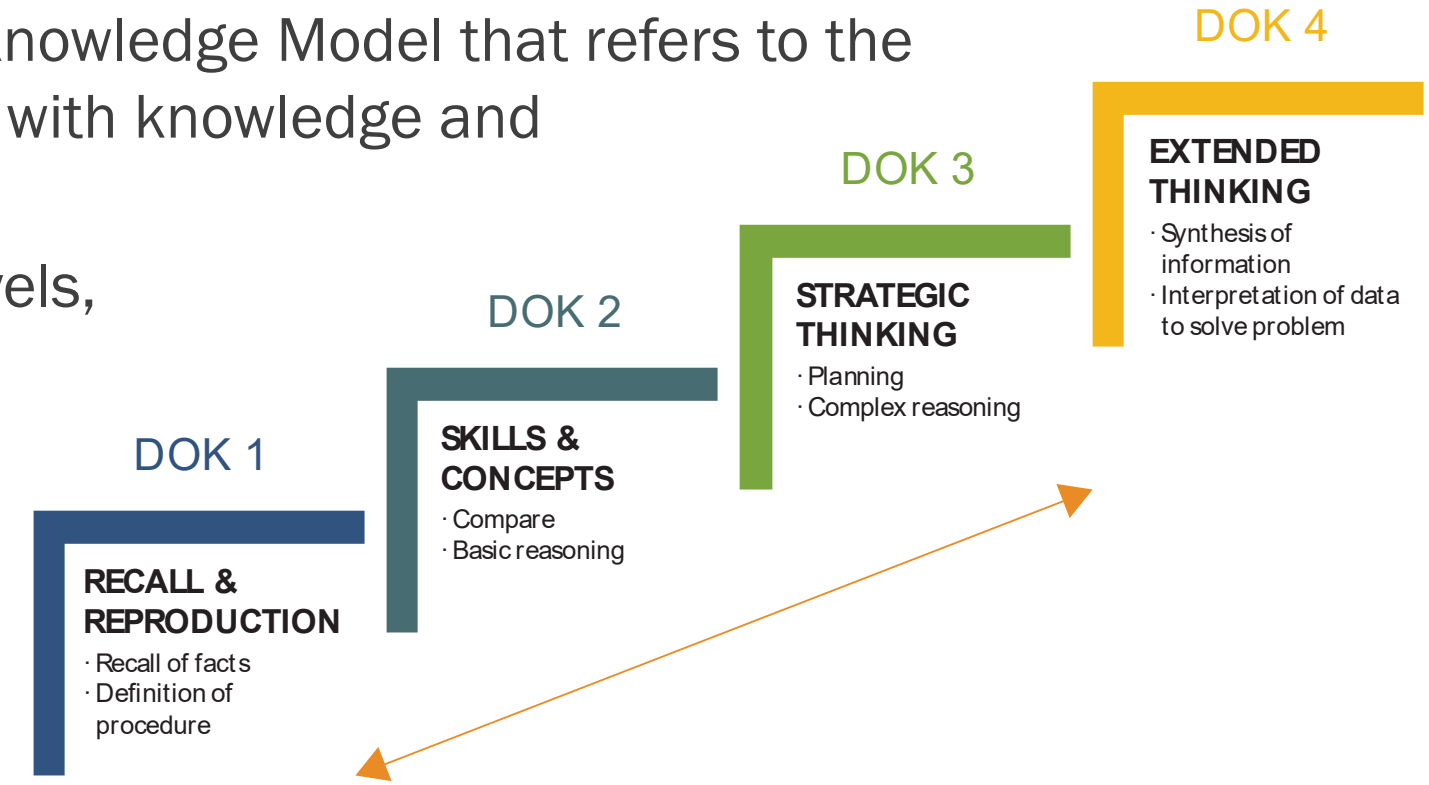
Bloom’s taxonomy

- A common approach to encode the learning outcomes is the use of wide range of verbs to express the level according to the taxonomy
- Sometimes used as a “standard” to encode learning outcomes (e.g. at my university)
- Does it really lead to a better structure or understanding?

Source: https://www.teachthought.com/critical-thinking/blooms-digital-taxonomy-verbs/

The Depth of Knowledge model (DOK)

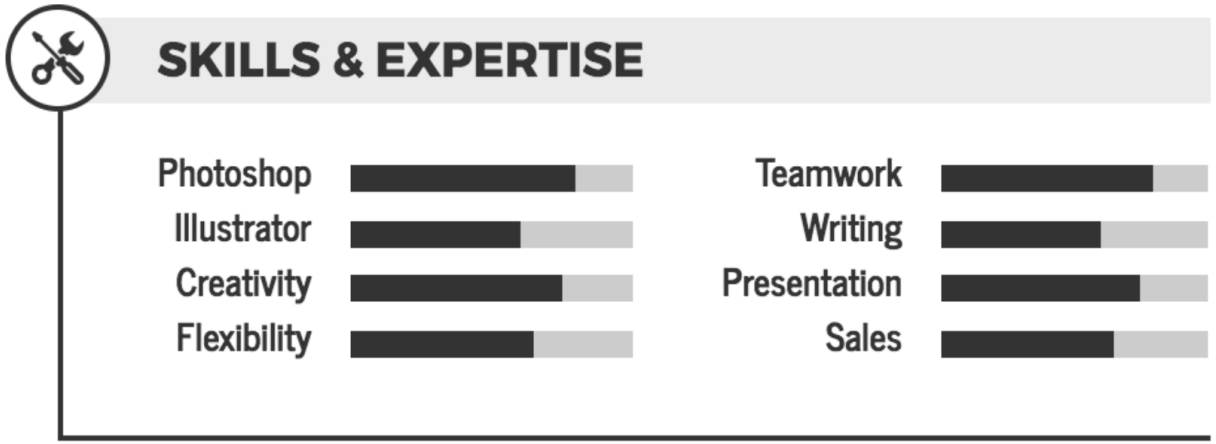
- Another model is the Depth of Knowledge Model that refers to the process of growth when dealing with knowledge and learning
- This framework consists of 4 levels, ranging from simple to complex
- More details: https://blog.edmentum.com/webb%E2%80%99s-depth-knowledge-framework-basics



