Contributions to IT Project Portfolio Management and Individual Digital Study Assistants in Higher Education

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I. Abstract and Keywords

This cumulative dissertation outlines and discusses 12 scientific publications that contribute to the knowledge of Information Technology (IT) project portfolio management and individual digital study assistants in higher education. The papers developed models and frameworks that describe crucial IT project portfolio management phases and activities, enable an objective IT project evaluation, and define IT project portfolio management maturity levels. In addition, they deduced an optimization model for IT project portfolio management evaluation, selection, and scheduling decisions and implemented it in a decision support system prototype. Developed taxonomies and archetypes classify existing IT project portfolio management tools as well as requirements and corporate benefits of IT project manager positions to identify patterns, similarities, and differences. Further, critical success factors, challenges, and requirements for an individual digital study assistant were identified, analyzed, and discussed. Based on these and during several iterations, an individual digital study assistant prototype was developed, evaluated, adapted, and guidelines derived. The articles contribute knowledge on how to design more efficient and value-driven IT project portfolio management processes to minimize subjective influences. Also, they provide knowledge to support higher education institutions in the design, development, and operation of individual digital study assistants. Based on existing limitations, a further research agenda is deduced, including 13 further research directions for IT project portfolio management and individual digital study assistants in higher education institutions. They serve as a basis for further researchers in these fields of topics.

Keywords: Digital Transformation, IT Project Portfolio Management, Models and Frameworks, Decision Support, Individual Digital Study Assistants, Critical Success Factors, Requirements

II. Zusammenfassung und Schlagworte

Diese kumulative Dissertation beschreibt und diskutiert 12 wissenschaftliche Artikel, die einen Beitrag zur Forschung in den Themenbereichen Informationstechnik (IT) Projektportfoliomanagement und individuelle, digitale Studienassistenten an Universitäten umfasst. Dafür wurden Modelle und Rahmenwerke entwickelt, die wesentliche IT Projektportfoliomanagement Phasen und Aktivitäten beschreiben, eine objektive IT Projektevaluation ermöglichen und Reifegrade von IT Projektportfoliomanagement Prozessen bestimmen. Außerdem wurde ein Optimierungsmodell zur Auswahl und Planung des IT Projektportfoliomanagement Prozesses aufgestellt und in einem Entscheidungsunterstützungssystem-Prototypen integriert. Bestehende IT Projektportfoliomanagement Tools, sowie Anforderungen und unternehmerische Vorteile für IT Projektmanager wurden jeweils in Taxonomien klassifiziert, Muster erkannt und Gemeinsamkeiten und Unterschiede aufgezeigt. Zusätzlich wurden kritische Erfolgsfaktoren, Herausforderungen und Anforderungen für individuelle, digitale Studienassistenten identifiziert, analysiert und diskutiert. In mehreren Iterationen wurde basierend darauf ein Prototyp entwickelt, evaluiert, modifiziert und allgemeine Leitlinien für das Design, die Entwicklung und den Betrieb eines individuellen, digitalen Studienassistenten abgeleitet. Die Forschungsarbeiten ermöglichen IT Projektportfoliomanagement Prozesse effizienter und werteorientiert zu gestalten und subjektive Einflüsse zu minimieren sowie Hochschulen bei dem Design, der Entwicklung und dem Betrieb von individuellen, digitalen Studienassistenten zu unterstützen. Basierend auf Limitationen wird eine Forschungsagenda aufgestellt, die 13 weitere Forschungsmöglichkeiten im Themenbereich IT Projektportfoliomanagement und individuelle, digitale Studienassistenten aufzeigt und als Grundlage für weitere Forschung in diesen Themenfeldern dient.

Schlagworte: Digitale Transformation, IT Projektportfoliomanagement, Modelle und Rahmenwerke, Entscheidungsunterstützung, Individuelle Digitale Studienassistenten, Kritische Erfolgsfaktoren, Anforderungsanalyse

III. Management Summary

The persuasive digital transformation and usage of new technologies have become an important information system (IS) research field, along with opportunities and challenges for societies as well as private and public organizations (Abad-Segura et al., 2020; Vial, 2019). Within companies and organizations, the digitization has emphasized the importance of Information Technologies (IT) (Almeida et al., 2020). In the public sector, especially in the higher education context, the digital transformation led to new possibilities for knowledge and competency transmission and changes in teaching, advising, and learning possibilities (Bond et al., 2018).

Companies and organizations need to strategically address the digital transformation and adapt their structures to enable value creation and remain competitive (Vial, 2019). Thereby, organizational IT has a crucial influence on this (Bezdrob et al., 2020). In general, there are more IT projects to select from than can be implemented. A value-driven evaluation, selection, and scheduling aligned with the organizational strategy is part of the IT project portfolio management (PPM) (Asosheh et al., 2010; Daniel et al., 2014; Linhart et al., 2020). However, organizational ITPPM often misses structures and decisions are based on a gut feeling, resulting in deviations from objectives, incomplete projects, and high failure rates (Varajão & Trigo, 2016). Using an ITPPM tool to support processes can lead to more efficient, transparent, and consistent decisions (Caniëls & Bakens, 2012; Killen et al., 2020). Companies and organizations need adequate, structured, and value-driven ITPPM processes and guidelines aligned to their strategy to increase performance, objectivity, decision quality, and remain competitive (Chiang & Nunez, 2013; Kester et al., 2011).

Within higher education institutions (HEI), new technologies resulting from the digital transformation enable better accessibility to learning content and educational resources (Abad-Segura et al., 2020; Telukdarie & Munsamy, 2019). Previous reforms in HEI led to higher student numbers and more diverse backgrounds. Thus, the need for personal counseling and advising increased (Clarke et al., 2013; Van der Wende, 2000; Wong & Li, 2019). Digital assistants provide solutions to react to these changes and challenges. One example are individual digital study assistants (IDSA) that support students in learning on a reflective level, enable automatized first-level support, and strengthen self-regulation and self-organization abilities. Relying on different information sources, individual objectives, interests, and competencies, IDSA support students with recommendations and reminders (Karrenbauer et al., 2023b; König et al., 2024). While there is already much research on requirements and design principles for pedagogical conversational agents (PCA) (e.g., Hobert, 2019; Wambsganss et al., 2021a), research for IDSA is still limited. It requires detailed and user-centric analyses of their critical success factors (CSF), requirements, design-, and implementation processes.

This cumulative dissertation consists of 12 scientific papers of which ten are already published and two are submitted. All articles contribute to the knowledge base of either ITPPM or IDSA in HEI research. They enable more objective, efficient, and value-driven ITPPM processes and support HEI in the design, development, and operation of IDSA for students. Therefore, we developed and deduced different CSF, requirements, models, frameworks, taxonomies, and archetypes. In doing so, we used different research designs, including Design Science Research (DSR), Action Design Research (ADR), mixed methods, taxonomy and archetype development, and various research methods, such as literature reviews, qualitative and quantitative studies.

The research field of ITPPM in this dissertation includes six scientific publications. A structured ITPPM is critical to align IT projects with organizational strategy and achieve goals. However, these structures are often missing within companies and organizations, leading to resource exceedances and failure (Daniel et al., 2014; Trigo & Varajão, 2020). Guided by DSR with literature reviews and expert interviews, in Karrenbauer and Breitner (2022b), we developed an integrated ITPPM process model that synthesizes and expands existing ones. Our proposed process model supports value-driven and objective ITPPM, provides flexibility to adapt to changes and uncertainties, integrates different stakeholders, and allows re-cycles between and within phases and activities.

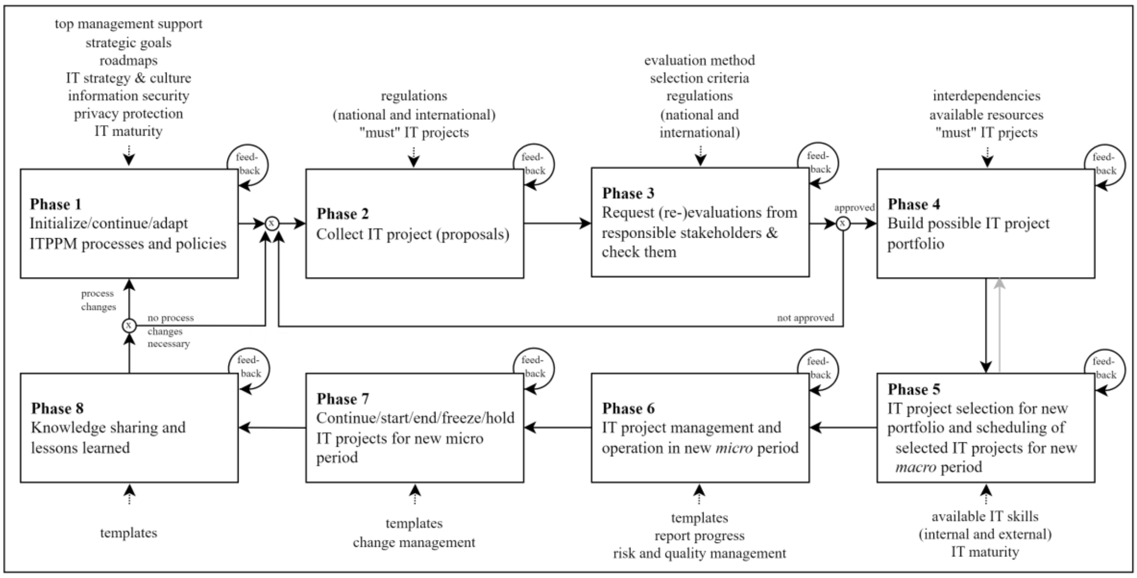

Figure 1. Process model for ITPPM (Karrenbauer & Breitner, 2022b)

Figure 1 shows the derived process model for ITPPM. It consists of eight phases with various activities. Further, Table 1 illustrates all identified ITPPM phases with their activities, compares them with existing process models, and shows how often the activities and phases were named in literature and expert interviews.

