Master Data Management in Higher Education: Enhancing Effectiveness Study on Universities from Romania and Germany

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In the rapidly evolving European higher education landscape, effective data management is critical to achieving operational excellence and informed decision-making. Our study explores the importance of Master Data Management in European higher education, focusing on institutions in Romania and Germany. Using a maturity assessment framework, it evaluates current Master Data Management practices, identifies key gaps, and recommends strategic improvements to enhance data quality, consistency, and accessibility. These insights aim to help university administrators create efficient, data-driven educational ecosystems supported by modern IT infrastructure, ultimately aligning with academic and operational objectives.
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1 Introduction

The coronavirus pandemic is not the first event to highlight the rapidly changing situation in Higher Education: the systems on which teachers and students rely are becoming increasingly data-based [1]. Master Data Management is a central component of Data Management in the Higher Education landscape and forms the basis for informed decision-making, efficient processes, and strategic planning in Higher Education. In an increasingly digitized world, where data is considered the “new oil” [2], the quality and management of Master Data is becoming crucial [3]. Master Data includes an organization's core data, in the context of Higher Education, students, university staff, academic and non-academic departments, curricula, and other university programs that are reused in various business functions and processes.

The evaluation of Master Data Management aims to assess the maturity of the corresponding processes, technologies and organizational measures. A high level of maturity in Master Data Management reflects an organization's ability to effectively manage Master Data to ensure a consistent and reliable data foundation. This is particularly important in Higher Education institutions, as these organizations not only coordinate academic and administrative processes but also serve a variety of stakeholders, including students, faculty, and administrative staff.

This paper examines the maturity of Master Data Management using the example of Higher Education institutions in Romania and Germany. The selection of these countries allows for an interesting comparative analysis, as they have different educational systems, cultural backgrounds and levels of technological development. A comprehensive assessment is used to determine the extent to which the Higher Education institutions under consideration are able to manage their Master Data effectively and which factors influence the maturity of Master Data Management in these institutions.

The aim of this study is to gain practical insights into how to optimize Master Data Management in Higher Education institutions. It identifies both best practices and potential challenges that Universities in Germany and Romania should consider when implementing and developing their Master Data Management. In this way, the work contributes to improving data quality and the efficiency of University administration, which can ultimately help to increase the performance and competitiveness of the institutions concerned.

2 Foundation and related Work

To present the theoretical background, the researchers use a theoretical research framework (Fig. 1), with the central terms for this

study - the university as an operational system, Master Data and Master Data Management in the university system - being described in more detail.

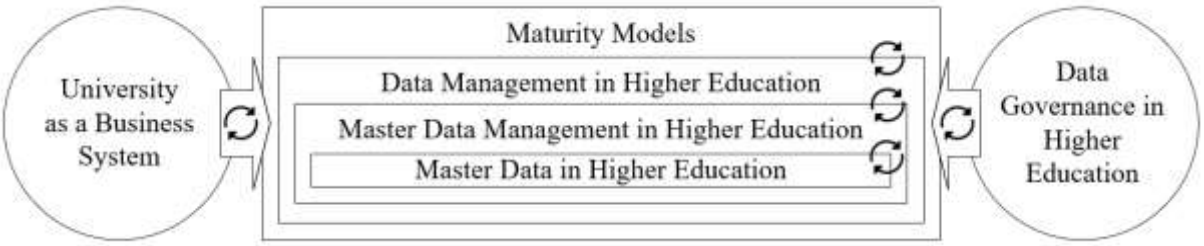

Fig. 1. Theoretical Research Framework

2.1 The University as a Business System

As an operational system, the university is a complex, organized unit that integrates various resources, structures and processes to achieve its goals. Like every operational system, it consists of several subsystems that interact dynamically with each other and are geared towards fulfilling the university's core tasks: education, research and knowledge transfer.

The primary goal of a university is to create, impart and transfer knowledge to society [4]. This is done through research, teaching and the promotion of young scientists. In addition to these core tasks, internationalization, cooperation with industry and social responsibility also play an important role.

The university is hierarchically organized in its structural sense, with a variety of organizational units, including faculties, departments, institutes, and administrative units. The administrative units support the core tasks by providing services in areas such as human resources, finance, IT, facility management, and student administration. Academic self-government, often through committees such as the senate or faculty councils, ensures participatory decision-making that considers the interests of teachers, researchers, and students.

As an operational system, the university requires various system resources to fulfil its tasks. These resources include material resources (buildings, laboratories, libraries, IT infrastructure and other facilities), financial resources (budget funds, third-party funds from research projects, tuition fees and other income), human resources (university teachers, scientific staff, administrative staff and students) and informational resources (data, research and teaching materials, as well as the knowledge and expertise of employees).

The university as a system encompasses a variety of processes that contribute to achieving its goals. These include teaching processes (planning, conducting and evaluating courses and supervising students), research processes (planning and conducting research projects, publishing research results, acquiring third-party funding), administrative processes (enrolment, examination administration, human resources administration, financial management and infrastructure management) and decision-making processes (strategic planning, committee work, quality management and accreditation procedures).

The university is in constant exchange with its surrounding environment. It interacts with the state (e.g. through laws and funding), the economy (e.g. through cooperation and technology transfer), society (e.g. through social projects and further education) and the global science system (e.g. through international cooperation and the exchange of knowledge).

The university management ensures that the various subsystems work together effectively. This includes strategic control by the executive board or the rector, as well as operational control at the lower levels by faculty leaders and administrative managers. Quality management and accreditation processes guarantee continuous improvement of teaching and research.

The cultural climate at a university shapes the way it functions as an operational system. Academic freedom, scientific excellence, equal opportunities and the promotion of critical

thinking are central values that guide the behavior of the actors within the university.
Overall, the university can be described as a complex, open, goal-oriented, socio-technical system [5], [6] that is determined by internal and external interactions. Their ability to respond flexibly to changes in their environment and to balance the diverse interests of their stakeholders is crucial to their long-term success and innovative strength. In this study, two universities – one in Romania and the other in Germany - are analyzed in terms of their maturity in Master Data Management.