Source: https://www.synergiseducation.com/blooms-taxonomy-and-webbs-depth-of-knowledge/

Competence Matrices as a Common Structure

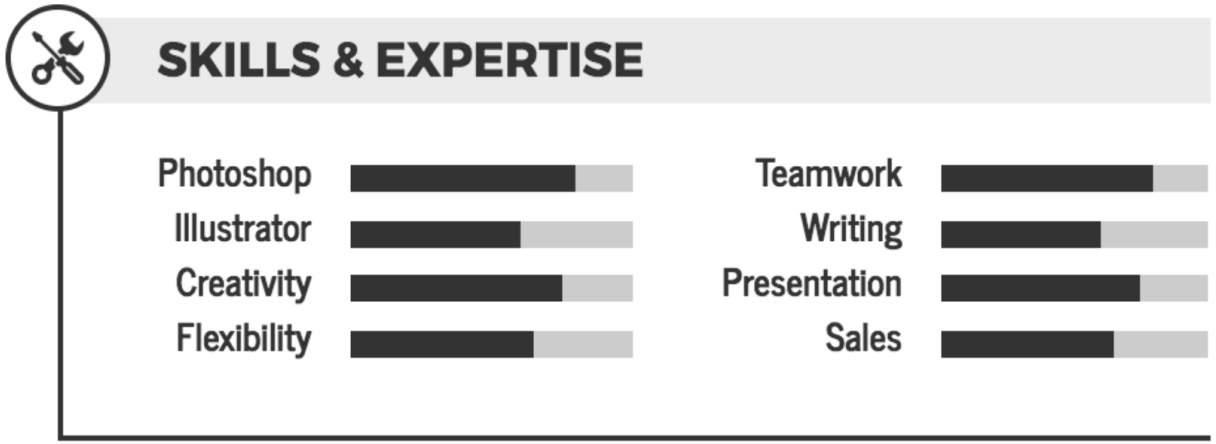
- Structural description of programs are built around learning outcomes
- Usually encoded in text and less formalized
- CVs increasingly use competence matrices (CM) to visualize type and level of skills in an easy to comprehend structure



- Structurally similar approach with Blooms taxonomy with different levels (remember – understand – apply – analyse – evaluate – create)
- → could be used for programs combining Bloom and CM

Competence Matrices and Self-Similarity

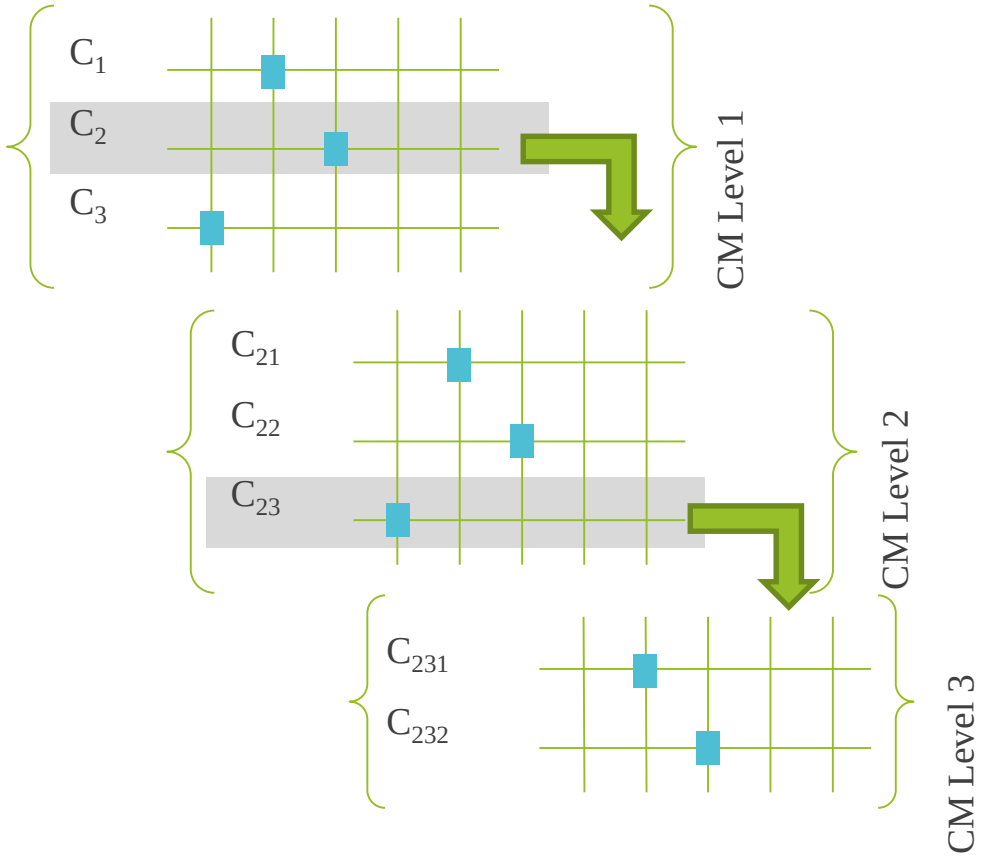
- CM are easy to grasp due to it's visual representation
- CM's might be harder to understand in terms of what's behind a certain leve
- The combination of CM as a structure a taxonomies as a way to express its meaning might be helpful to represent learning outcomes and competences



- CM's can be used at different levels of HEI specifications leading to a self-similarity in the descriptions
- Connecting those CM's leads to a more unified view and a scaffolding property