Table 1. Activities within an ITPPM process (Karrenbauer & Breitner, 2022b)

Phase (P) / Activity		Ajjan et al. (2016)	Alaeddini and Mir-Amini (2020)	Archer and Ghasemzadeh (1999)	Chiang and Nunez (2013)	Ghannadpour et al. (2021)	Miller (2002)	Montgomery (2007)	Project Management Institute (2017)	British Standards Institution (2015)	Number of experts	Number of literature
P1	Define roles, tasks, & responsibilities	x	x		x				x		-	10
	Determine resource availabilities	x		x*			x		x	x	2	9
	Decide on evaluation & selection method	x	x	x*			x		x	x	2	11
	Determine evaluation categories		x	x*			x	x	x	x	3	14
	Determine the criteria’s importance		x		x		x				4	6
	Define thresholds			x*					x		1	2
	Establish ITPPM policy	x		x*							7	9
P2	Identify IT project proposals	x	x	x*	x	x	x	x	x	x	10	10
	Define mandatory IT projects	x		x							2	3
P3	Check the IT project’s eligibility			x					x		1	3
	IT project (re-)evaluation	x	x	x	x	x		x	x	x	6	20
	Discuss the results	x						x			8	3
	Top management involvement	x			x			x			1	3
	Final evaluation							x			-	2
P4	Define interdependencies			x	x		x		x	x	4	8
	DSS / optimization model usage			x							2	6
	Optimal IT portfolio			x	x						-	4
	Scenario & sensitivity analysis		x	x	x		x		x		2	3
P5	Discussion of the “optimal” results	x	x		x				x		8	4
	Prioritization/selection	x		x	x	x		x	x	x	3	18
	Authorization	x			x			x		x	1	5
	Portfolio adjustments	x		x				x	x	x	-	5
	Final IT portfolio composition	x	x	x							1	5
P7	Periodically review of IT portfolio	x			x	x		x	x	x	5	5
	Measures in case of deviation	x			x	x	x	x	x	x	5	5
P8	Performance measurement			x*				x	x	x	4	4
	Knowledge generation	x		x*				x		x	3	3
	Lessons learned	x						x			6	10

* Pre/post activates; not included in main ITPPM phases

According to literature and our results and findings, effective IT project evaluation, prioritization, and selection are critical activities in ITPPM. Combining quantitative and qualitative methods, we further identified commonly used IT project evaluation criteria and developed a holistic evaluation framework (Karrenbauer & Breitner, 2022a, 2022b), see Table 2. It provides an objective evaluation method for IT projects of different sizes and types and quantifies subjective estimations. It is possible to score each IT project using the integer one to five scale and determine a weighted average, i.e., the individual IT project’s value contribution that allows a comparison. Companies and organizations can adapt the scale with organization-specific values. Our framework enables objective evaluations based on a predefined scale instead of unstructured evaluations influenced by personal perceptions.

Table 2. IT project evaluation framework (Karrenbauer & Breitner, 2022b)

(Sub-)Criteria		Score Value 1	Score Value 2	Score Value 3	Score Value 4	Score Value 5
Complexity	Involved business departments	numerous	many	several	individual	IT department specific
	Change management impact on teams/individuals	significant changes	considerable changes	isolated changes	minor changes	no changes
	Interrelation with other IT projects	numerous	many	several	individual	none
	Ease of implementation	very complex	complex	medium	simple	very simple
	IT architecture fit	significant customi-zations	considerable customizations	isolated customizations	minor cus-tomizations	no customizations
Efficiency	Investment recovery periods	very long	long	moderate	short	very short
	Long-term cost savings	no effects	barely noticeable	noticeable	considerable	highly significant
	Impact on growth rate	no effects	barely noticeable	noticeable	considerable	highly significant
	Employee performance improvement	none	barely noticeable	noticeable	considerable	highly significant
Risk	Risk profile	very high	high	moderate	low	very low
	Similar (un)successful past IT projects of leader/ team	in-experienced	little experienced	medium experienced	experienced	highly experienced
	Positive interrelation with other IT projects	none	barely noticeable	noticeable	considerable	highly significant
	Negative interrelation with other IT projects	highly significant	considerable	noticeable	barely noticeable	none
Strategy	Short-term business goals support	none	barely noticeable	noticeable	considerable	highly significant
	Long-term business goals support	none	barely noticeable	noticeable	considerable	highly significant
Urgency	Non-compliance with regulatory requirements	none existing	short-term disruptions	considerable disruptions	legal con-sequences	sanctions
	Needed to keep daily business processes running	no need	for few processes	for several processes	for many processes	for core processes
	Need for modernization	next 6+ years	next 5 years	next 4 years	next 3 years	next 2 years

Reliable information and appropriate tools contribute to more informed decisions while portfolio information visualizations support decision-making quality (Osuszek & Ledzianowski, 2020). However, many ITPPM tools lack accessibility and transparency, and decision parameters and processes are often unknown or difficult to understand (Karrenbauer et al., 2023a). This black box prevents an effective analysis of critical thresholds and influencing decision parameters. Relying on DSR with existing knowledge and expert insights, we deduced a value-driven optimization model in Karrenbauer and Breitner (2024) and implemented it in a decision support system (DSS) prototype in MATLAB. It supports the IT portfolio's evaluation, selection, and scheduling while it considers interdependencies, resource restrictions, and further constraints. Our results and findings guide IT portfolio decision-makers and enable more informed, transparent, objective, and value-driven decisions.

The applicability of ITPPM processes, tools, and models depends on the organizational IT maturity (Kock et al., 2020). Using a structured and holistic method to develop a maturity model (Becker et al., 2009), we developed and evaluated a comprehensive maturity model for ITPPM processes (Schulte et al., 2024). Table 3 shows an excerpt. In general, ITPPM processes can be classified within five maturity levels using the criteria IT portfolio management, IT project requirements, quality management and documentation, process participants, and integrated systems and their corresponding sub-criteria. Our results and findings enable companies and organizations to classify their ITPPM process and deduce value-driven and value-creating improvements considering the organizational strategy and objectives. An application enables to derive a transformation roadmap, make informed decisions, and rationale resource allocations.

Table 3. ITPPM maturity model (excerpt) (Schulte et al., 2024)

	IT portfolio management				
	Business processes	**Governance**	**Strategy alignment**	**Benefits**	**Approvals**
Level 1	None	None	None	Not seen by management	Ad hoc uncoordinated IT project approvals
Level 2	Defined, but workarounds exist	No standards	No rational investment decisions	Productivity gaps due to insufficient task automation	Uncoordinated IT project approvals
Level 3	Defined, but it may be still inefficient in some places	Defined standards	Specific strategic criteria developed	Clearer vision and overview of projects is set in place which allows better decision-making management	Approval process defined and shared with all departments and followed in most cases
Level 4	Defined and basically lived	Fully comprehensive governance structure	Prioritization on the basis of key figures and criteria aligned with strategy	Management sees benefits of an ITPPM process and understands the entire ITPPM process including participants	Portfolio composition based on an overall balance of risk, profit, return on investment, impact on project competition and on-time project delivery, including value creation
Level 5	Fully mature and considers different project types	Still a fully comprehensive governance structure	ITPPM process continuously optimized due to the structure and actively lived	All participants and stakeholders follow the ITPPM process as they recognize the efficiency	IT portfolio selection based on a clear, rigorous and formal optimization approach

Generally, companies and organizations tend to use tools for single project management only (Besner & Hobbs, 2008). Thereby, ITPPM tools support portfolio-related activities and support strategic decisions to accomplish more successful IT projects. Existing ITPPM tools differ in their functionalities and scope which make decisions for a suitable tool difficult (Killen et al., 2020; Kock et al., 2020). In Karrenbauer et al. (2023a), we classified existing literature and 60 real-world ITPPM tools, developed a taxonomy, and deduced five archetypes. We identified

20 dimensions and 51 characteristics to classify ITPPM tools (Kock et al., 2020). We used the taxonomy to deduce five archetypical patterns and evaluate their applicability (Kundisch et al., 2021). Identified clusters expand a taxonomy's knowledge and its descriptive nature (Möller et al., 2021). They include IT portfolio overview tools with predefined or customizable parameters, customizable evaluation and analysis tools with and without data extraction, and "in-between" IT portfolio evaluation and analysis tools. With our results and findings, we synthesized scientific and practical knowledge and contribute to the ITPPM tool knowledge base. We structure the ITPPM tool market and support practitioners to choose a suitable ITPPM tool.