2.2 Data Governance in Higher Education

In the digital world, Data Management is becoming increasingly central as companies are becoming more and more data-driven. Solid Data Governance ensures that data provides a reliable basis for informed decisions, minimizes risks, and ensures compliance with legal requirements [7].
Data Governance refers to the framework and processes that an organization implements to ensure that its data is managed, used, and protected in a systematic and effective manner [8, p. 148]. It includes guidelines, standards, and responsibilities that control the handling of data and ensure its quality, security, and availability [9, p. 37]. It also includes control mechanisms to monitor the value contribution of Data Governance, as well as successful communication to inform all parties involved about the reasons for Data Governance and to present all defined standards transparently [10].
In the real world of business, Master Data Management and Data Governance are closely related concepts, since both aim at the efficient and controlled management of data. Master Data is often one of the most important categories of data in a company. Despite their different focuses, Data Governance and Master Data Management work complementarily to one another. Data Governance establishes the guidelines for managing Master Data, while Master Data Management implements these guidelines through concrete processes. If Master Data is of inferior or poor quality, it can have a massive impact on decision-making and operational efficiency. In this respect, Data Governance addresses the issue of ensuring data quality. Data Governance sets guidelines for security and compliance, while Master Data Management ensures that Master Data meets these requirements. This may mean that Master Data is correctly encrypted, secured and can only be viewed by authorized users.
In summary, Data Governance provides the basic foundation and set of rules, while Master Data Management ensures the practical management and maintenance of the most important data resources. Both must work hand in hand to ensure that data in an organization can be used effectively and protected.

2.3 Master Data in Higher Education

In the Higher Education sector, Master Data refers to the core data that is essential for the basic operations of educational institutions such as universities or colleges. In general, Master Data is usually consistent, non-transactional, and relatively stable over time [11], [12]. They serve as the authoritative source for critical entities and help maintain consistency across different systems and processes.
Master Data in Higher Education is a critical element for maintaining efficient, consistent and reliable operations in various areas of an Higher Education institution. This includes data on students, courses, programs, faculty, staff, departments and campuses, as well as financial and governance data (Fig. 2; Appendix, Table 3).

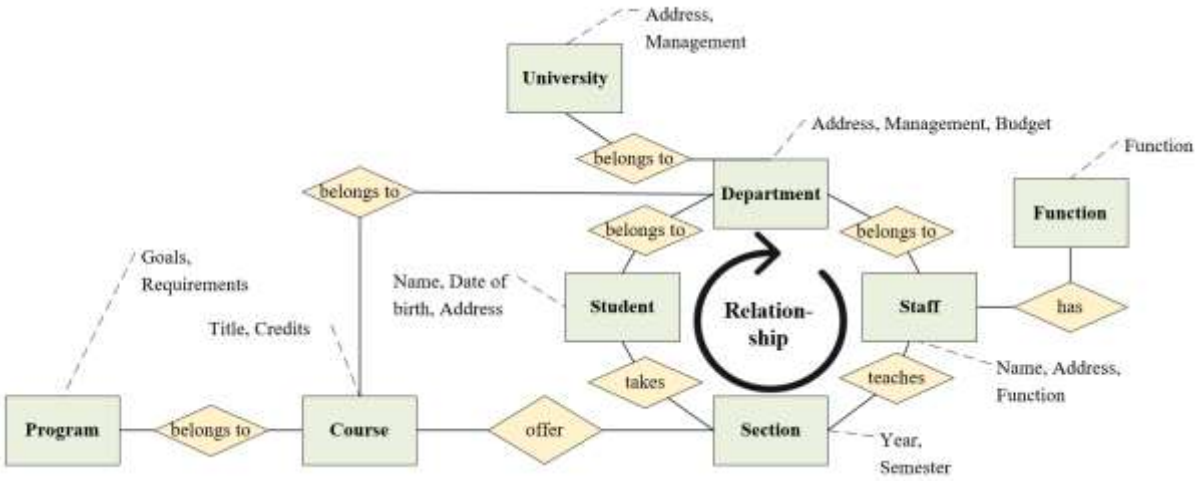

Fig. 2. Master Data Model for Higher Education (Excerpt)

The importance of Master Data in the Higher Education sector lies in its role as the "single source of truth" for its important entities and concerns the following points in detail:

1. Operational efficiency: Master Data serves as the single source of truth, ensuring that all departments and systems have access to consistent and accurate information. This reduces duplicate work, minimizes errors, and streamlines processes such as admissions, course registration, and financial aid management.
2. Improved decision making: Accurate and reliable Master Data is essential for data-driven decision making. It helps administrators and faculty analyze trends, monitor performance, and strategize for the future.
3. Regulatory compliance: Educational institutions must comply with various regulations and accreditation standards. Master Data helps ensure that data reported to regulatory bodies is accurate and consistent.
4. Improved student experience: Consistent and accurate data on students, courses, and programs ensures that students receive the right information and services, improving their overall experience at the institution.
5. Data integration and interoperability: Master Data serves as the basis for integrating various information systems, such as student information systems (SIS) and learning management systems (LMS), and promotes interoperability and seamless data sharing.

Those responsible for managing Master Data in the Higher Education sector face the following challenges:

1. Data quality and accuracy: Ensuring that Master Data is accurate, up-to-date, and free of duplicates or errors is a major challenge.
2. Data Governance: Establishing clear guidelines, roles, and responsibilities for Data Governance across departments can be complex in decentralized institutions.
3. Data integration: Integrating Master Data across multiple systems and platforms, especially in institutions with legacy systems, can be technically challenging.
4. Security and privacy: Protecting sensitive information (e.g. personal data of students and employees) in accordance with data protection regulations such as FERPA in the US or GDPR in Europe requires robust security measures.