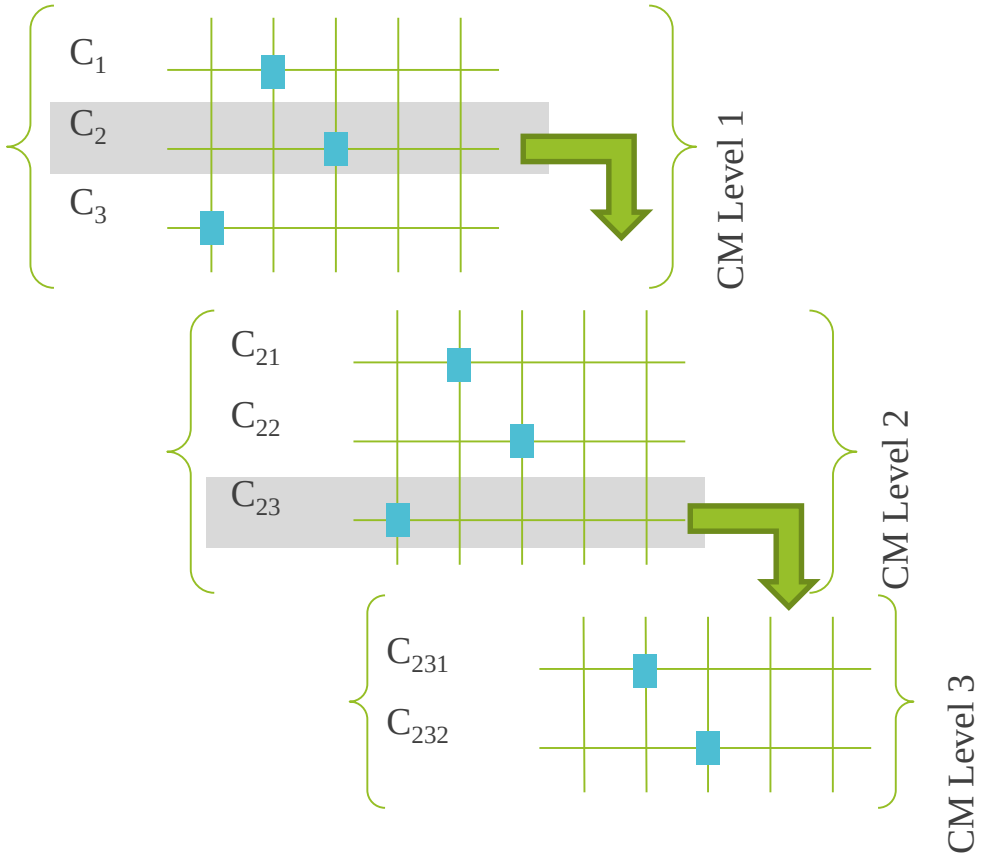
Hierarchical Concept Matrices (HCM)

- Building on the CM approach we realize that learning outcome are usually organized in a hierarchical way
- Top-Down: Module – Lecture Series – Lecture Unit (generic to specific and vice versa)
- Could be used to build an hierarchy of connected CMs → HCM



Hierarchical Concept Matrices (HCM)

- Leads to <u>a consistent backbone structure</u> over all levels
- supports modelling and execution
  - Program designers can see the trace from top level qualifications in the program to the learning outcomes of the individual lectures
  - Lecturers can see the greater context of their lecture and the contribution to the education program(s)
  - All type of checks are possible on that scaffolding, once it is in place: consistency, plausibility, quality checks of learning outcomes generated and required



A self reflection on structured modelling of learning outcomes

- Personal observation in using the concept for my own purposes:
  - Moving from unstructured descriptions to a more structured form requires to overcome some inertia
  - Existing material does not help (because it needs to be converted and reshaped)
  - Thinking in a connected way from a lecture unit to the program and back is a challenge
  - New lectures might provide a chance to “start on a blank page” but is hard due to time pressures
  - A good approach might be to start “small” and “experimental” with (reshaping of) existing content

The road to the implementation of an ICT support system

Semantic Concepts for HEI: Capturing and Bridging the Levels

- Semantic concepts are already present in HEI research
- Chung et. al. suggest in their research in 2016 different conceptual levels that are represented as ontologies
  - This structure provides the opportunity to bridge/connect the different layers shown before on a conceptual level rather than by documents and fixed processes
  - Research includes an implementation of a new system with the primary use for the personalization based on assessment results
  - Ontologies and implementation not (publicly) available, project seem to be discontinued

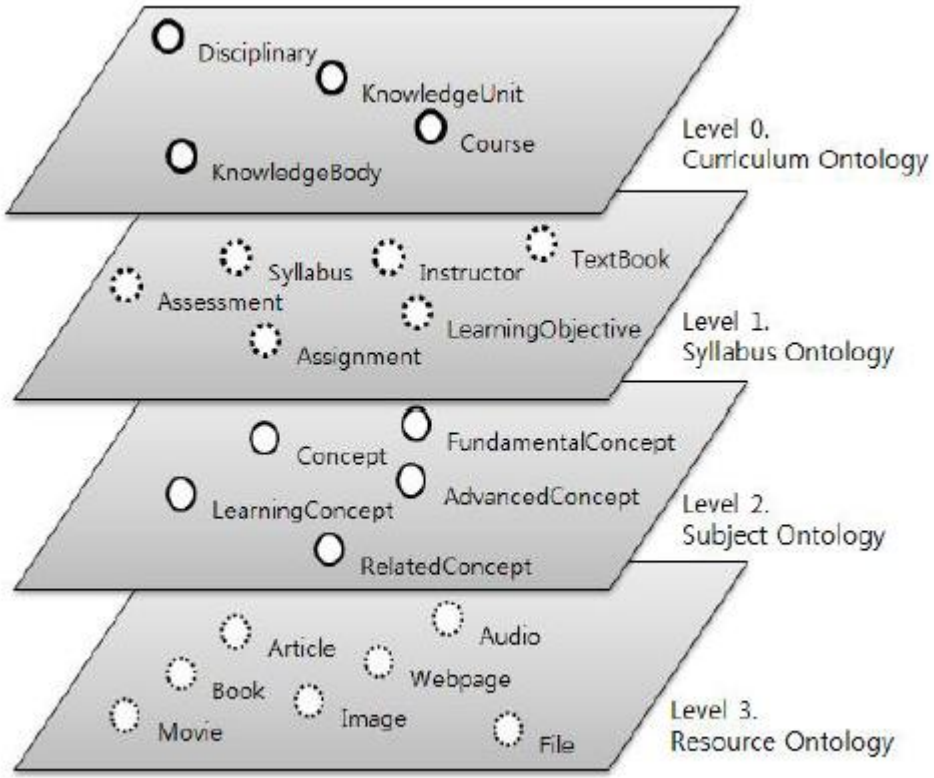
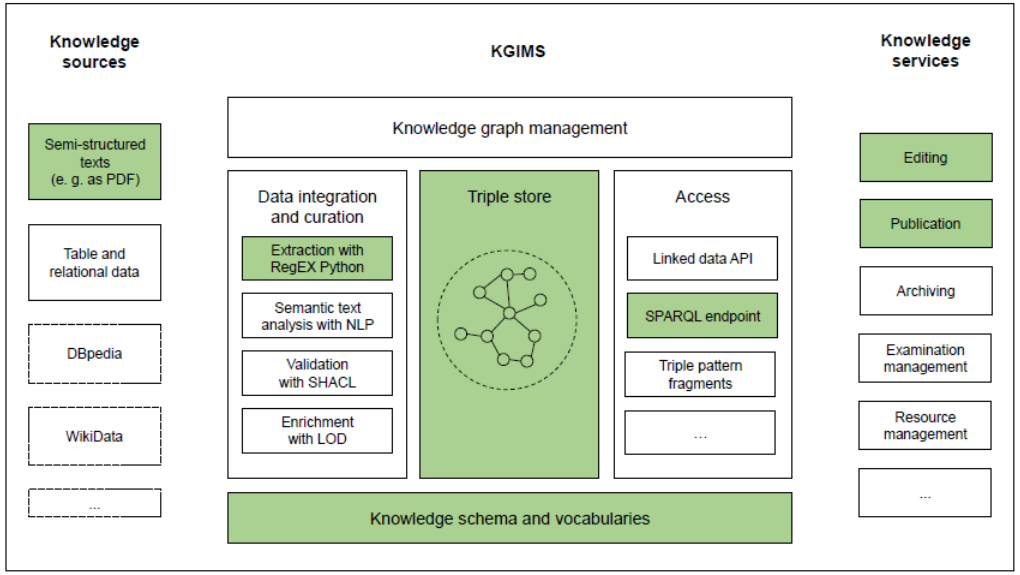