On an IT project level, skilled and experienced IT project managers contribute to successful IT project completion (Adzmi & Hassan, 2018; Gheni et al., 2017; Trigo & Varajão, 2020). However, the recruitment and selection of suitable and qualified IT project managers is difficult (Ahsan et al., 2013). In Karrenbauer et al. (2024), we first classified and evaluated IT project manager job advertisements and then deduced archetypes. We used them to develop a decision tree as a decision support framework for IT project manager recruitment. Based on four questions, the framework recommends which benefits and requirements a job advertisement for an IT project manager should highlight. Our results and findings identify key requirements and corporate benefits for IT project manager positions. The decision framework supports the entire recruitment process, assists to create targeted job advertisements to attract suitable candidates, supports conducting interviews, and the final candidate selection.

The research field of IDSA in HEI includes six scientific publications. Digital assistants resulting from the digital transformation enable to address the need for more individual study support and counseling. IDSA provide ubiquitous online access to automate first-level support and study-specific and individual guidance. In our research, we performed a long-term project to design, develop, and evaluate an IDSA in HEI. ADR-oriented, with different participants from research and practice, we iteratively designed, developed, evaluated, and adapted an IDSA prototype and derived guidelines. In the beginning, part of the ADR team performed 28 expert interviews with lecturers from different disciplines, HEI stakeholders, and an additional quantitative student survey (n = 570). During our research process, we analyzed the interview transcripts and student survey results from different perspectives, triangulated them, and used them for our results and findings, supplemented by various literature reviews.

We identified (non-)functionalities of IDSA to get an overview of the status quo in König et al. (2020) and Karrenbauer et al. (2021), based on literature reviews, market searches, qualitative, and quantitative analyses. Regarding the non-functionalities, we identified nine dimensions with 26 characteristics. For example, DSA differ in their communication mode, intelligence, authorization, and privacy protection. Further, we identified several functionalities and structured them along the three student lifecycle phases before study, during study, and after study (Sprenger et al., 2010). For the before study phase, an IDSA encompasses functionalities, including self-assessments with study recommendations. Regarding the phase during study, IDSA offer functionalities to support the scheduling of classes and exams or major and institution suggestions. Concerning the after study phase, IDSA are mainly used to provide alumni activities with links to a list of graduates. Our results and findings structure commonly used IDSA (non-)functionalities and serve as a knowledge base for IDSA development and introduction.

Next, we deduced CSF and challenges for IDSA in König et al. (2023) using mixed methods. We structured our results within the six IS success dimensions of DeLone and McLean (2016). CSF and challenges in the dimension system quality and maturity include ease of use, data privacy, and security. The dimension information quality encompasses, inter alia, reliable and unique information and the possibility to integrate existing data. Skilled personnel and answer quality are assigned to the service quality dimension. The dimension user satisfaction includes, for example, positive experiences and involvement with an IDSA. Further, an IDSA’s possibility for learning enhancement and added value of the functionalities influence its net impact. Self-regulation and defined target groups are critical for the intention to use dimension. Our results and findings benefit IDSA system developers and vendors, contribute to integrate IDSA knowledge within the IS success model, and advance the theoretical understanding in this field.

Based on the CSF, we developed requirements for IDSA functionalities, its design, and implementation and implemented and evaluated a prototype in an iterative process (Karrenbauer et al., 2023b; König et al., 2024). We aggregated identified requirements into seven groups: functionalities, contact options, data-based responsiveness and individuality, well-tested system, marketing strategies, data protection, and usability, all with several sub-requirements. Based on these, a prototype within several iterations was developed within the project team. More than 2,500 students tested the prototype and gave feedback. Relying on this, we modified existing functionalities and introduced new ones. Based on our gained knowledge during the design and development process, we abstracted general guidelines for an IDSA design and development, see Table 4. In general, our results and findings contribute insights and knowledge about IDSA in HEI and provide requirements and guidelines for the design, implementation, and adaption of IDSA for researchers and practitioners.

One functionality within the IDSA included open educational resources (OER) and inter-university exchange network (IUTEN) recommendations. In König et al. (2021), we deduced requirements and incentives for OER usage and IUTEN participation based on expert interviews. We identified, for example, the OERs’ preparation, content relevance, and need to be target group

Table 4. IDSA guidelines for HEI decision-makers (adapted from König et al., 2024)

Guidelines		
1. Framework	1.1	Check HEI IT and IS for maturity, choose one LMS that all stakeholders use, and ensure top HEI management commitment to support openness.
	1.2.	Carefully determine all target groups.
	1.3.	Build a team for core tasks depending on the fields of expertise.
	1.4.	Define specific, attractive, and reachable goals of an IDSA.
2. Project Management	2.1.	Build a team of mainly experienced software developers.
	2.2	Choose one environment and (virtual) place, if possible, and use hybrid/agile project management methods.
3. Content	3.1.	Consider internal data and privacy protection challenges and barriers.
	3.2.	Ensure efficient and visible IT project management also for content.
	3.3.	Create an easily useable and inviting, up-to-date design, including mobile devices.
	3.4.	Ensure user-centered IDSA development.
	3.5.	Have testers of all target groups reliably available.
	3.6.	Pay attention to appropriate and user-oriented language.
	3.7.	Ensure that content is structured in a pedagogically efficient way.
	3.8.	Redefine and enrich target groups, if necessary.
	3.9.	Build a team for all content tasks depending on the fields of expertise.
	3.10.	Redefine specific, attractive, and reachable goals of an IDSA.
4. Team selection	4.1.	Group members must have time capacity, professional competence, and social competencies.
5. Team development	5.1.	The desired performance and synergy effects can be achieved by supporting team development.
6. Marketing	6.1.	Begin marketing efforts, both internally and externally, at an early stage.
	6.2.	Top management – the board of directors – must be involved as soon as possible.
7. (Team) Communication	7.1.	A good mix of online and face-to-face meetings strengthens team communication.
8. Student habits	8.1.	Ensure that students are well organized in their virtual support environment.

focused as relevant for OER usage. Regarding incentives to participate in IUTEN, we identified performance certification, the availability of a technical framework, and a balanced distribution as essential. Using these results, we developed two incentive models to encourage lecturers to engage in IUTEN collaborations and produce and use OER. Our incentive models provide opportunities for HEI to improve OER usage and IUTEN participation. They contribute knowledge on how to implement measures to enhance collaboration and usage.

Based on the results and findings and limitations of the 12 papers, this dissertation discusses a further research agenda for ITPPM and IDSA in HEI. It includes 13 general research directions with explicit research topics. In the ITPPM field, further research can analyze cultural influences on ITPPM, our artifacts' proof of use and proof of value, and the expansion of our optimization model and DSS prototype. In IDSA research, it is possible to further investigate the long-term effects of our IDSA, its acceptance and trust, and privacy-related topics. We provide scientific contributions and extend the ITPPM and IDSA knowledge base. Practitioners can use our results and findings of the ITPPM research to increase transparency in their ITPPM decisions, contribute to strategy, and reduce failures. The IDSA research serves as a knowledge base for decision-makers in HEI when introducing an IDSA. The derived research agendas address further research directions and topics in the two important research fields. They can be a foundation for initiating discussions and conducting tailored research in the continuously changing ITPPM and HEI environment.

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VII. List of Abbreviations

ADR	Action Design Research
AI	Artificial Intelligence
AMCIS	Americas Conference on Information Systems
C2E	Conceptual-to-Empirical
CSF	Critical Success Factors
DSA	Digital Study Assistant
DSR	Design Science Research
DSS	Decision Support System
E2C	Empirical-to-Conceptual
Eq	Equation
FRD	Further Research Direction
HEI	Higher Education Institutions
HICSS	Hawaii International Conference on System Sciences
ICERI	International Conference of Education, Research and Innovation
ICIS	International Conference on Information Systems
IDSA	Individual Digital Study Assistant
IF	Impact Factor
IS	Information System
IT	Information Technology
ITPPM	IT Project Portfolio Management
IUTEN	Inter-University Teaching Exchange Networks
LMS	Learning Management System
OER	Open Educational Resources
PCA	Pedagogical Conversational Agents
PPM	Project Portfolio Management
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
R	Requirement
SJR	ScImago Journal & Country Ranks
SLC	Student Lifecycle
SPA	Smart Personal Assistants
SWOT	Strengths, Weaknesses, Opportunities, Threats
VHB	VHB-JOURQUAL3

VIII. Overview of Publications and Task Allocation

This cumulative dissertation consists of 12 papers, all of which were written collaboratively with a total of ten co-authors in various teams between 2020 and 2024. Tables 5 and 6 provide a chronological overview of all papers included in this dissertation with titles, authors, outlets, and different metrics. One leading metric used to assess a journal's or conference's quality is the VHB-JOURQUAL3 (VHB) ranking. It classifies relevant business research journals and conferences and is used within the German Information System (IS) discipline. Researchers rated journals and conferences leading to quality metrics from "A+" to "D" (German Academic Association for Business Research, 2015). However, the VHB ranking does not include all disciplines and used outlets for this dissertation. Therefore, Tables 5 and 6 additionally provide the impact factor (IF) and Scimago Journal & Country Ranks (SJR), which are multi-disciplinary (Scimago Journal & Country Rank, 2022a). The IF measures the relative importance of a journal in a respective field. It is calculated based on the average number of citations published articles within a journal received in a certain period (Clarivate, 2021). The IF is considered a quality criterion for a journal and a researcher's publication, with a higher IF being more prestigious. However, this must be viewed critically. Depending on the field, different high IF are considered normal and they can be reported differently. Thus, the IF is only one of several quality indicators in this dissertation. The SJR metric categorizes journals within their research areas into quartiles. Journals ranked in the Q1 category are considered to be among the top 25% of all journals within their specific research area (Scimago Journal & Country Rank, 2022a). Each research article included in this dissertation, both published and submitted, was and is subject to rigorous peer-review processes. Below, the specific contributions of each author for each article are described chronologically.

