MODAL - INSIGHTS INTO AN INTERDISCIPLINARY DATA LITERACY PROJECT WITH A PRACTICAL APPROACH

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One of the main missions of higher education is to prepare students for an increasingly digitalised future. This requires classic and digital competencies – the "Future Skills". "Mannheimer Model Data Literacy Education" (modal) is an interdisciplinary learning and teaching project at the Mannheim UAS, in which Bachelor's students of every faculty can train digital competencies. The following article introduces into the lecture series unimodal$_1$ and the data project bimodal$_2$. Both programmes encourage the training of Data Literacy, a model of competencies with a similar approach to Statistical Literacy and related terms. This involves participation in the "Skill Week", a workshop series that includes entry-level modules in statistics, data analytics, and visualisation. Both programmes follow a modal Data Literacy framework comprising five competency fields. Through self-assessment, the participants were asked to judge their own development in each competency after the modal programme.

THE MOTIVATION BEHIND A DATA LITERACY EDUCATION PROGRAMME

The Mannheim University of Applied Sciences (Mannheim UAS) is committed to preparing students to take an active part in technological, professional, and societal transformations that require a specific set of competencies. The mission is to create a setting for students to develop competencies for Citizenship and Employability, as declared learning outcomes for German university graduates. In its implementational strategy to shape digital change, the federal government aims to create infrastructures for every citizen to take advantage of the opportunities offered by digitisation, shape digital change themselves in a self-determined manner, and be able to deal with the risks responsibly. All levels of the education system should be further geared towards digital life (Die Bundesregierung, 2021). It is important to systematically integrate these future-oriented competencies into education; especially into curricula of universities (Schüller, 2020). Concerning the world of work, companies from all industries are seeing an increasing demand for employees with fundamental data skills (Kirchherr et al., 2018).

Future Skills framework as a starting point and the role of Data Literacy

To prepare its students for an increasingly digitalised world as best as possible, the Mannheim UAS educates its students with a wide range of classic and digital competencies. To do this, the concept of *Future Skills*, shown in Figure 1, is taken as a basis (Kircherr et al., 2018).

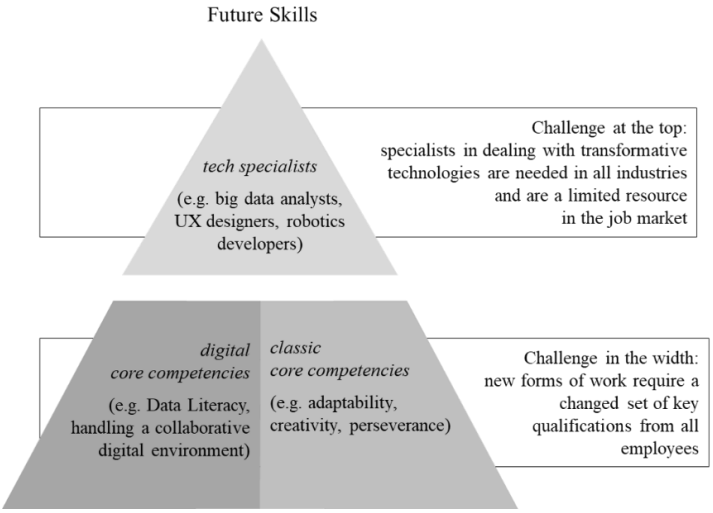

Figure 1. Future Skills pyramid by McKinsey and Stifterverband (Kircherr et al., 2018)

Especially for the future viability of graduates, this requires a bundle of classic and digital core competencies and technological competencies. Thus, the Future Skills form a bundle of interdisciplinary competencies in order to take an active part in digital transformations in society and employment. Future Skills become more and more important across all branches and disciplines (Kircherr et al., 2018).

In the context of Future Skills, Data Literacy is seen as a bundle of cross-sectional digital core competencies (Figure 1), which are essential for the orientation and participation in the digital world of science, as well as work and society. Data Literacy is the ability to deal with data in a planned manner, to use data in appropriate contexts, and question data consciously. This includes collecting, exploring, managing, curating, analysing, visualizing, interpreting, contextualizing, assessing, and applying all forms of data (Stifterverband, n.d.). In this understanding of Data Literacy, other terms as "Information Literacy", "Digital Literacy" and "Statistical Literacy" are often interchangeable, since the underlying concepts are quite similar (Schüller et al., 2019).