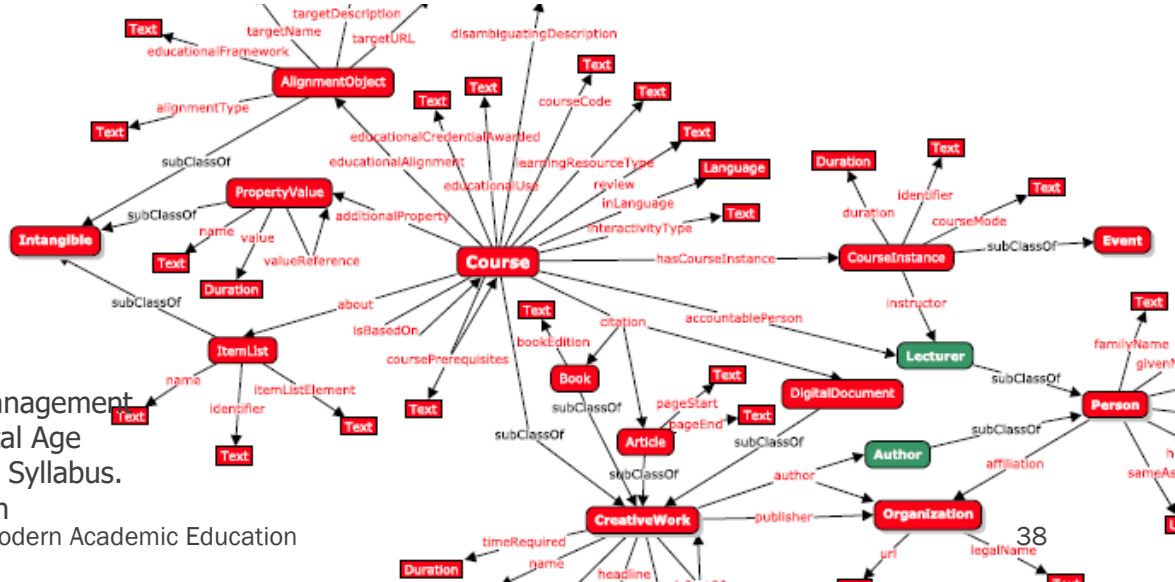
Fig. 1. Four-layered integrated learning ontology.

Source: Chung, H. and Jeongmin, K. (2016b) 'An Ontological Approach for Semantic Modeling of Curriculum and Syllabus in Higher Education'. doi: 10.7763/IJIET.2016.V6.715.

Knowledge Graph Based Systems: Structuring planning phase

- Meister et. al propose a Knowledge Graph-based Information Management Systems (KGIMS) to support processes and information organization in HEI.
- Ontology (lower right) is used to drive a flexible IT system (upper right)
- Other extensive example is the Curriculum Course Syllabus Ontology (CCSO) by Katis et al. (2018)
- Ontologies available based on existing work from schema.org, implementation project specific for a German HEI





Sources: Meister, V.; Wenxin, H.: „A Knowledge Graph for Course Modules as an Efficient Information Management System for HEI", Proc. 6th International GSOM Emerging Markets Conference 2019: Management in Digital Age
Katis E., Kondylakis H., Agathangelos G., Vassilakis K. (2018) Developing an Ontology for Curriculum and Syllabus. In: Gangemi A. et al. (eds) The Semantic Web: ESWC 2018 Satellite Events. ESWC 2018. Lecture Notes in Computer Science, vol 11155. Springer, Cham. https://doi.org/10.1007/978-3-319-98192-5_11

Blooms Taxonomy as Semantic Structures: Capturing Competences

- Chimalakonda et. Al. present a number of structural ontologies to support learning processes (in schools)
- Here, focus is being put on the competence models as example to bridge the gap between design and execution level.
- Ontologies available, implementation project specific for schools in India