The article "Dialogue-Driven Digital Study Assistants for Higher Education – A Morphological Analysis", written by Claudia M. König, Christin Karrenbauer, Nadine Guhr, and Michael H. Breitner (König et al., 2020; Appendix 1) analyzes functionalities and non-functionalities for individual digital study assistants (IDSA) and structures them within a morphological box. Claudia M. König coordinated the research process and wrote large parts of the abstract, introduction, discussion, implications, and limitations. I was responsible to describe the results and conclusions. Together, Claudia M. König and I wrote the theoretical foundations and described the research method. Nadine Guhr and Michael H. Breitner made essential contributions by reviewing and editing the paper. Claudia M. König recorded a video presenting the paper at the virtual 13th International Conference of Education, Research and Innovation (ICERI). The paper is published in the conference proceedings.

The paper “Optimal IT Project Selection – Quantification of Critical Scoring Criteria”, written by Christin Karrenbauer and Michael H. Breitner (Karrenbauer & Breitner, 2022a; Appendix 2), deduces commonly used criteria for an Information Technology (IT) project evaluation based on a literature review and expert interviews. Michael H. Breitner and I developed the idea of the paper and discussed the results and findings. I wrote the manuscript and Michael H. Breitner made further essential contributions by reviewing and editing it. The paper was initially accepted for the conference Projektmanagement und Vorgehensmodelle 2020, which was cancelled because of the COVID-19 pandemic. Finally, I presented the paper at the proceedings of the Projektmanagement und Vorgehensmodelle 2022 and it is published in the book “Projektmanagement und Vorgehensmodelle 2022 - Virtuelle Zusammenarbeit und verlorene Kulturen?”

The paper “Individual Digital Study Assistant for Higher Education Institutions: Status Quo Analysis and Further Research Agenda” authored by Christin Karrenbauer, Claudia M. König, and Michael H. Breitner (Karrenbauer et al., 2021; Appendix 3) presents a status quo analysis of common IDSA functionalities. These are grouped within a morphological box along the phase of a student life cycle (before-, during-, and after university study). Together with Claudia M. König and Michael H. Breitner, we developed the idea of the paper and I coordinated the research process. I wrote the introduction, method, limitations, and conclusion sections, while Claudia M. König was responsible for the abstract. Claudia M. König and I wrote the theoretical background, results, discussion, implications, and recommendations sections. Michael H. Breitner was a discussant and made essential contributions by reviewing and editing the paper. I presented the paper at the virtual 16th International Conference on Wirtschaftsinformatik and it is published in the conference proceedings. According to the German Academic Association for Business Research (2015) the conference is ranked as “C” in the IS research field.

“Incentives for Lecturers to Use OERs and Participate in Inter-University Teaching Exchange Networks” by Claudia M. König, Carla Reinken, Paul Greiff, Christin Karrenbauer, Uwe Hoppe, and Michael H. Breitner (König et al., 2021; Appendix 4) examines requirements and incentives to use open educational resources (OER) and participate in inter-university teaching exchange networks (IUTEN). The results served as input to design incentive models for OER usage and IUTEN participation. All involved authors deduced the idea of the paper. Claudia M. König was responsible for the paper’s coordination. While Claudia M. König, Carla Reinken, and Paul Greiff conducted the interviews and transcribed them, I was equally involved in analyzing the data and identifying requirements and incentives. I wrote large parts of the theoretical background, some parts of the results, and significant parts of the limitation and outlook section. Claudia M. König wrote the introduction, developed and described the incentive models and contributed to the implications and recommendations section. Carla Reinken and Paul Greiff wrote significant parts of the research design and method, requirements and incentives, discussion, and conclusions sections. Uwe Hoppe and Michael H. Breitner were discussants and made essential contributions by reviewing and editing the paper. Claudia M. König recorded a video presenting the paper and I participated at the virtual 27th Americas Conference on Information Systems (AMCIS) where I was the responsible session chair for our session. The paper is published in the conference proceedings. According to the German Academic Association for Business Research (2015) the conference is ranked as "D" in the IS research domain.

The paper "Value-driven IT Project Portfolio Management: Process Model, Evaluation Framework, and Decision Support" (Karrenbauer & Breitner, 2022b; Appendix 5) contains a process model for ITPPM, identifies commonly used IT project evaluation criteria, uses them as a basis for an IT project evaluation framework, and a DSS prototype to support ITPPM decisions. Michael H. Breitner and I iteratively developed the idea of the paper and discussed the procedure, results, and findings. I synthesized the process model and evaluation framework and developed the first version of the DSS prototype and mathematical model, while several students developed the DSS prototype and mathematical model further in seminar papers and master theses. I wrote the manuscript and Michael H. Breitner made further essential contributions by reviewing and editing it. The paper was accepted for the 43rd International Conference on Information Systems (ICIS) and it is published in the conference proceedings. I presented the paper at the ICIS in Copenhagen. The ICIS is ranked as an "A" conference in the IS research field (German Academic Association for Business Research, 2015).

The paper "Critical Success Factors and Challenges for Individual Digital Study Assistants in Higher Education" authored by Claudia M. König, Christin Karrenbauer, and Michael H. Breitner (König et al., 2023; Appendix 6) is published in the journal Education and Information Technologies after one double-blinded peer review round. The journal has a five-year impact factor of 3.61 (Education and Information Technologies, 2023). According to SJR metrics, the journal is ranked as Q1 in the fields of Education, E-learning, and Information Science (Scimago Journal & Country Rank, 2022b). We used the IS success model of DeLone and McLean (2016) to structure critical success factors and challenges for an IDSA identified through a mixed-method analysis. While all authors developed the idea of the paper, Claudia. M. König coordinated the research process and was responsible for the abstract and most parts of the theoretical background. Together, Claudia M. König and I analyzed the data. I wrote large parts of the introduction, method, limitations, and conclusions sections. In the results and findings section, Claudia M. König and I both described the results of three IS success dimensions and the discussion section with implications and recommendations was developed together in an iterative process. Michael H. Breitner was a discussant and made essential contributions by reviewing and editing the paper.

The paper “IT Project Portfolio Management Tools: Towards Taxonomy-based Archetypes” written by Christin Karrenbauer, Florian Bergmann, and Michael H. Breitner (Karrenbauer et al., 2023a; Appendix 7) classifies design elements of IT project portfolio management tools through a taxonomic approach and identifies patterns between them. I developed the idea of the paper and coordinated the research process. The whole paper is based on the master thesis of Florian Bergmann. Florian Bergmann classified all IT project portfolio management tools, developed the taxonomy, and performed the evaluation. Based on this, I wrote the manuscript, expanded it with further literature, conducted a new cluster analysis, and identified and described the archetypes. Michael H. Breitner was a discussant and made essential contributions by reviewing and editing the paper. I presented the paper at the 56th Hawaii International Conference on System Sciences (HICSS) in Maui and the paper is published in the conference proceedings. The HICSS is ranked as a “C” conference in the IS research field according to the German Academic Association for Business Research (2015).

The article “Design, Development, and Evaluation of an Individual Digital Study Assistant for Higher Education Students” by Christin Karrenbauer, Tim Brauner, Claudia M. König, and Michael H. Breitner (Karrenbauer et al., 2023b; Appendix 8) deals with IDSA requirements, the development, and evaluation of an IDSA prototype. I coordinated the research process and wrote the abstract, introduction, limitations, and conclusions sections and parts of the theoretical background. Claudia M. König contributed to the theoretical background and wrote significant parts of the research design and methodologies. Together, Claudia M. König and I analyzed the data to identify requirements. Tim Brauner, Claudia M. König and I all contributed to the results and findings sections. I described the requirements derived from the qualitative and quantitative analyses and analyzed and described the usage data. Tim Brauner was responsible to write the IDSA development and discussion sections while Claudia M. König described requirements retrieved from literature. Michael H. Breitner was a discussant and made essential contributions by reviewing and editing the paper. The paper is published in the journal Educational Technology Research and Development, after one double-blinded peer-review round. The journal has a five-year impact factor of 5.61 (Educational Technology Research and Development, 2023) and is one of the leading journals in the education field (Q1) (Scimago Journal & Country Rank, 2022c).