The acquisition of competencies

In general, acquisition of competencies takes place through reflected testing and experience within a social situation (Dirsch-Weigand & Hampe, 2018). Development of competencies is a prerequisite for, and a result of, self-organised learning (Arnold, 2010). Self-organisation means active learning, in which the students design their own learning processes and take ownership of their own education (Arnold & Schön 2019). This assumes the abilities to reflect on one's own actions and the social learning situation in its entirety (Arnold, 2018). Accordingly, to promote the acquisition of competencies, activating methods and project work on complex problems should be applied (Lerch, 2017).

Interdisciplinary teaching-learning environments represent a particularly promising didactic setting for the development of interdisciplinary competencies such as Data Literacy (Bandtel & Trefs, 2019). According to Schüller et al. (2019) complex data projects require interdisciplinary perspectives and collaborative work. Furthermore, for Ridsdale et al. (2015), interdisciplinary cooperation between teachers is a necessary condition for the systematic promotion of Data Literacy.

INTERDISCIPLINARY DATA LITERACY EDUCATION AT THE MANNHEIM UAS

The majority of Mannheim UAS students already have courses integrated in their curricula, in which they can elaborate on field-specific data competencies and, especially in STEM courses, technological competencies. However, modules and courses that involve active training on digital and classic core competencies are rarely implemented in the Bachelor's courses, which often have a purely theoretical and subject-specific approach. *Open Disciplines* is a strategic central concern of the Mannheim UAS with the goal of systematically promoting the acquisition of interdisciplinary problem-solving competencies for its students (Hochschule Mannheim, 2017).

The learning and teaching project Mannheimer Model Data Literacy Education (modal) addresses this mission: A three-level programme enables students of all Bachelor's courses an entry-level introduction and consecutive development of Data Literacy competencies and Future Skills in interdisciplinary contexts. The modal project is funded by the Heinz Nixdorf Foundation and Stifterverband since the winter semester of 2018-19.

For the Mannheim UAS, this means the conception of a Data Literacy education programme for approximately 5,200 students in 9 faculties including 24 different bachelor's courses. This programme must address students of STEM, social, and design courses in an interdisciplinary setting in order to train Future Skills beyond the borders of various academic fields, especially Employability, Citizenship, and technological maturity.

Building on a broad foundation with the entry-level unimodal_1, more advanced skills are gradually trained in an application-related manner. In level bimodal_2, interdisciplinary data-driven teamwork is introduced, and in level trimodal_3, a research project is carried out in cooperation with practice partners and their data sets. Each competency level is geared towards a five-competency-field modal specific framework, which is further explained in the following chapter.

This paper gives a closer insight into the operationalisation of Data Literacy competencies and their promotion in activating interdisciplinary teaching-learning environments of modal – especially into the entry-level unimodal_1 (sensitisation on data handling), and the mid-level bimodal_2 (experience

of data handling). These two programmes were successfully transferred into a digital setting due to COVID-19 distance measures.

Operationalisation of the modal Data Literacy competencies framework

To operationalise the specific learning outcomes of modal, the Data Literacy frameworks by Ridsdale et al. (2015) and Schüller et al. (2019) were merged. The result is a suitable five-competency-field framework for modal:

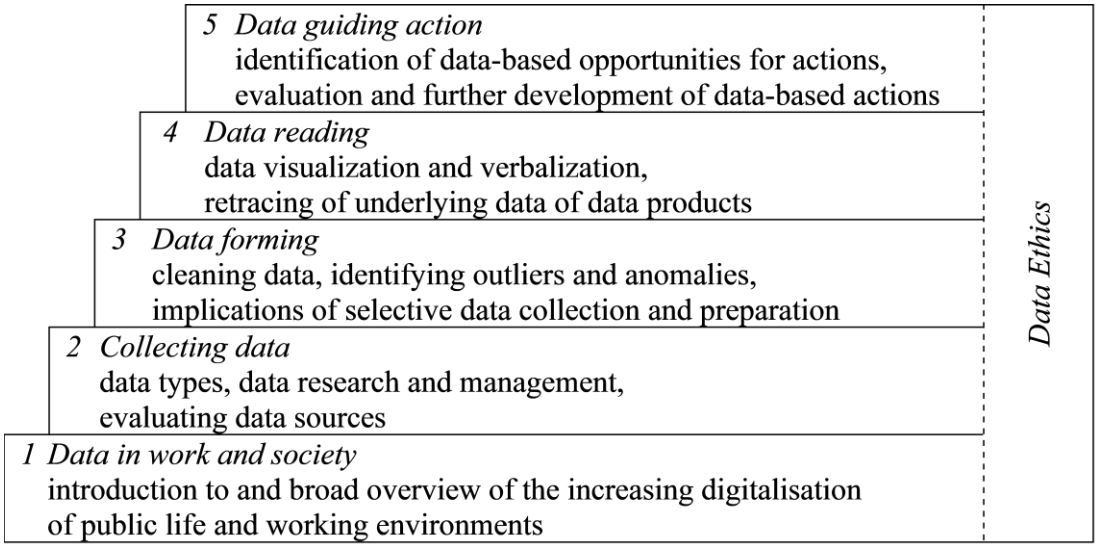

Figure 2. Five competency fields of modal Data Literacy framework

This five-competency-field framework shown in Figure 2 is based on the cyclical process model of value creation by Schüller et. al (2019). Each field depicts one step of the iterative movement from objects in the real world to data, information, knowledge, and wisdom. Following this value creation process from bottom to top, there is an increase of complexity. According to Schüller et. al (2019) *Data Ethics* is perceived as fundamental for Data Literacy and accompanies all steps throughout the process of creating value from data.

Level unimodal$_1$ - Lecture series

Ridsdale et. al. (2015) point out "Introduction to Data" as the starting point of the acquisition of Data Literacy. Therefor, "knowledge and understanding of data" as well as "knowledge and understanding of the uses and applications of data" are underlying tasks. With respect to modal, the entry level unimodal$_1$ concerns sensitisation on cautious handling of data within professional and societal environments, and reflection on one's own attitude towards data handling.

The unimodal$_1$ level consists of an (online) lecture series called "Donuts & Digitalisation", which primarily addresses university entrants. The series consists of five non-iterative lectures from speakers of various fields of practice, assigned to the five competency fields of modal framework. The focus lies in practical relevance and orientation. The speakers present their lectures clearly and encourage a high level of interaction. Each lecture stands alone, no previous knowledge is necessary, shown in Figure 3 (competence field, title, institution, semester).

Every lecture is complemented by a thematically related online assignment, provided on the commonly used learning management system of the Mannheim UAS. Participants individually practice data collection, management, evaluation, interpretation, and visualisation with basic tools and methods. Successful participation in at least 3 of 5 lectures and online exercises is rewarded with the *unimodal$_1$ certificate for digital core competencies*, signed by the vice-rector for academic affairs.