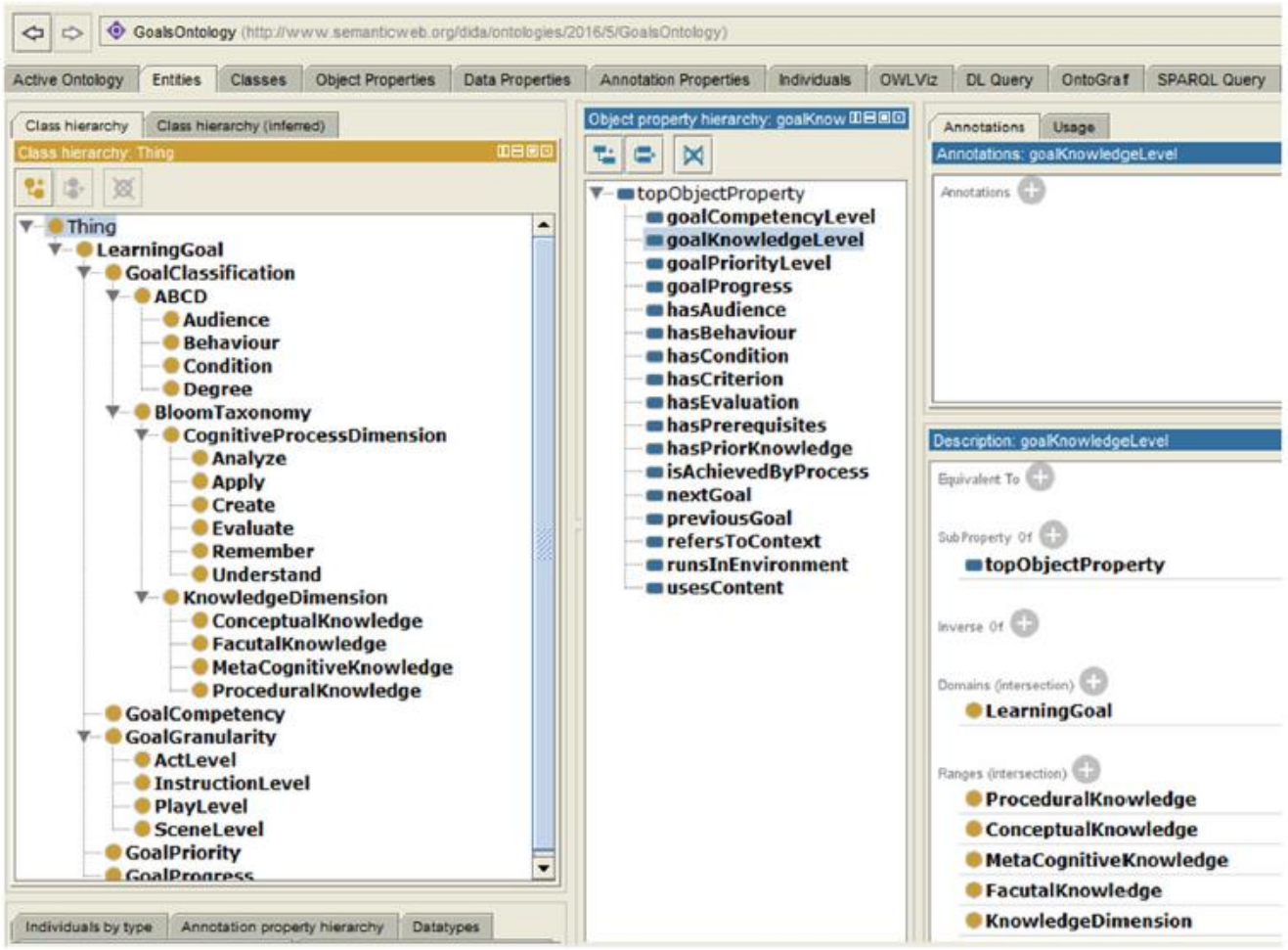


Fig. 6 A fragment of *GoalsOntology*

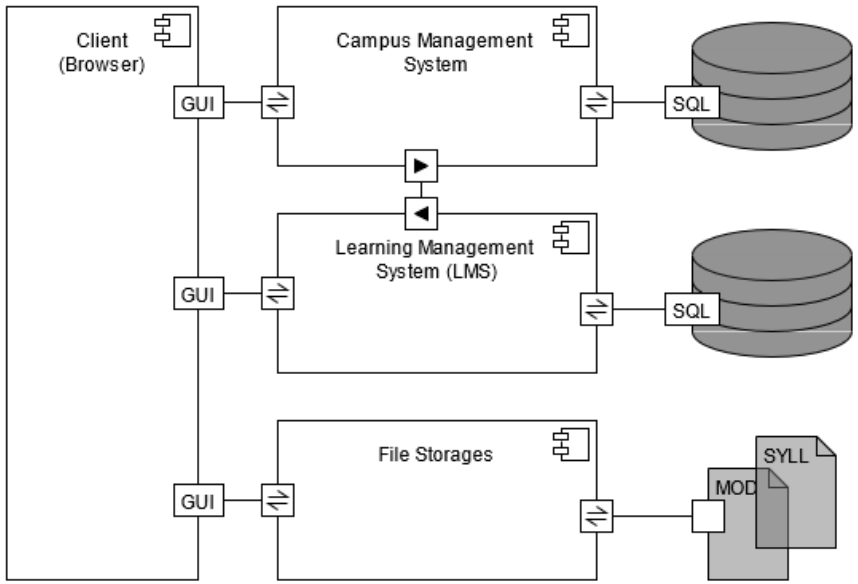
Source: Chimalakonda, S., Nori, K.V. An ontology based modeling framework for design of educational technologies. *Smart Learn. Environ.* **7,** 28 (2020). https://doi.org/10.1186/s40561-020-00135-6

Current approaches did not (yet?) find wide application

- Some hypothesis about possible reasons:
  - Approaches often followed a “new system perspective”
  - Knowledge representation tried to model the “whole universe of the HEI”
  - Are not easy to apply as they require a good understanding of new tools and methods (requires new knowledge and effort (!))
- With the concepts of clarity and agility in mind a more lightweight approach might be useful