The paper “Development Guidelines for Individual Digital Study Assistants in Higher Education” (König et al., 2024; Appendix 10) authored by Claudia M. König, Christin Karrenbauer, and Michael H. Breitner reveals guidelines for an IDSA development based on an Action Design Research (ADR) study. All three authors developed the idea of the paper and discussed its results and findings. Claudia M. König coordinated the research process and was responsible for most parts of the research design and methods and the whole discussion section. I wrote the introduction, parts of the research design and method, limitations, further research, and conclusions sections. Together, we described the theoretical background and results and findings. Michael H. Breitner was a discussant and made essential contributions by reviewing and editing the paper. The paper is published in the International Journal of Educational Technology in Higher Education. According to SJR it is ranked as Q1 in the field of Education (Scimago Journal & Country Rank, 2022e) and has a five-year impact factor of 9.4 (International Journal of Educational Technology in Higher Education, 2024).

The paper “Decision Support Framework for IT Project Manager Recruitment” written by Christin Karrenbauer, Jana Gerlach, and Michael H. Breitner (Karrenbauer et al., 2024; Appendix 10) classifies job advertisements for IT project manager positions and related literature to develop a taxonomy, identifies patterns, and designs a decision support framework for IT project manager recruitment. Jana Gerlach and I developed the idea of the paper. I wrote the introduction, theoretical background, and conclusions, while Jana Gerlach was responsible for the description of the research design and methodologies. Together, we described the taxonomy, archetypes, and decision tree and discussed the results and findings and limitations. Michael H. Breitner was a discussant and made essential contributions by reviewing and editing the paper. The paper is published in Heliyon which has an impact factor of 4.0 (Heliyon, 2023) and an SJR multidisciplinary journal Q1 ranking (Scimago Journal & Country Rank, 2022d).

The article “Mathematical Optimization Model and Decision Support for IT Project Management” (Karrenbauer & Breitner, 2024; Appendix 11) develops a value-driven optimization model and DSS prototype to support IT project evaluation, selection, and scheduling. Michael H. Breitner and I developed the idea of the paper and discussed the procedure. I wrote the manuscript and developed the initial version of the mathematical model and DSS prototype. Different students built on this initial version and developed it further and we used their results for the paper. Michael H. Breitner made further essential contributions by reviewing and editing the paper. The paper is submitted to the Journal of Decision Science. It is ranked as “B” in the field of Operations Research and IS (German Academic Association for Business Research, 2015).

The paper “Maturity Model for IT Project Portfolio Management Processes” (Schulte et al., 2024; Appendix 12) develops a maturity model for ITPPM processes. I developed the idea of the paper and it relies on the master thesis of Fenja Schulte. I wrote the introduction and motivation, research design and methods, discussion, implication, recommendation, and conclusion and limitations sections. Fenja Schulte coordinated the research process and was responsible for the results and findings and developed the initial maturity model. Together, we discussed the maturity model and made adaptions, wrote the theoretical background section, and evaluated the maturity model. The paper is submitted to the International Journal of Information Systems and Project

Management (International Journal of Information Systems and Project Management, 2024). In the IS field, it is ranked as a Q2 journal (Scimago Journal & Country Rank, 2022f).

Table 5. Chronological overview of publications (I)

#	Year	Title	Authors	Outlet	Status	VHB[1]	IF[2]	SRJ[3]	Chapter	Appendix
P12	2024	Maturity Model for IT Project Portfolio Management Processes	Fenja Schulte, **Christin Karrenbauer**, Micheal H. Breitner	International Journal of Information Systems and Project Management	Submitted	-	-	Q2	3.5	A12
P11	2024	Mathematical Optimization Model and Decision Support for IT Project Portfolio Management	**Christin Karrenbauer**, Micheal H. Breitner	Decision Science	Submitted	B	5.5	Q1	3.4	A11
P10	2024	Decision Support Framework for IT Project Manager Recruitment	**Christin Karrenbauer**, Jana Gerlach, Michael H. Breitner	Heliyon	Published	-	4.0	Q1	3.7	A10
P9	2024	Development Guidelines for Individual Digital Study Assistants in Higher Education	Claudia M. König, Christin Karrenbauer, Michael H. Breitner	International Journal of Educational Technology in Higher Education	Published	-	9.5	Q1	4.6	A9
P8	2023	Design, Development, and Evaluation of an Individual Digital Study Assistant for Higher Education Students	**Christin Karrenbauer**, Tim Brauner, Claudia M. König, Michael H. Breitner	Educational Technology Research and Development	Published	-	5.61	Q1	4.5	A8
P7	2023	IT Project Portfolio Management Tools: Towards Taxonomy-based Archetypes	**Christin Karrenbauer**, Florian Bergmann, Michael H. Breitner	Proceedings of the 56th Hawaii International Conference on System Sciences	Published	C	-	-	3.6	A7
P6	2023	Critical Success Factors and Challenges for Individual Digital Study Assistants in Higher Education	Claudia M. König, **Christin Karrenbauer**, Michael H. Breitner	Education and Information Technologies	Published	-	3.61	Q1	4.4	A6
P5	2022	Value-driven IT Project Portfolio Management: Process Model, Evaluation Framework, and Decision Support	**Christin Karrenbauer**, Michael H. Breitner	Proceedings of the 43rd International Conference on Information Systems	Published	A	-	-	3.3	A5

[1] German Academic Association for Business Research (2015); all rankings are for the IS research field, except P11 which is also ranked in the Operation Research field
[2] Based on journal homepages and Clarivate (2021); all IF represent a five-year IF, except in P10
[3] Scimago Journal & Country Rank (2022a); all rankings are in the IS, Education, E-learning, or Information Science disciplines

Table 6. Chronological overview of publications (II)

#	Year	Title	Authors	Outlet	Status	VHB[1]	IF[2]	SRJ[3]	Chapter	Appendix
P4	2021	Incentives for Lecturers to use OERs and Participate in Inter-University Teaching Exchange Networks	Claudia M. König, Carla Reinken, Paul Greiff, **Christin Karrenbauer**, Uwe A. Hoppe, Michael H. Breitner	Proceedings of the 27th Americas Conference on Information Systems	Published	D	-	-	4.7	A4
P3	2021	Individual Digital Study Assistant for Higher Education Institutions: Status Quo Analysis and Further Research Agenda	**Christin Karrenbauer**, Claudia M. König, Michael H. Breitner	Proceedings of the 16th International Conference on Wirtschaftsinformatik	Published	C	-	-	4.3	A3
P2	2022	Optimal IT Project Selection– Quantification of Critical Scoring Criteria	**Christin Karrenbauer**, Michael H. Breitner	Projektmanagement und Vorgehensmodelle 2022	Published	-	-	-	3.2	A2
P1	2020	Dialogue-Driven Digital Study Assistants for Higher Education – A Morphological Analysis	Claudia M. König, **Christin Karrenbauer**, Nadine Guhr, Michael H. Breitner	Proceedings of the 13th International Conference of Education, Research and Innovation	Published	-	-	-	4.2	A1

[1] German Academic Association for Business Research (2015); all rankings are for the IS research field, except P11 which is also ranked in the Operation Research field
[2] Based on journal homepages and Clarivate (2021); all IF represent a five-year IF, except in P10
[3] Scimago Journal & Country Rank (2022a); all rankings are in the IS, Education, E-learning, or Information Science disciplines

1. Research Motivation and Relevance

The persuasive digital transformation and its usage of new technologies has become an important Information System (IS) research field (e.g., Bharadwaj et al., 2013; Piccinini et al., 2015) along with opportunities and challenges for societies as well as private and public organizations (Abad-Segura et al., 2020; Vial, 2019). Digital transformation is “a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies” (Vial, 2019, p. 121). Within companies and organizations, the digitization of products and processes has emphasized the importance of Information Technologies (IT) (Almeida et al., 2020). Within the public sector, especially in the higher education context, the digital transformation led to new possibilities for knowledge transmission and changes in teaching, advising, and learning possibilities (Bond et al., 2018).

Companies and organizations must strategically address the changes and adapt their structures to enable value creation through the digital transformation and remain competitive (Vial, 2019). Organizational IT has a crucial influence on this (Bezdrob et al., 2020). IT investments have risen in the last years and projections show that this trend will continue (Gartner, 2020). These investments are characterized by a duality. Besides IT-related routine processes, a large share is spent on IT projects (Bezdrob et al., 2020). An IT project is “a nonrecurring temporary endeavor requiring a significant amount of IT resources and/or significant changes in the IT infrastructure or application landscape” (Frey, 2014, p. 48) and it is characterized by complexity, cross-functionality, dynamics, non-routine, temporality, and uncertainty (Chiang & Nunez, 2013; Kester et al., 2011). In general, there are more IT projects to select from than can be implemented, for example, because of resource restrictions. Thus, value-driven evaluation, selection, and scheduling aligned to the company and organization strategy are critical business activities and competitive factors (Asosheh et al., 2010; Daniel et al., 2014; Linhart et al., 2020). This holistic management occurs in the IT project portfolio management (PPM). ITPPM is “a continuous and dynamic process to identify IT projects and proposals and to (re-)score, (re-)prioritize, (re-)select, and (re-)schedule them, taking into account interdependencies, limitations, and stakeholder interests to optimize value creation and fit to company goals” (Karrenbauer & Breitner, 2022b, p. 2). However, organizational ITPPM processes often miss structures, and decisions rely on a gut feeling and ad hoc basis, resulting in deviations from objectives, incomplete IT projects, and high failure rates (Varajão & Trigo, 2016). A structured and value-driven ITPPM can promote informed decisions, addresses complexity, and manages multiple IT projects simultaneously to increase success rates.