An appropriate MDM system must address the challenges mentioned.

2.4 Master Data Management as a Process for increasing the Value of critical Entities in Higher Education

Master Data Management as a specialized Data Management can be used in Higher Education to significantly increase the value of Master Data on students, courses, study programs, faculty, staff, departments and campuses, as well as financial and governance data. This is reflected in the mention of Master Data Management in the "Hype Cycle of

Education 2023", "Slope of Enlightenment" area [13]. Gartner analysts predict that the "Plateau of Productivity" will be reached in 2 to 5 years.

Master Data Management is the process of collecting, organizing, maintaining, and curating Master Data in a central, reliable, and consistent data source [11], [14], [15]. In terms of the aforementioned Master Data, this means that the information remains consistent, accurate, and up to date and can be used efficiently by different departments and systems. The main components of Master Data Management include dimensions like the object of Master Data, Data Culture, Data Quality, Data Protection and Security, Organization, Resources and Controlling [16].

The importance of Master Data Management in Higher Education can be broken down into several key points:

1. Create a central data source: Effective Master Data Management ensures that Master Data is centralized, consolidated and uniformly managed in Higher Education institutions to avoid redundancies and increase data quality.
2. Improved data quality: Master Data Management enables Higher Education institutions to ensure that their Master Data is accurate, consistent and up-to-date, which is particularly important for reporting, accreditation, research analysis and general decision-making.
3. Efficient administration and compliance: Master Data Management helps universities comply with legal requirements and data protection guidelines related to their Master Data by defining clear responsibilities for data administration and ensuring compliance through continuous monitoring and audits.
4. Optimization of business processes: Well-implemented Master Data Management can help to improve efficiency in the administrative and operational processes of the university. It facilitates the administration of admissions, enrolment, examinations, finance and human resources by providing access to consistent and up-to-date Master Data.
5. Supporting digital transformation: Higher Education institutions are faced with the challenge of digitizing their processes and integrating new technologies. Master Data Management plays a key role here, as it enables the integration and analysis of large amounts of data and forms the basis for innovative approaches such as learning analytics, personalized learning paths and data-driven research.
6. Improved decision-making: Centralized Master Data Management provides a "single source of truth" that delivers consistent and reliable data to the university's managers and decision-makers. This facilitates informed decision-making and strategic planning, such as developing new study programs or optimizing resource allocation.

Overall, Master Data Management in Higher Education helps to promote a data-driven culture, increase efficiency and quality in all areas of the institution, and better adapt to the changing demands of the digital world.

2.5 Maturity Model

A maturity model is a structured tool for evaluating and improving processes, capabilities or structures within an organization [17]. It describes various stages of development (maturity levels) that an organization or a specific area can go through, from initial and often poorly structured conditions to optimal, efficient and highly optimized conditions.

A maturity model consists of several stages that reflect the progressive development of a specific area, with each stage describing a higher level of effectiveness, efficiency or control. The number of maturity levels can vary, but five or six levels are known. It is used to assess the current state (maturity level) of an organization in a defined area - here, Master Data Management - and to identify potential for improvement, which organizations can use to identify weaknesses and take measures to achieve higher maturity levels. It is important to note that maturity levels cannot be skipped; each level must be passed through.

Examples of maturity models are the "Capability Maturity Model Integration (CMMI)" [18] for assessing the level of maturity in project management or the "EFQM Excellence Model" [19] or "DIN EN ISO 9004:2018" [20] for assessing the level of maturity in process management.

3 Methodology

The methodological approach in this research is carried out in several steps (Fig. 3).

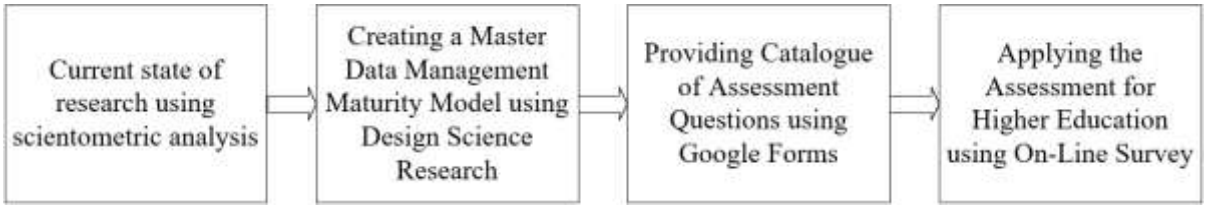

Fig. 3. Theoretical Framework

The starting point for the research was a scientometric study of the current state of research in the field of Master Data Management [21]. The results show that Master Data and their meaningful management represents a long-term challenge for business organizations over time. In order to derive targeted options for improvement in this area, it is recommended that business organizations determine their level of maturity in Master Data Management.

In a second step, a maturity model for Master Data Management was created according to Design Science Research [16], [23], which considers the previous results on maturity models in data management, Master Data Management and Data Governance and overcomes identified gaps. It consists of six organizational factors, 23 assessment factors in eight areas and six maturity levels.

To test the developed maturity model in real-world organizations, a questionnaire for an assessment was developed [22]. Each assessment factor was addressed by a question with one answer for each maturity level, with only one answer possible per question. The questionnaire was pre-tested and validated and applied for the first time at a Germany-based industrial company [24]. In this study, the questionnaire was applied to Higher Education.

4. Use Cases

The organizations evaluated in this study are Higher Education institutions, one in Romania (ORG1) and one in Germany (ORG2). Table 1 shows the results for the organizational factors that can influence Master Data Management in general and in its parts at an ORG

The location (No. 1) provides an indication of the regulatory environment in which the company operates. The industry (No. 2) can provide clues as to whether the company belongs, for example, to a country's critical infrastructure. The headcount (No. 3) and turnover (No. 4) provide an indication of the company's personnel and financial strength. The other characteristics (Nos. 5-9) provide information on the complexity of the operational organization in terms of structure and behavior.