Design goals of an IT-system to support CMs

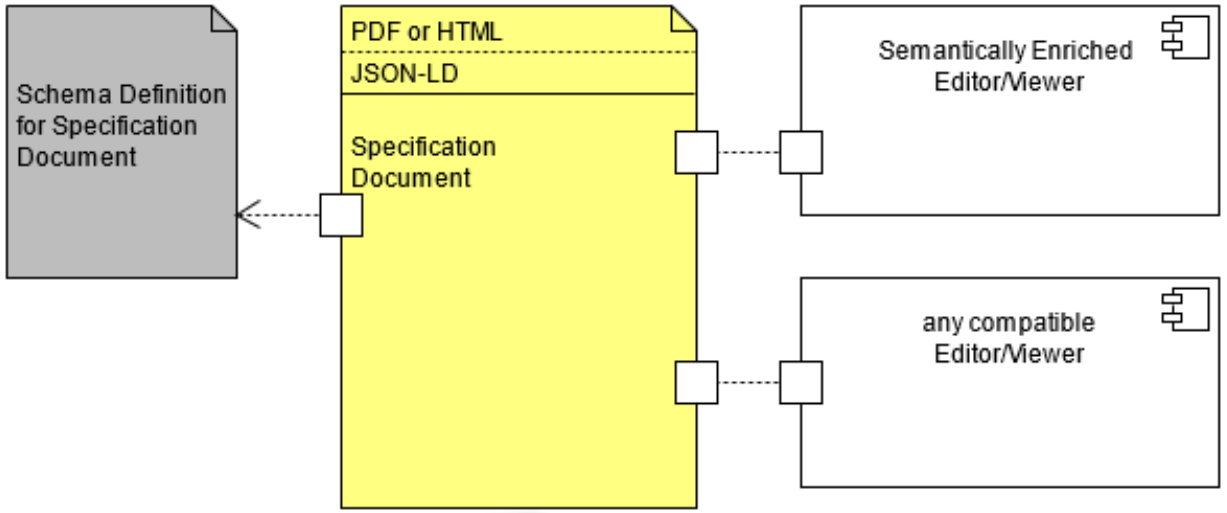
- Design goals for a more lightweight approach:
  - A system that can be used by lecturers and course designers without specific knowledge, e.g. about knowledge modelling
  - A system that can be used independently and in addition to existing system
  - A system that is document based and provides aggregation functions



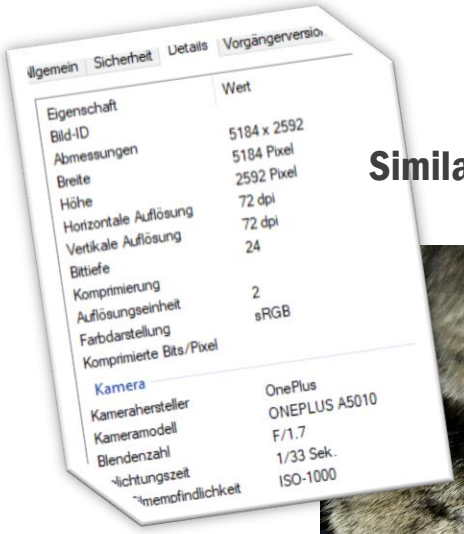
- Realization with a two-step approach

PreBuilt Information Spaces for education – Step I: Robust Web-based semantic documents

- Concept of a Semantic Specification Document (SSD)
  - Self-contained (content + semantic information)
  - Agnostic to semantic tooling
  - Robust local edits (only client needed)
  - Ease of use & low entry barrier (Browser-only, no Semantic Web knowledge needed)
  - Instances only, Schemas predefined



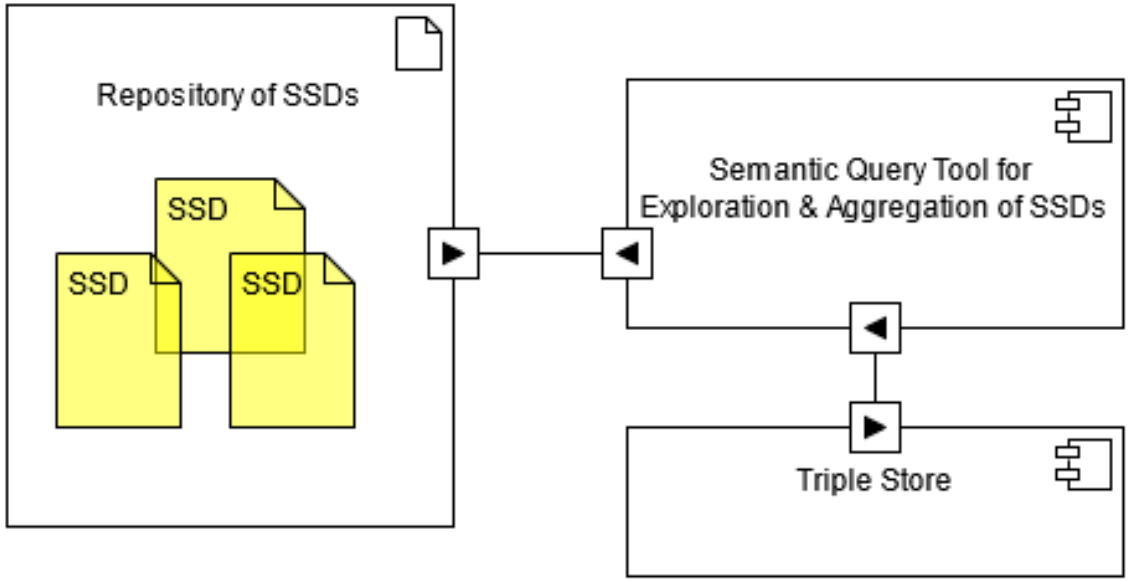
- A SSD contain a single description of a MOD or SYL
  - Local information on the instance level
  - Can easily be shared (as any other document)



Similar usage pattern: a digital photo

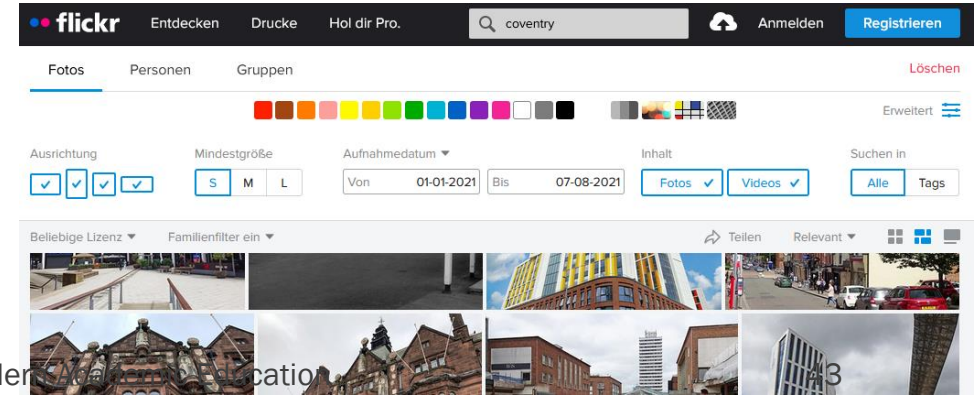
PreBuilt Information Spaces for education – Step II: Aggregation of documents