According to Lee et al. (2021), approximately two third of implemented IT projects exceed their planned budget while one-third require longer than planned. Also, failures because of weak ITPPM processes result in project abandonment, resource losses and exceedances, or even bankruptcies. For example, Dell lost $200 million due to project termination because of weak ITPPM (Fadlalla & Amani, 2015; Hughes et al., 2017). Therefore, the selection of the right IT projects and their implementation at the right time is essential (Tavana et al., 2019). Companies and organizations need adequate, resilient, structured, and value-driven ITPPM processes and guidelines aligned to their strategy to increase performance, remain competitive, and increase objectivity and decision quality (Chiang & Nunez, 2013; Kester et al., 2011; Martin, 2006). Using an ITPPM tool to support processes can lead to more efficient, transparent, and consistent decisions (Caniëls & Bakens, 2012; Killen et al., 2020).

Within higher education institutions (HEI) new technologies resulting from the digital transformation enable better accessibility to learning content and educational resources, with a change to more hybrid and digital solutions rather than traditional face-to-face lectures (Abad-Segura et al., 2020; Telukdarie & Munsamy, 2019). Digital transformation impacts teaching modes and enables technological tools, including digital assistants, to support e-learning, automatized first-level support, and digital study-organization and self-regulation (Bennett et al., 2015; Wambsganns et al., 2021a). Adapting to the changes and new possibilities, the flexibility and dynamic in HEI increases, and it is possible to reach, teach, and communicate with many students at reasonable costs (Funamori, 2016). This is important as previous reforms in HEI, including the Bologna Process in Europe and the Bradly Report in Australia, led to higher student numbers and more diverse backgrounds and educational experiences. Thus, the need for personal counseling and advising increased (Clarke et al., 2013; Van der Wende, 2000; Wong & Li, 2019). At the same time, the number of lecturers and administrators remained relatively constant. This makes personal advising and counseling difficult, while the need for students to study self-organized and self-regulated increases (Hornsby & Osman, 2014; Marczok, 2016; OECD, 2023). The COVID-19 pandemic with predominant online lectures, remote learning, and low interaction rates (Lehmann et al., 2022) has intensified the need for students to be self-organized and self-structured. Even after the pandemic, online lectures are likely to be increasingly used. However, recent studies showed that online learning with low interaction rates influence dropout rates, learning effectiveness, and satisfaction (Eom & Ashill, 2016; Hone & El Said, 2016; Ritz et al., 2022).

There is a need for personalized and individualized study support. Digital assistants provide solutions to react to these changes and challenges. Daradoumis et al. (2021), Lee et al. (2022), and Wambsganss et al. (2021b) demonstrated that digital assistants can increase self-regulation competencies, study performance, and soft skills. One example are pedagogical conversational agents (PCA), chatbots used within a learning-oriented context (Wellnhammer et al., 2020). They can support direct learning, including idea generation (Vladova et al., 2019), programming and argumentation skills (Hobert, 2019; Wambsganss et al., 2021a), math education (Cai et al., 2021), or general learning improvements (Winkler et al., 2020). Instead of this direct learning support, individual digital study assistants (IDSA) support students on a more reflective level and enable automatized first-level support. An IDSA is defined as “an efficient online student support tool that strengthens self-regulation skills, goal achievement, and study organization through suitable functionalities” (Karrenbauer et al., 2023b, pp. 6-7). Using different information sources, individual objectives, interests, and competencies, IDSA support students with recommendations and reminders. This includes, for example, assistance for a more efficiently planned and managed study and individual learning strategies based on completed modules or strengths and weaknesses (Karrenbauer et al., 2023b; König et al., 2023). For instance, an IDSA can assist students with major and course selection (Karrenbauer et al., 2021), whereas PCA can then be used to learn the specific course contents through quizzes (Ruan et al., 2019). While there is already much research on requirements and design principles for PCA (e.g., Hobert, 2019; Wambsganss et al., 2021a), research for IDSA is still limited. It requires detailed and user-centric analysis of their critical success factors (CSF), requirements, and design and implementation processes.

In general, IS research is diverse with many different research fields and topics (Recker, 2013), which is also reflected in this cumulative dissertation. This dissertation contributes to the field of ITPPM and IDSA in HEI for researchers and practitioners. Both research topics unite that digital transformation offers new opportunities leading to new structures and possibilities. The ITPPM research within this dissertation focuses on models, frameworks, and tools to minimize subjective influences in ITPPM processes and improve value-oriented and informed decisions. While this theoretically addresses IT(P)PM, we researched and implemented a concrete project to design and develop an IDSA during a three-year research process. We analyzed CSF and requirements for IDSA and created knowledge and guidelines about an IDSA design and implementation that are valuable for researchers and practitioners.

This cumulative dissertation is divided into six parts. Section 1 already gave an overview of the research need and motivation for the dissertation. Section 2 describes the applied research designs and methods within the scientific papers in this dissertation. The following two sections are arranged thematically. Section 3 describes the performed research within the ITPPM field with its corresponding papers, and section 4 focuses on the research papers in the field of IDSA in HEI. This dissertation concludes with an overall discussion of recommendations, implications, limitations, 13 further research opportunities, and concluding remarks.

2. Applied Research Designs and Methods

IS research covers a broad range of topics and is diverse. Applied research designs and methods are also divers and dependent on the overall research objectives, environment, and theory (Recker, 2013). The 12 papers within this cumulative dissertation are based on multiple research designs and methods. Depending on the underlying research objectives and questions, we applied a suitable research design and research methods. Table 12 gives an overview of the applied designs and methods and they are described in more detail in the upcoming sections.

2.1. Design Science Research

Design Science Research (DSR) is an iterative process that strives to develop innovative artifacts and design knowledge for real-world problems (Hevner, 2007; vom Brocke et al., 2020a). DSR is widely recognized as a central research paradigm in the field of IS (Hevner et al., 2019). It often builds on existing (design) knowledge and solutions by combining, extending, or revising them. Table 7 gives an exemplary overview of how we applied DSR research within our papers.

Table 7. Overview of exemplary DSR studies

	P5: Karrenbauer and Breitner (2022b)	**P11: Karrenbauer and Breitner (2024)**
Method in rigor cycles	Literature reviews	Literature review
Method in relevance cycles	Qualitative study (24 experts), applicability check	Discussions at conferences
Method in evaluation cycles	Online Survey (7 experts), qualitative study (12 experts)	Qualitative study (4 experts)
Artifact in design cycles	ITPPM process model, evaluation framework, DSS prototype	Optimization model, DSS prototype

DSR constitutes three interrelated activity cycles: the rigor cycle, which draws on scientific-, method-, and domain knowledge; the relevance cycle, which considers environmental perspectives including people, organizations, and technical systems; and the design cycle, which involves building and evaluating artifacts, like models, frameworks, and prototypes (Hevner, 2007; Hevner et al., 2019; vom Brocke 2020a). In addition to designing the artifacts, evaluating their applicability, gathering early suggestions for improvements, and implementing them are central components of the design cycle (vom Brocke et al., 2020b). As proposed by Sonnenberg and vom Brocke (2012) and Gregor and Hevner (2013) we evaluated our artifact’s comprehensibility, relevancy, usability, completeness, functionality, fit with the company, and added value, applying different methods in the evaluation cycles (see Table 7). Figure 2 shows the applied DSR research design with its iterations in Karrenbauer and Breitner (2022b).

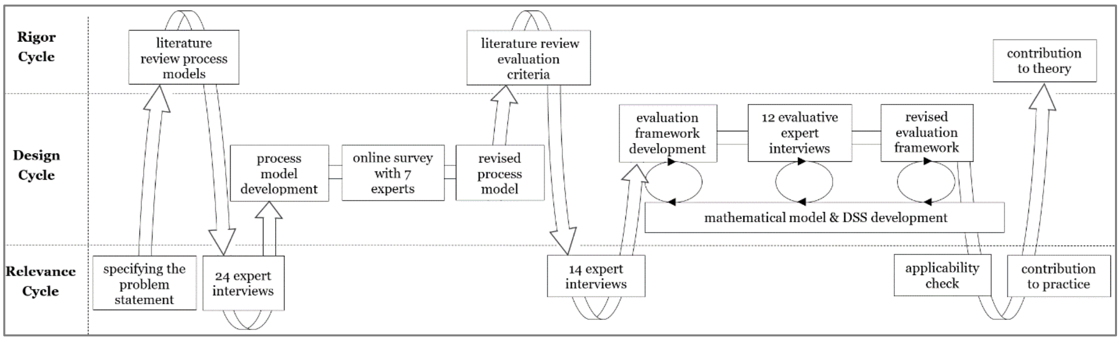

Figure 2. DSR research design and iterations (Karrenbauer & Breitner, 2022b)

2.2. Action Design Research

DSR focuses on designing and building IT artifacts to generate design knowledge and has a technological view. It focuses less on the influence of the organizational context in that the artifacts are developed and applied. Artifacts are first built and then separately evaluated in a later phase. Therefore, DSR-oriented artifacts are often either technologically rigorous or organizationally relevant but fall short of being both. To address this problem, Sein et al. (2011) proposed Action Design Research (ADR) that aims to build innovative IT artifacts in an organizational context while it is inseparable from the intervention and evaluation procedure. ADR emphasizes the impact of the relevance cycle and provides concrete guidance to combine building, intervention, and evaluation to address an explicit research problem. Its goal is to “link theory with practice, and thinking with doing” (Sein et al., 2011, p. 39). Sein et al. (2011) proposed various tasks within seven principles and four stages: (1) problem formulation, (2) building, intervention, and evaluation, (3) reflection and learning, and (4) formalization of learning. Table 8 shows an exemplary ADR research process and conduced stages in Karrenbauer et al. (2023b).