Table 1. Organizational factors that can influence Master Data Management

No.	Organizational Factor	Organization 1	Organization 2
0	Abbreviation	ORG1	ORG2
1	Location	Romania	Germany
2	Type of Higher Education Institution	Research University	University of Applied Science
3	Headcount	0 bis 49	0 bis 49
4	Revenue (last year) in EUR	< 2 Mio	< 2 Mio
5	Does the organization have other independent legal entities?	Does not apply	Applies
6	Are different business processes established in the organization?	Does not apply	Does not apply

No.	Organizational Factor	Organization 1	Organization 2
7	Are different business processes established in the organization?	Applies	Applies
8	Does the organization use different IT systems?	Applies	Applies
9	Is there a regular exchange of data between the organizations?	Applies	Applies
Additional Comments		- approx. 7.500 students - isolated applications	- approx. 550 students - introduction of a central campus IT program

The headcount and budget figures in both organizations indicate significant human and financial resources. The other factors point to a high degree of complexity in structure and behavior in the organizational and operational structure. The details of the assessment are discussed below.

In Germany, the Basic Law for the Federal Republic of Germany (known as "Grundgesetz, GG") in general and Art. 30, 70 GG in particular, the constitution of the Federal Republic of Germany is the legal foundation of the German Higher Education system. Another important legal basis in the federal system of the Federal Republic are the state laws and constitutions, since the federal states are fundamentally responsible for all matters relating to the education system (cultural sovereignty of the federal states). This regulation is intended to counteract the ideological abuse of art, culture, universities and schools. The provisions applicable to universities can be found in the individual Higher Education acts of the federal states. The German Higher Education system is decentralized. The Romanian Higher Education system is also based on the constitution (Art. 72. Constitutia Romaniei/1991) and the laws based on it (including the 1993 Accreditation Act and the 1995 Education Act). In contrast to the German Higher Education system, control is centralized. Both Germany and Romania are still members of the European Union (EU). Most Romanian and German universities align their programs with the Bologna System, so that their degrees and qualifications are recognized throughout Europe.

The German institution is a university of applied sciences whose mission is applied research and development, which implies a clear practical approach and a vocational orientation of the studies, often including integrated and supervised internships in industry, business or other relevant institutions. It does not have the right to award doctorates. The Romanian institution is a university. It offers the entire spectrum of academic disciplines, in particular basic research, so that advanced study is primarily theoretical and research-oriented. In addition, it has the so-called right to award doctorates, that is, the right to award doctoral degrees.

The following chapter presents and discusses the results of the Assessment.

5. Results and Discussions

Table 2 shows the results of the answers to the questions asked in the assessment according to the main topics and separately for ORG1 and ORG2.

Table 2. Organizational factors that can influence Master Data Management

Main Topic	No.	Evaluation Criteria	ORG1			ORG2		
			ML	Σ	⌀	ML	Σ	⌀
Master Data	1	Definition of Master Data	2	4,0	1,0	2	8,0	2,0
	2	Master Data Model	1			2		
	3	Master Data Map	1			1		
	4	Master Data Life Cycle	0			3		
Data Culture	5	MDM Strategy	1	2,0	0,7	2	5,0	1,7
	6	MDM Goal Catalogue	0			2		
	7	MDM Standards	1			1		
Data Quality	8	Quality Awareness in MDM	2	8,0	2,7	1	4,0	1,3
	9	Impacts on Organisation	4			2		
	10	Improvements in Data Quality	2			1		
Data Protection	11	External Factors in Data Protection	4	6,0	3,0	1	3,0	1,5
	12	Internal Factors in Data Protection	2			2		
Data Security	13	Threat Awareness in MDM	2	5,0	1,7	2	4,0	1,3
	14	Threat Modelling in MDM	1			0		
	15	Security Actions in MDM	2			2		
Organization	16	Ownership in MDM	1	6,0	1,5	1	6,0	1,5
	17	Responsibility in MDM	2			2		
	18	Data Access on Master Data	2			2		
	19	Data use of Master Data	1			1		
Resources	20	Staff in MDM	3	6,0	2,0	1	5,0	1,7
	21	Technology Evaluation	1			2		
	22	Application Systems for MDM	2			2		
Controlling	23	Metrics in MDM	2	4,0	2,0	0	1	0,5
	24	Data Analysis in MDM	2			1		
Legend: ML = Maturity Level | Σ = Sum | ⌀ = Average | MDM = Master Data Management								

Fig. 4 till Fig. 6 visualizes the results of the assessment: Fig. 4 the maturity level for individual key topics as the mean of the maturity levels in the respective key topic details, Fig. 5 the maturity levels in the respective key topic details and Fig. 6 the overall result for ORG1 and ORG2. The results of the assessment show that both university operators have a considerable amount of catching up to do in the area of Master Data Management.