- In order to go beyond instance view, an aggregation of the SSDs is needed (the notion of Linked Data)
  - Connects the semantic information of the individual SSDs in a common place
  - Enables aggregated queries and view as well as consistency checks
  - Web-based Client/Server-system but still agnostic to a specific system → open to integration in existing systems via data transformation & filtering



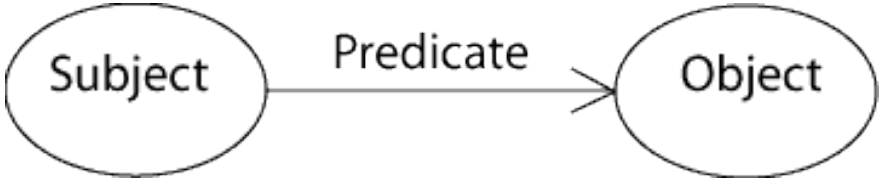
- Aggregation results in a in prebuilt information space that is supporting knowledge structuring in a HEI

Similar usage pattern: Flickr as platform

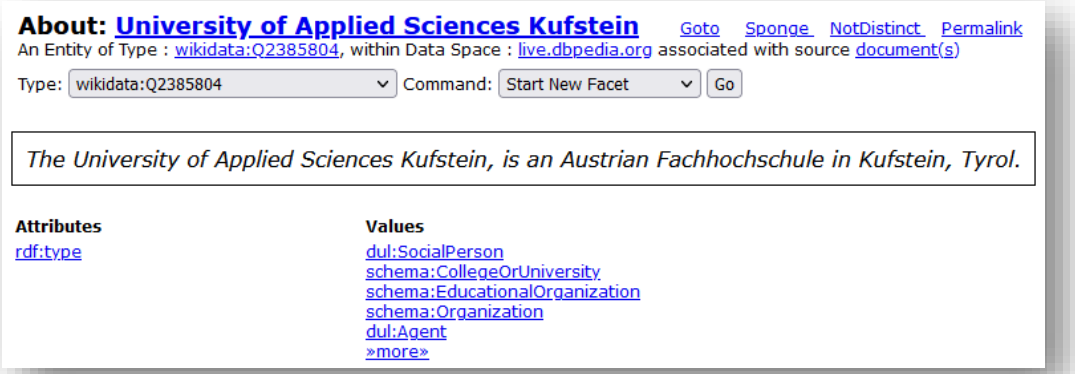


Implementation notes: Using semantic technologies

- The implementation will make use of Semantic Web technologies
- In brief "The Semantic Web is an extension of the current Web, in which information is given well-defined meaning, better enabling computers and people to work in cooperation."
  (minor edits of the quote for brevity, Source: T. Berners-Lee, J. Hendler, and O. Lassila. The Semantic Web, Scientific American, May 2001)



Source: https://www.w3.org/TR/rdf-concepts



http://live.dbpedia.org/describe/?url=http%3A%2F%2Fdbpedia.org%2Fresource%2FUniversity_of_Applied_Sciences_Kufstein&sid=40553

Implementation notes: Using semantic technologies

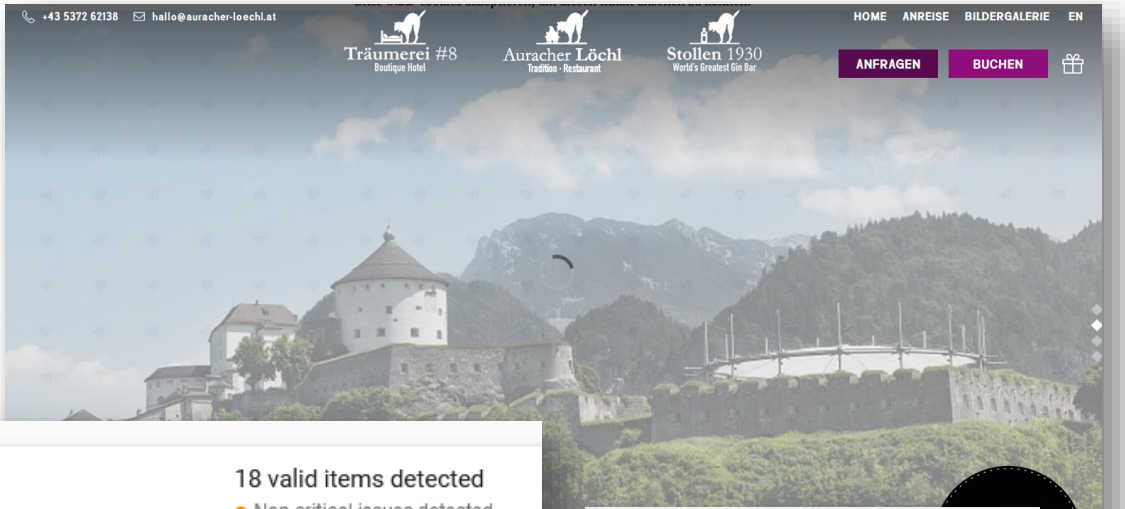
- Often called Linked Data or Knowledge Graphs – which puts the emphasis on linking structured data in a distributed environment (technical, organizational)
- The knowledge graph on linked Competence Matrices (CM) will represent the scaffolding of a education program of a HEI