Table 8. ADR: Phases, tasks, and outcomes (Karrenbauer et al., 2023b)

Stages, tasks	Outcomes
(1) Problem formulation	
Identify, articulate, and conceptualize a research opportunity	Student numbers have increased while the number of employees within higher education institutions has remained static, eroding student support. Courses and content are becoming increasingly diverse, while student needs are becoming more individualized. An IDSA can support students and positively impact self-regulation.
Formulate an initial research question	What requirements guide user-centric design and development of an IDSA? How can an IDSA be designed based on the identified requirements?
Identify theoretical bases and prior technological advances	The IDSA literature was reviewed to identify unique selling propositions to support formulating design and development requirements accordingly.
Secure a long-term commitment	Researchers participated in all stages of the development process and beyond.
Define roles and responsibilities	The ADR team included researchers from IS, cognitive science, information management, business management, digital teaching, campus management, and higher education didactics. The researchers’ tasks were divided into the conception, design, and development of the IDSA.

(2) Building, intervention, and evaluation	
Select initial participants	A student survey of 557 students from three German higher education institutions was conducted.
Further select participants	Nine lecturers and 19 employees of different organizational units within a German higher education institution were interviewed to analyze the practical perspective.
Ongoing iterative development, testing, and evaluation	Requirements were derived qualitatively, quantitatively, and from the literature. In parallel, the IDSA prototype was developed based on the requirements engineering. The ADR researchers and selected students continuously tested it. The prototype was launched for a 3-month test phase.
(3) Reflection and learning	
Ongoing formalization and discussion of requirements for an IDSA in higher education	The findings were compared with recently published papers and advanced requirements formulated that must be considered during IDSA design and development.
Submit findings to workshops/ conferences for academic and practical feedback	The findings were published and discussed with IS and higher education administration and management experts at conferences and workshops.
Analyze the intervention results according to the research objects	Further requirements were formulated for IDSA design and development and compared to the research goals.
Describe the organizational outcomes	The organizational changes necessary for higher education institutions were discussed with associated experts.
(4) Learning formalization	
Abstract results to a class of field problems	The generalizable requirements were abstracted through multi-perspective requirements and a subsequent prototype evaluation.
Focus on the transferability of results and communication of outcomes	The results and findings were triangulated. The findings supported the identification of outcomes and recommendations for higher education institutions.
Specify the outcomes	The results and findings considered all data for the requirements and recommendations of IDSA design and development.

2.3. Taxonomy and Archetype Development

Taxonomy Development

A taxonomy is a systematic classification of design objects to organize and structure complex information into a more manageable and understandable structure, i.e., a classification. It shows similarities and differences between classified objectives (Kundisch et al., 2021; Nickerson et al., 2013). We used the taxonomy development procedure of Nickerson et al. (2013) that was updated by Kundisch et al. (2021) to classify ITPPM tools (Karrenbauer et al., 2023a) and IT project manager job advertisements (Karrenbauer et al., 2024) within this dissertation.

Taxonomies are positioned in the DSR paradigm because they provide structured artifacts to ease the understanding of complex topics and then to analyze them further (Hevner et al., 2004; Kundisch, 2021; Szopinski et al., 2019, 2020). Following Nickerson et al. (2013) each taxonomy consists of various dimensions with at least two characteristics while each object needs to be classified to exactly one characteristic in each dimension. The taxonomy development process composes seven steps (Kundisch et al., 2021; Nickerson et al., 2013). At first, it requires to define meta characteristics to guide the overall taxonomy development process, dimension, and characteristic definition. Used meta characteristics of the two taxonomy papers in this dissertation are shown in Table 9. Second, ending conditions need to be defined. Once they are all met, the iterative taxonomy development process is complete. In our papers, we used the proposed subjective and objective ending conditions from Nickerson et al. (2013) with no modifications. Third, iterative conceptual-to-empirical (C2E) and empirical-to-conceptual (E2C) iterations are performed until all ending conditions are met. In both papers, we started with a C2E approach and performed a structured literature review following vom Brocke et al. (2009, 2015), Webster and Watson (2002), and Watson and Webster (2020) (see section 2.4), to derive initial dimensions and characteristics. Thereafter, we performed E2C iterations and classified a total of 60 (Karrenbauer et al., 2023a) and 125 (Karrenbauer et al., 2024) objects to derive, delete, rename, or reorganize perspectives, dimensions, and characteristics. We met all ending conditions after five (Karrenbauer et al., 2023a) and four (Karrenbauer et al., 2024) E2C and C2E iterations and completed the taxonomy development process.

After we theoretically and empirically deduced the taxonomies, we evaluated their usefulness, applicability, understandability, extendibility, and comprehensiveness (Prat et al., 2014; Sonnenberg & vom Brocke, 2012; Szopinski et al., 2019, 2020). Szopinski et al. (2019) developed a taxonomy evaluation framework focusing on the categories evaluation subject (who?), evaluation object (what?), and evaluation method (how?). In both papers, we performed qualitative expert interviews or surveys (evaluation method) with practitioners with domain-specific knowledge who had no previous contact with the taxonomy (evaluation subject). We used "ITPPM tools and their (non-)functionalities" (Karrenbauer et al., 2023a) and "the search for an IT project manager position" (Karrenbauer et al., 2024) as the real-word problems to investigate (object of evaluation).

Archetype Analysis

Once the taxonomy is developed, a cluster analysis enables to identify patterns and evaluates the taxonomy's applicability (Kundisch et al., 2021; Weking et al., 2020). The clusters can be identified using the k-means algorithm. It calculates the distance between all classified objects and groups them, maximizing the distances between clusters and minimizing them within each cluster (Kaufmann & Rousseeuw, 1990). Determining the optimal cluster number (k) is crucial to enable an effective cluster analysis. The Elbow and Silhouette methods calculate the clusters' cohesion, separation, and support to graphically assess the resulting clusters' quality (Saputra et al., 2020). The Elbow technique is a heuristic method, relying on the principle that k-means clustering aims to reduce variances. The optimal number of clusters can be identified by plotting the variance to the number of clusters. The "elbow" point of the curve than indicates the optimal number of clusters. The Silhouette method is also a heuristic that analyzes the fit of each point into its respective cluster, relying on its size (Kaufmann & Rousseeuw, 1990). Results from the Elbow and Silhouette methods suggested that five clusters are ideal for both papers (Karrenbauer et al., 2023a, 2024). Each cluster can be interpreted as an archetype (Kundisch et al., 2021). Table 9 gives an overview of the used taxonomic approach and archetype analysis in this dissertation.

Table 9. Overview of taxonomy studies

	P7: Karrenbauer et al. (2023a)	**P9: Karrenbauer et al. (2024)**
Meta characteristic	Functional and non-functional capabilities in ITPPM tools	Elements for requirements and benefits for IT PM positions
Conceptual-to-empirical iterations	1	1
Empirical-to-conceptual iterations	4	3
Classified objectives	ITPPM tools	IT project manager job advertisements
#Classified objectives	60	125
Perspectives	4	5
Dimensions	20	33
Characteristics	51	77
Evaluation method	Qualitative interviews (5), archetype analysis	Online experts survey (7), archetype analysis
Archetypes	5	5
Decision Tree	No	Yes

2.4. Literature Review

A literature review in IS is a key step in the research process, as it helps researchers to situate their research within the existing body of knowledge, identifies knowledge gaps and problems, provides a foundation for own research, and develops an understanding of a domain (Templier & Paré, 2015; Webster & Watson, 2002; vom Brocke et al., 2015). According to Fink (2010) a literature review is a "a systematic, explicit, and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars, and practitioners" (Fink, 2010, p. 3). A literature review can be a standalone review, a background review for further research progress, or serve as a basis for the theoretical background section (vom Brocke et al., 2015).

Conducting a literature review has become easier in some ways because of advances in technology and the availability of online databases, but more complicated and complex because of a huge amount of available publications, leading to a "literature overload" (vom Brocke et al., 2015; Watson & Webster, 2020). Therefore, different guidelines to conduct a structured literature review have been proposed (Templier & Paré 2015; vom Brocke et al., 2009, 2015; Watson & Webster, 2020; Webster & Watson, 2002). In almost all papers within this dissertation we conducted a systematic literature review following the guidelines of Templier and Paré (2015), vom Brocke et al. (2009, 2015), Watson and Webser (2020), and Webster and Watson (2002). Most of them were background reviews (e.g., Karrenbauer & Breitner, 2022b, 2023a, 2023b, 2024; König et al., 2023, 2024), while others were standalone reviews (e.g., Karrenbauer et al., 2021; König et al., 2020). In König et al. (2021), the literature review served as a foundation for the theoretical background. Further, in König et al. (2023), we followed the principles of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Moher et al., 2009) to comply with the journal's requirements. The guidelines are similar, while PRISMA includes the phases identification, screening, eligibility, and inclusion (Moher et al., 2009). Table 10 provides an overview of literature reviews from three exemplary papers within this dissertation.