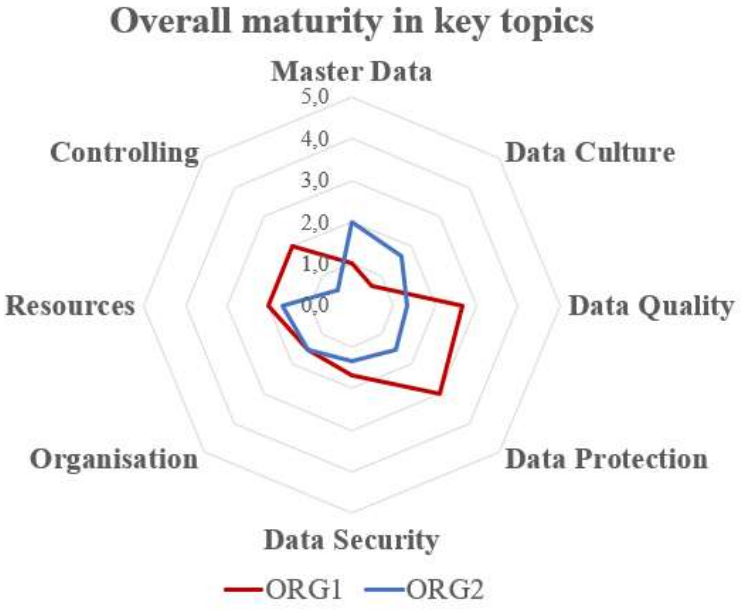

Fig. 4. Maturity Level of individual Key Topics

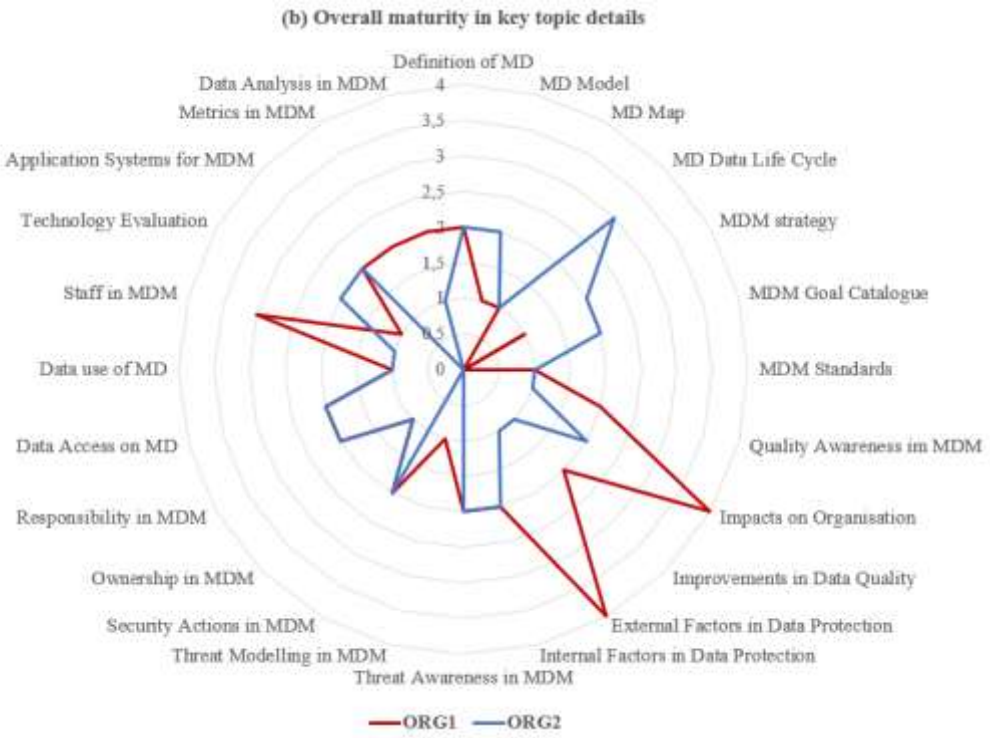

Fig. 5. Maturity Levels of individual Key Topic Details

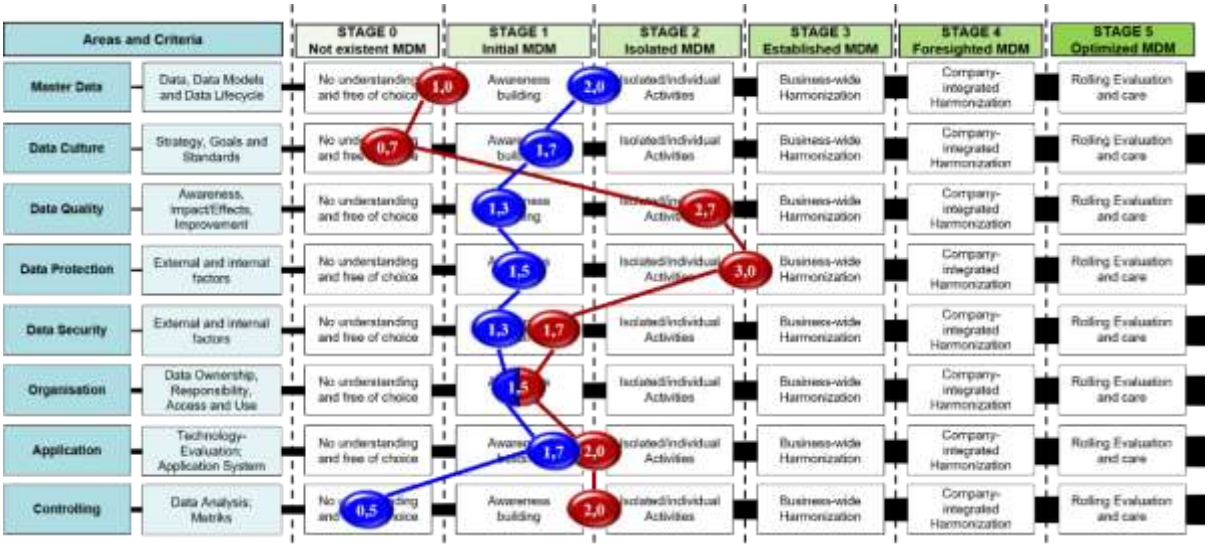

Fig. 6. Overview of the Assessment

Initial discussions have taken place in both institutions in order to achieve a common, company-wide understanding of Master Data. ORG2 already handles this data according to its lifecycle; this is not (yet) the case for ORG1. In both organizations, initial attempts have been made to systematize Master Data, including its relationships, in the form of models or maps. ORG2 indicated that complete, department-related models are already available.