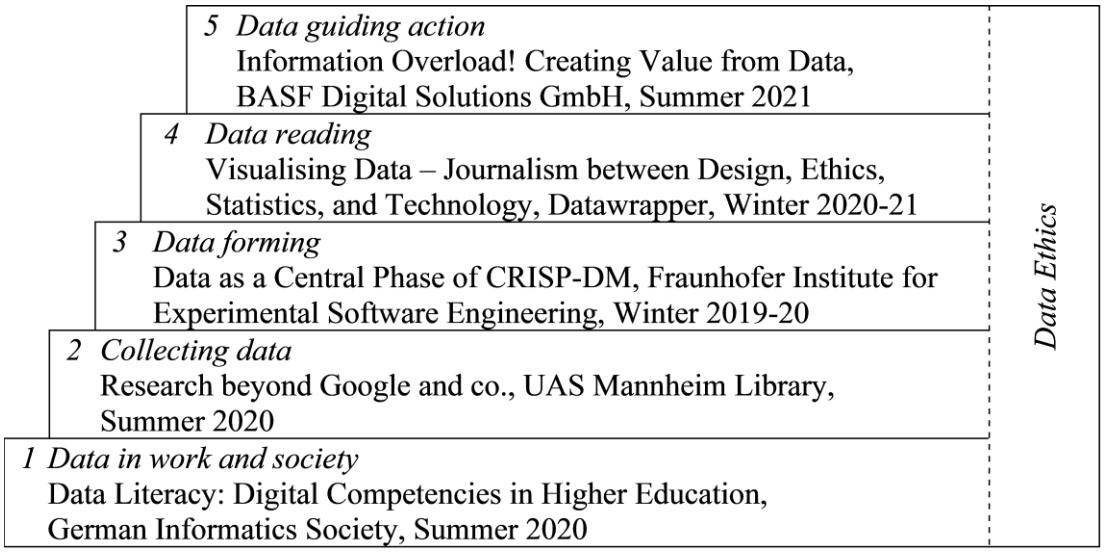

Figure 3. unimodal$_1$: operationalisation of the modal Data Literacy framework

unimodal$_1$ gives an overview on data-driven work in different branches and contexts. The targeted learning outcomes are the sensitisation on various practical fields of Data Literacy, the reflection of one's own handling of data in a critical, methodical, and responsible manner, and a fundamental understanding of Data Ethics as cross-sectional competencies. Therefore, the experience of heterogeneity and diversity is a central concern of unimodal$_1$. For instance, students can debate and interact with role models like women in STEM regarding various data and digitalisation contexts.

Level bimodal$_2$ - Interdisciplinary Data Project

In the interest of the deepening training of Data Literacy competencies, the focus of the level bimodal$_2$ lies on trying out and developing hands-on experience in Future Skills in an interdisciplinary project-based environment. Bachelor's students of all subjects, usually in their second semester, work in small groups on current complex social issues within the span of ten weeks. The participants elaborate data-driven concepts and prototypes for self-chosen issues from broad social umbrella topics with direct relevance to their lives, such as urban life, mobility, and digitisation of learning and teaching. The development of concepts and prototypes takes place in a user-oriented iterative design process. Thereby, the students work in the best possible self-coordinated manner. Participation in bimodal$_2$ is recognized as a study achievement in all faculties at the Mannheim UAS.

The interdisciplinary teams compete against each other in a closing event open to members of the Mannheim UAS and pitch their projects in front of an expert panel. The most convincing solutions win attractive and topic-related prizes. Proficient peer tutors from senior semesters support the participants in their interdisciplinary data-driven teamwork. A working group of professors from all faculties and employees from central units (e.g. library or technical management) support the teams in solving field-specific and technical problems. Cooperation partners from business, administration, and civil institutions also support the students with their expertise.

Training of Data Literacy competencies and Future Skills

Regarding the Future Skills pyramid in Figure 1, both digital and classical core competencies are trained equally in interdisciplinary data-driven teamwork. Ideas and preparations within the interdisciplinary teamwork are meant to be data-driven and identify challenges and user needs in ecological, societal, and economic dimensions. For the data driven concept development, participation in the so-called *Skill Week* is mandatory. This workshop programme includes entry-level modules on collecting and analysing data with statistical methods, as well as visualizing and presenting data. The workshops are held by data professionals of the Mannheim UAS. At least one member of all teams takes part in one unit of the Skill Week. Students not only become familiar with the tools, but also actively pass their knowledge on to other team members (jigsaw method). The Skill Week workshops provide methods and tools for data-driven concept development steps:

Data Collection. At the beginning of the teamwork, the teams research existing data sets and studies related to the umbrella topic. In this way, they develop an understanding of the problem and identify different sub-issues and research questions. In sources such as Mannheim Open Data (City of Mannheim) or professional databases such as the database of the Institute of Electrical and Electronics Engineers (IEEE), students will find for example initial information about their target group(s). Based on this data, they develop solution concepts for their chosen question and build first prototypes.