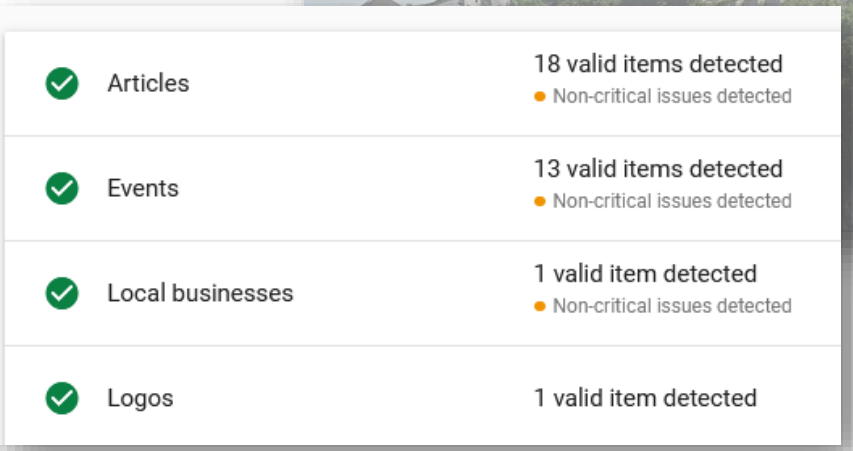
- Primary function of Linked Data / Knowledge Graphs are
  - (OK) the explicit and formal specification of data (facts) and their relation in triples
  - (OK) Accumulation in specific data-stores that can be queried to extract knowledge (triple-stores)
  - (not yet) A generalization of common concepts in so called ontologies

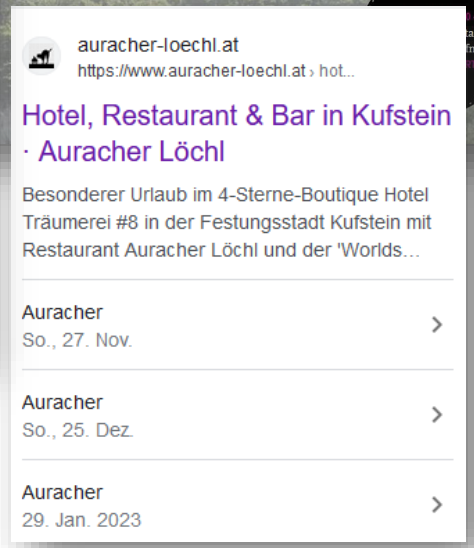
Implementation notes: Use of Microformats

- Microformats provide ways to include semantic information into a Web-page in a machine readable way

- Example with Restaurant information:
  - Source: https://www.auracher-loechl.at
  - Semantic information on the location and events the embedded
  - Used by Google in the presentation of search results







Beyond HEI's – the interfacing challenge: Prior Learning

- HEI Programs are not existing in isolation, integration becomes more important

- The Recognition of Prior Learning → Anticipating formal and informal competences when enrolling to the program
  - Is becoming more important for HEI
  - Interface between BA and MA programs → matching different curricula, a cumbersome task for program managers
  - Includes the recognition of informal competences → competences from job experiences hard to match due to the variety of task and the descriptive character of specifications

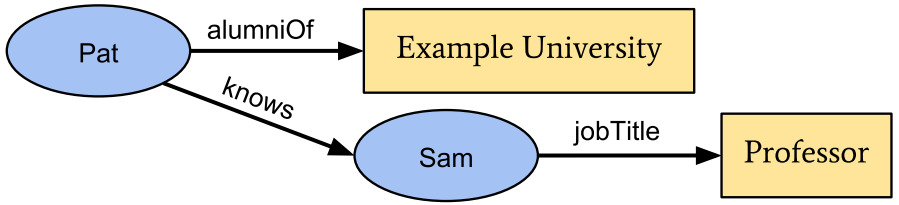
Beyond HEI's – the interfacing challenge: Lifelong Learning

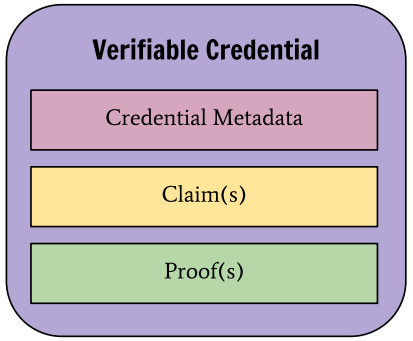
- HEI Programs are not existing in isolation, integration becomes more important

- Lifelong Learning → Documenting achieved competences at detailed level for consecutive programs or human resource departments of companies
  - More education components in CVs
  - More fragmentation of the skill sets among different education formats in different organizations
  - The documentation of results and achievements is/will be more detailed (e.g. transcript of records)
  - Unified view of skill sets is hard to obtain for HR departments (a manual work)

Beyond HEI's – the certification challenge

- Movements on providing universal means for standardization of achievements:
  - EU Europass Digital Credentials Infrastructure (EDCI)
    Source: https://ec.europa.eu/futurium/en/europass/europass-digital-credentials-infrastructure
  - W3C Recommendation: "Verifiable Credentials Data Model 1.1" (2022)
    Source: https://www.w3.org/TR/vc-data-model/#claims





Agenda

- 14.00 – 14.45h Introduction on the current situation in HEI & current developments
- 15.00 – 15.30h Interactive session: Warmup by reflecting the situation of the participants
- 15.30 – 16.15h Introduction of Pre-built information spaces for learning environments
- 16.30 – 17.00h Interactive session: Application of the concepts for different educational domains
- 17:00 – 17:30h Summary, Reflection and Wrap up, Take Away and preparations for the spring-session in 2023

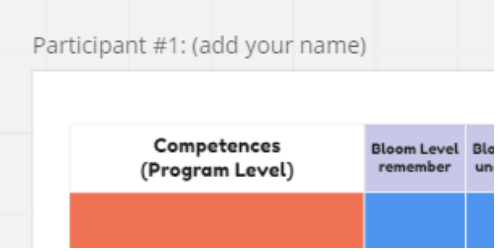
+15" Break

+15" Break

- All timing in CET

Interactive Part – your choice to try and reflect on HCMs

- A Miro board has been prepared to try our hierarchical concept maps for yourself:
  - Link to access the board: https://miro.com/app/board/uXjVPBBPnwI=/?share_link_id=780764949008
  - Pick one of the #18 boards for yourself and add your name at the top of your template to mark the board as yours



- Your Task: For one of your lectures, try to select a couple of competences and describe and classify them according to the Bloom-Taxonomy. Link the competence across the three levels: program / lecture series / lecture unit. You can start bottom up (from the indiv. lecture or top down from the Program level)
- Reflect on your observations and take notes with stickies on the template.

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Conclusion and Outlook

Summary // Outlook // Q&A

- **Get in touch** if you like:
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