ORG1 recognizes the necessity of a data strategy, but also indicates that a targeted approach is not yet in place and that only isolated departments have defined (isolated) standards for Master Data. ORG2 is more mature in this respect overall, as it has not only recognized the necessity of a data strategy, but has also identified relevant use cases including data functions as a basis for its strategy, and a targeted approach is established in individual departments.

The topic of data quality has been initiated in both organizations. Within ORG1, the reasons for quality problems are known, their effects can be assessed, and isolated measures to eliminate these problems have been implemented. In contrast, ORG2 can only identify quality problems in general terms and assess them on a case-by-case basis. Quality problems are then eliminated on a case-by-case basis, i.e. whenever specific issues are identified.

Surprisingly, the level of maturity for data protection and data security is different and at a low level, although the researchers assumed that the GDPR should be a driver for action. The data protection-compliant handling of confidential information is addressed in both organizations. ORG1 has initiated a specific resource planning for data protection-relevant content, i.e. necessary activities have been assigned to people in the organization. In contrast, ORG 2 has collected initial, simple data protection-related activities, but without fulfilling specifically defined requirements. Both organizations are aware of the potential threat arising from the Master Data, but here, too, there is a lack of an organization-wide approach to systematizing the topic of data security. Data security measures are only catalogued and applied in individual cases.

From an organizational point of view, both universities recognize that it is of crucial importance to assign responsibilities for Master Data in the sense of data ownership. The approach of deriving responsibilities from business processes is favored. Responsibilities are currently exercised on a case-by-case basis and often change over time. In both universities, data access is aligned with subject-specific standards, and data usage is aligned with daily needs, supported by reporting.

With regard to data literacy among the personnel, differences are apparent. At ORG1, motivation, skills and knowledge are widely available. Management and employees decide together how to proceed with Master Data and training is provided. By contrast, personnel at ORG2 lack knowledge and skills in the data domain. Management here acts in an instructive manner, and the need for qualification is recognized. Both organizations recognize the possibilities of using special technology for MDM, but a systematic evaluation of these possibilities is not planned yet. In both organizations, Master Data maintenance is carried out in the respective application systems, i.e. the individual application system determines the type and scope of Master Data maintenance. The result is a lack of harmonization.

Both organizations recognize that measures in Master Data Management need to be monitored over time. In ORG1, isolated metrics, e.g. to measure data quality, are defined for this purpose. Modern tools are used to visualize these metrics. In contrast, ORG2 stated that it has not yet defined any metrics. As a result, monitoring is cumbersome and prone to errors.

Overall, the maturity level of Master Data Management at both universities is still low and requires a much more systematic approach to Master Data Management in order to improve it sustainably and continuously. The results of the assessment were presented to the decision-makers. Initial recommendations were made and measures were decided upon, which are presented below.

6 Recommendations

Implementing the maturity model is a key step for Higher Education organizations seeking to systematically advance their Master Data Management. A well-thought-out approach can mean the difference between success and stagnation. Each phase of the implementation must be completed, bringing with it specific goals and challenges that need to be overcome.

At this point, recommendations are given on how to improve the maturity level of Master Data Management at both universities. The basis is an action plan based on a framework (Fig. 7), a detailed plan to close the identified gaps over time.

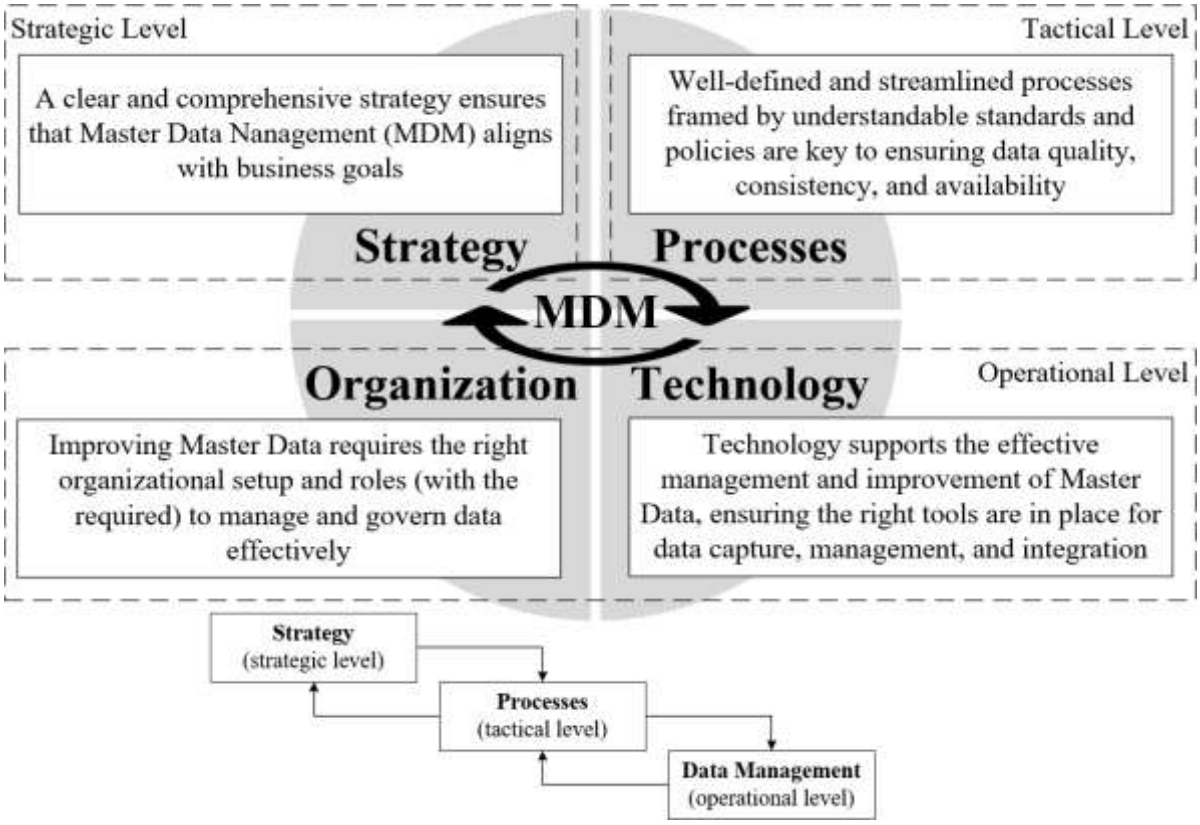

Fig. 7. Higher Education Master Data Management Framework

Each of these areas should work together to create a unified approach that treats data as a strategic asset. Adequate investment in strategy, processes, governance, technology and organizational culture is essential for sustainable improvements in the quality and management of Master Data.