Data Inquiry. To further develop the project, the teams seek feedback from domain experts inside and outside the Mannheim UAS. Based on the method of the guideline-based expert interview, they inquire after experience and specialist knowledge on specific problems in construction and/or challenges in implementation. The students then approach their target group(s) with their solution concepts and first prototypes and ask for feedback. Usually, the teams are interested in whether the proposed solutions are suitable for their identified demands, and what suggestions for improvement the potential users might have, which are collected through questionnaires and (online) surveys.

Data Analysis. The collected data is evaluated according to the principles of quantitative and qualitative methods of empirical social research, e.g., diagrams and creating personas. The results are used as a basis for further development of concepts and prototypes. Also, the results are pointing the way for the project elaboration.

Data Visualisation and Presenting Results. The teams compete against each other in a final event, in which they are required to visualise the results of their data handling. In the pitch, it becomes clear which data was used and how the results of the analysis were incorporated into the concept development.

Pertaining the modal Data Literacy framework, the workshops primarily cover the competency fields of *collecting*, *forming* and *reading data*, shown in Figure 2. Beyond the Skill Week, the entire programme of bimodal$_2$ is geared towards the training of all five modal fields of competencies. Students work with real data from work, society, science, and business (*level 1 Data in work and society*) and make data-driven decisions for their concepts (*level 5 Data guiding action*).

The focus of the project is centred around trying out to work with data, gaining initial experiences in the application of statistical methods, and following the value creation cycle through to presentation of the student's own results in order to practice applying empirical social research methods.

EVALUATION AND ACCOMPANYING RESEARCH

In the trial phase of these innovative teaching-learning formats, evaluation is of great importance. In modal, formative and summative procedures as well as standardized and qualitative instruments are used in the course of each semester. Regular feedback sessions with tutors have proven to be particularly beneficial.

The bimodal$_2$ participants (n=28) were asked in a multiple-choice question which competencies of Skill Week they found most beneficial for their project work. Selected results from the winter semester 2020-21 are listed as an example. The design of presentations was the most popular at 16%, alongside interview/survey evaluation (16%), followed by preparing questionnaires (15%), introduction to survey software (13%), and preparing interview guides (10%).

In addition, the effectiveness of each programme was measured by self-assessment from the participants. With the competency grid from Eichhorn & Tillmann (2018), digital competencies of all participants were recorded on six sub-dimensions. All scales used meet the appropriate statistical test quality standards. Surveys took place at the beginning and the end of the semester through an online questionnaire. In the pre-post design, mean value comparisons are made.

In the winter semester of 2020-21, the bimodal$_2$ participants (n_{entry}=27; n_{exit}=28) rate themselves as average or below average. On the *Digital Science* subscale (mean $score_{entry}$ = 2.53; six-point answer scale) the self-assessment results were relatively low, whereas the input scores on the subscale *Analysis and Reflection* were higher (mean $score_{entry}$ = 4.22). By the end of the Semester, a higher mean value was observed compared to the beginning of the semester on five out of six subscales. The largest difference between the questionnaires at the start and the end of the semester was shown on the *Digital Science* subscale (mean $score_{entry}$ =2.53 and mean $score_{exit}$ = 3.69, respectively). This means at the end of the bimodal$_2$ project, the participants rated their competencies to "use and produce digital data, sources, methods and publications in order to achieve scientific

goals" (Eichhorn & Tillmann, 2018) higher compared to the beginning. More profound insights into evaluation methods and results can be taken from Bandtel, Kauz & Weissker (in press).

The discussed findings should be interpreted cautiously considering the small sample size and numerous uncontrolled variables. Nevertheless, they indicate that students perceive a strong requirement for the development of digital competencies that is not currently addressed by existing curricular teaching-learning offers.

It should be noted, however, that the exit survey revealed considerable development potential for digital competencies in all dimensions. It is clear, that teaching and learning programmes should not only once and selectively be offered, but over the course of the whole curriculum with a gradually increasing complexity. Integrating Data Literacy more deeply into the curricula of all subjects should be a priority in the development of higher education.

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