6.1 Strategy

As a first step, the creation and organizational anchoring of a Master Data strategy is recommended, because both universities stated that they do not have such a strategy.

A clear and comprehensive Master Data strategy ensures that Master Data Management is anchored in the university management and aligned with the university's business objectives. It should be consistently aligned with the corporate strategy to link all Master Data initiatives with broader corporate goals, such as improving the student experience, increasing operational efficiency in research and teaching, or supporting the university's digital transformation into a data-driven organization. In addition, the development and implementation of a governance framework is recommended that includes data policies, standards, and responsibilities to ensure that Master Data is treated as a mission-critical asset with an increasing value. The responsibilities should be implemented in roles (including the required competencies). To track improvements in data quality over time, e.g. in terms of accuracy, completeness, consistency and timeliness of data, measurable targets and KPIs are set.

A Master Data strategy is used to address the maturity areas of data, data culture, data quality and organization.

6.2 Processes

Well-defined and streamlined processes are key to ensuring data quality, consistency and availability for Master Data.

Master Data must be managed throughout its lifecycle, i.e. from its creation, use, update, archiving and deletion. This requires ensuring that there is a clear process for each phase. Data entry processes must be standardized to ensure consistency and reduce errors. This can be achieved, for example, by using data validation rules and mandatory fields in the input

masks to ensure the quality of the data entry. Regular data cleansing and enrichment ensures that any duplicates are removed, missing information is added, and that the data is up to date. To avoid discrepancies and ensure the consistency of Master Data across the entire university, processes must be implemented to synchronize Master Data across all systems and applications. Furthermore, cooperation processes between departments (e.g. IT, chairs, administration) must be established to ensure that data requirements are understood and met in all business functions.

With the help of well-defined processes, the maturity areas of data, data culture, data quality, data protection and security, organization and resources are operationalized.

6.3 Organization

Improving Master Data requires the right organizational structure and the right roles, equipped with the right competencies and authorizations, to effectively manage and control data.

One suggestion would be to set up a cross-functional team or a Data Governance committee to oversee Master Data Management initiatives and compliance with Data Governance guidelines (policies and standards). This should be accompanied by the appointment of Data Stewards (Data Custodians) to manage the quality of specific data areas (e.g. customer, product and supplier data). All employees involved in data entry or management should receive regular training on data quality standards, tools and their role in maintaining data accuracy. This creates awareness of Master Data and improves data excellence. Furthermore, incentives supported by gamification, as well as the introduction of accountability and operational accountability mechanisms, can promote active participation in data quality efforts. And with the help of performance metrics, Master Data and its quality become part of the employees. Change management processes ensure that new data management practices are adopted and that teams understand the value of good data practices.

The areas of organizational, resource, and controlling maturity are addressed with the help of an organization that is aligned with the current level of maturity.

6.4 Technology

The right technology supports the effective management and improvement of Master Data and ensures that the right tools are in place for data collection, management and integration.

Thus, the implementation of a specialized Master Data Management platform or software can help centralize and standardize Master Data across the entire university. Data quality tools help to automatically identify data quality issues such as duplicates, inconsistencies, missing data, and validation errors. Data integration tools ensure seamless data sharing and consistency across multiple systems. Automation tools and artificial intelligence help to detect data anomalies, suggest corrections, and automate repetitive data management tasks. And tools that support the management of metadata to track the structure, origin, and context of Master Data make it easier to ensure data consistency and traceability.

The maturity area of resources is addressed with the help of technology tailored to specific needs.

7 Conclusion

7.1 Contribution to knowledge

The present study provides a timely and important contribution to knowledge in the field of Master Data Management, particularly in Higher Education.

Master Data Management is an ongoing area of research and is essential in Higher Education to ensure the quality and availability of the basic data needed to manage students, staff, programs, and other Higher Education - related processes. Good Master Data Management ensures that Master Data is standardized, consistent, reliable and can be used correctly in all relevant systems and applications. The starting point for a holistic approach is to determine the level of maturity in Master Data Management.

This study presents the results of the assessment using the example of two universities in

Germany and Romania and identifies strengths and weaknesses in the current Master Data Management processes of these organizations. The focus is on essential dimensions of Master Data Management, including Master Data as an increasingly important asset, data culture, data quality, data protection, data security, and resources (human and machine), as well as controlling. Based on the results, recommendations were made to support continuous and optimizing improvement. The recommendations identify, structure and link the various factors of the different categories, thus developing a holistic understanding of the transformative process for improving Master Data Management.

In summary, the evaluation provides a detailed overview of the current state of Master Data Management using the example of two universities and shows ways in which universities can sustainably improve their Master Data Management and use in an environment of increasing globalization and advancing digitalization, thus developing their Master Data into a real asset.

7.2 Consequences for theory and research

Assessing the maturity level of Master Data Management at two universities has several interesting consequences for theory and research that can contribute to a better understanding and a more profound further development of the subject area.

Examining maturity levels in specific environments such as Higher Education provides valuable insights into the suitability and adaptability of maturity models for the education sector. Maturity models can thus be tailored to the needs and characteristics of universities. These findings support research into adapting universal models or developing new models that are particularly suitable for universities and similar institutions.

The study also expands the theory of Master Data Management by highlighting challenges that have not yet been considered in theoretical approaches, such as specific regulatory requirements or governance structures in universities.

The findings can also help to promote interdisciplinary approaches in Master Data Management, since universities combine a wide range of data types and usage requirements. An interdisciplinary approach could bring together computer science, business administration and educational science to develop models that meet the specific requirements of research and teaching. This can drive the development of new, subject-specific models and expand research beyond previous boundaries.

Research can continue to learn from this how Master Data Management can be successfully implemented in decentralized and diversely structured organizations. This can be transferable to other organizations with similar structures.

7.3 Consequences for Practice

There are also specific consequences for practice that can contribute to the improvement and more effective design of Master Data Management, some of which are mentioned here.

The analysis of universities can be used to identify specific requirements and challenges in Master Data Management for the Higher Education sector. Universities have different priorities that differ from those in business. This makes it possible to derive specific best practices and approaches.

A higher level of maturity in Master Data Management ensures better data quality and consistency, which has a positive impact in practically all areas of the university. Faculties, administrations and research institutions can thus access clean, up-to-date data, making processes such as enrolment, examination administration or research applications smoother and more effective.

A structured Master Data Management reduces redundant data storage and the susceptibility to errors in data entry and processing. This reduces the costs for data corrections and data cleansing, and resources can be used more efficiently. Efficient data structures relieve employees and enable smooth collaboration between departments, which makes the entire organization more efficient.

The maturity assessment provides insights

into how well Master Data Management processes are digitized and automated. Universities that systematically increase their maturity level benefit in the long term from higher automation and better integration of digital processes, which also supports the digital transformation of Higher Education institutions. Automated data processes ensure greater speed and fewer manual steps, which reduces administrative overhead and frees up resources for strategic tasks. Standardized processes and clearly documented data flows also improve internal control and enable universities to respond more quickly and effectively to requests or audits.

A more mature Master Data Management system provides a better basis for decision-making and makes it easier for university management to set strategic priorities that serve the long-term development of the university, for example in areas such as digital teaching, international exchange or research.

Well-developed Master Data Management can also provide a competitive advantage in the Higher Education sector, because universities that demonstrate a high level of data management expertise can better keep pace with international standards and are more attractive to students and researchers. In addition, universities gain a better overview of their own strengths and weaknesses, which can be an advantage in public relations and in international competition.

7.4 Limitations of the study

Like any research, this study also has its limitations. For one thing, only two universities were evaluated, which limits the generalizability of the results. The specific conditions and contexts (e.g. size, geographical location, organizational structure, financing models) of the individual universities Therefore, the number of evaluations in the education sector should be increased. It would also be helpful to conduct more research on specific subject areas or at different types of schools (e.g. high school or primary school).

Universities differ in many ways, such as in their range of subjects, the number of students, their technical infrastructure and the degree of digitization. An investigation of only two universities cannot cover many of these variables and therefore does not provide a comprehensive picture of the possible challenges and conditions in Master Data Management. Regional and organizational differences, such as national regulations or political influences, could have a significant impact on Master Data Management and may not be adequately reflected in such a small sample. Again, the only solution is to increase the number of evaluations in the education sector. Since only two universities are evaluated, there is still a higher risk that specific organizational characteristics, individual management approaches or the skills of the employees involved will unduly influence the results. This could lead to distortions that do not reflect the general reality in other universities. Random variables, such as a particularly advanced or underdeveloped state of Master Data Management at one of the two universities, can severely distort the picture. A broader spectrum of universities, covering different levels of maturity, would be needed to gain a more thorough understanding of the development paths in Master Data Management.

With only two universities, it is also difficult to observe developments and changes in Master Data Management over time. Longitudinal data could show how universities develop their maturity levels over several years, which measures are particularly effective and which challenges remain. Without the possibility of analyzing a larger group of universities over time, insights into the dynamics and sustainable effect of certain measures in Master Data Management remain limited.

7.5 Future research direction

In future research, the developed maturity model is to be applied to a broader spectrum of educational institutions (e.g., primary schools, regular schools, middle schools, high schools) as well as universities. The goal is to validate the effectiveness and adaptability of the model in different contexts.

In addition, longitudinal studies are planned to provide insights into the development of Master Data Management in the education sector

over time. In addition, research is to be conducted to determine whether and to what extent new technologies, including artificial intelligence, influence Master Data Management.

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Appendix

Table 3. Types of master data by main category

Main Categories	Content	Example(s)
Student-related data	information about individual students	Student Identify Card; Name; Contact details and demographic information; Enrollment status; Academic records (e.g. grades, courses taken, degrees pursued); Admissions data; Financial information (e.g. scholarships, grants, tuition fees)
Course data	Details of the courses offered by the institution	Course codes, titles and descriptions; Credit hours; Prerequisites and co-requisites; Curriculum information; Course schedules (dates, times and locations); Teacher assignments
Study program data	Information on academic programs	Program codes and names; Degree requirements; Specializations or emphases; Accreditation status; Program objectives and outcomes
Data on teachers and staff	Data on academic and administrative staff	Identification of faculty and staff; Names; Contact information; Demographic information; Employment status and responsibilities; Academic qualifications and teaching experience; Administrative duties and committee memberships
Organization data	Data on the structure of the organization	Schools, colleges, departments and administrative units; Hierarchical relationships between organizational units; Department codes and descriptions
Facilities and location data	Information on the physical infrastructure of the facility	Building and room numbers; Campus locations and addresses; Facilities and resources (e.g. laboratories, libraries); Maintenance schedules
Finance data	key data related to financial operations	Account plan; Budget codes; Types and guidelines of financial support; Structures of tuition and fees
Governance and policy data	Information on the organization's rules and regulations	Academic policies (e.g. grading, attendance); Governance structures (e.g. boards, committees); Compliance and accreditation requirements

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