Table 10. Overview of exemplary literature review studies

	P3: Karrenbauer et al. (2021)	**P5: Karrenbauer and Breitner (2022b)**	**P6: König et al. (2023)**
Purpose	Standalone review	Background review	Background review
Keyword search string	("digital" OR "automated" OR "intelligent" OR "virtual" OR "personal" OR "cognitive") AND ("student" OR "study") AND ("assistant" OR "system" OR "advisor") AND ("academic" OR "college" OR "university" OR "higher education")	("IT project selection" OR "IT project evaluation" OR "IT portfolio selection" OR "IT portfolio evaluation" OR "IT portfolio management") AND ("framework" OR "process model" OR "procedure model" OR "cycle")	("critical success factors" OR "challenges" AND "digital study assistant" OR "conversational agent" OR "chatbot" OR "intelligent tutoring system" OR "smart assistant" OR "digital assistant" OR "personal assistant" OR "e-learning") AND ("higher education" OR "university")
Databases	ACM Digital Library, AISeL, Emerald Insight, IEEE Xplore, Informs PubsOnLine, Jstor, Sages, Science Direct, Semantic Scholar, Springer Link, Wiley	ACM Digital Library, AISeL, IEEE Xplore, Informs PubsOnLine, Jstor, Sages, Science Direct, Semantic Scholar, Springer Link, Web of Science, Wiley, International Journal, of Project Management, Project Management Journal	ACM Digital Library, AISeL, Google Scholar, IEEE Xplore, Informs PubsOnLine, Jstor, Sages, Science Direct, Semantic Scholar, Springer Link, Taylor and Francis, Wiley
Initial publications	1,047	989	4,426
Relevant publications	54	26	54

Each systematic review starts with a definition of key words and search strings. As IS research covers a wide variety of topics, it requires the use of several databases to ensure that a wide range of relevant journals and conferences are included and to present the current state of research (vom Brocke et al., 2015; Webster & Watson, 2002). For literature reviews within this dissertation, we searched various databases. We applied inclusion and exclusion criteria for initial hits to reduce the initial (mostly high) number of publications to relevant papers for the underlying topic (vom Brocke et al., 2015; Webster & Watson, 2002). We then performed forward-, backward-, Google author-, and similarity searches (Webster & Watson, 2002). For most papers, we developed a concept matrix according to Webster and Watson (2002) for the final set of key literature.

2.5. Qualitative Research

Qualitative research methods enable to gather practical knowledge and experience from experts when there is limited information and domain-specific knowledge available or when participants are requested to express their feelings and viewpoints about a specific topic (Gioia et al., 2013; Myers & Newman, 2007; Yin, 2018). In this dissertation, we conducted several expert interviews and surveys, which were used for ten publications. Thereby, expert interviews can be explorative to generate new knowledge (e.g., Karrenbauer et al., 2023b) or evaluative to get feedback (e.g., Karrenbauer et al., 2023a). In addition, they can be used as a single research method (König et al., 2021) or as one research method within a research design (Karrenbauer et al., 2024; König et al., 2023) and can be performed several times with different purposes within one paper (Karrenbauer & Breitner, 2022b). All exploratory interviews in this dissertation were semi-structured and guideline-oriented to ensure reliability while being flexible to respond to the interview situation (Silverman, 2016). We conducted pre-tests to ensure that all questions were understandable. Depending on the results, we adapted the interview guidelines (Johnston & Warkentin, 2010). In all papers, we sent the guidelines to the experts in advance to allow preparation for the interview and ensure that the experts had expertise in the relevant field (Myers & Newman, 2007). We coded and analyzed transcripts mostly following Corbin and Strauss (2014), supported by MAXQDA support. We conducted interviews until we reached saturation and gained no new insights (Corbin & Strauss, 2014). For the evaluations, we either conducted semi-structured and guideline-oriented expert interviews (e.g., Karrenbauer & Breitner, 2022b) or created online questionnaires (e.g., Schulte et al., 2024).

We recruited experts for the exploratory or evaluative studies through different career network sites, projectmanagement.com, within our HEI network, and personal contacts. We ensured that all had profound knowledge, including several years of experience in the analyzed field, and were working in different industries and positions. We conducted the interviews in person or online due to geographical distances and COVID-19. Table 11 provides information about selected qualitative studies within this dissertation.

Table 11. Overview of exemplary qualitative studies

	P5: Karrenbauer and Breitner (2022b) (excerpt process model)		**P7: Karrenbauer et al. (2023a)**
Purpose	Exploration	Evaluation	Evaluation
Approach	Qualitative interviews	Online questionnaire	Online questionnaire
Number of experts	24	9	5
Focus	Experts involved in ITPPM process	Experts involved in ITPPM process	Experts with knowledge in field of ITPPM tools
Countries	Germany, France, Canada, USA	Germany, France, Canada, USA	Germany
Duration	32-85 min.	-	-

2.6. Quantitative Research

Quantitative research encompasses quantitative data to address and answer an underlying research question. Using statistical techniques, it is possible to analyze the results and draw conclusions.

Surveys are often used to get this quantitative data. A survey must include many randomly selected participants in the analysis to describe the research topic. These participants must represent the general population as closely as possible (Recker, 2013). We used quantitative research in the IDSA in HEI research field within three papers. In 2019, project participants conducted an online survey with 570 students from three German HEI to get their options for essential IDSA functionalities, incentives, and barriers to use them. Students could prioritize different functionalities, rate an IDSA's attributes on a 10-point Likert scale from 1 (*unimportant*) to 10 (*highly relevant*), and provide their opinions about CSF, incentives, and barriers within a free text field. In addition, the IDSA prototypes included a functionality that involved a questionnaire about the IDSA's usability, added value, acceptance, and wording using a 5-point Likert scale ranging from 1 (*don't agree*) to 5 (*fully agree).* Further, we got usage data from more than 2,500 students that used the IDSA prototypes. We analyzed all data using descriptive analyses and determined frequencies, mean values, and standard deviations. Based on them, it was possible to derive insights for our IDSA development iterations.

2.7. Mixed Methods

Mixed method research combines quantitative and qualitative methods within one research project to overcome the disadvantages of applying one method only. It allows a deeper understanding and enables more detailed discussions and interpretations that would not be possible using one method only (Creswell & Plano Clark, 2018; Sousa, 2004). In König et al. (2023), we used mixed methods to identify CSF for IDSA. We used a qualitative and quantitative analysis combined with a literature review and applied a convergent parallel design to include various stakeholder perspectives (Creswell & Planko Clark, 2018; Kerrigan, 2014). This means we first separated findings of one study from the others using parallel research and then mixed the results primarily during the data interpretation phase. Lastly, we triangulated our results and findings, which served as a meta-view to allow several perspectives (Creswell & Plano Clark, 2018; Flick, 2017; Flick et al., 2012).

Table 12. Overview of applied research designs and methods in the papers within this dissertation

#	Year	Title	Research method			Research design
			Literature review	Qualitative study	Quantitative study	
P12	2024	Maturity Model for IT Project Portfolio Management Processes	x	x		Design Science Research
P11	2024	Mathematical Optimization Model and Decision Support for IT Project Portfolio Management	x	x		Design Science Research
P10	2024	Development Guidelines for Individual Digital Study Assistants in Higher Education	x	x	x	Action Design Research
P9	2024	Decision Support Framework for IT Project Manager Recruitment	x	x		Taxonomy, Archetypes
P8	2023	Design, Development, and Evaluation of an Individual Digital Study Assistant for Higher Education Students	x	x	x	Action Design Research
P7	2023	IT Project Portfolio Management Tools: Towards Taxonomy-based Archetypes	x	x		Taxonomy, Archetypes
P6	2023	Critical Success Factors and Challenges for Individual Digital Study Assistants in Higher Education	x	x	x	Mixed Methods
P5	2022	Value-driven IT Project Portfolio Management: Process Model, Evaluation Framework, and Decision Support	x	x		Design Science Research
P4	2021	Incentives for Lecturers to use OERs and Participate in Inter-University Teaching Exchange Networks		x		-
P3	2021	Individual Digital Study Assistant for Higher Education Institutions: Status Quo Analysis and Further Research Agenda	x			-
P2	2022	Optimal IT Project Selection–Quantification of Critical Scoring Criteria	x	x		-
P1	2020	Dialogue-Driven Digital Study Assistants for Higher Education – A Morphological Analysis	x			-

3. Contributions to Value-driven IT Project Portfolio Management

3.1. Introduction and Motivation

ITPPM manages many company and organizational IT projects and aims to create value while all IT projects compete for scarce resources (Archer & Ghasemzadeh, 1999; Linhart et al., 2020). ITPPM is characterized by uncertainties, changing information, dynamic opportunities, and multiple goals, making it challenging (Mohagheghi et al., 2019). Besides resources allocated to IT projects, many are also spent on routine processes, indicating the duality of IT spending (Bezdrob et al., 2020). Therefore, an effective and value-driven ITPPM is critical to ensure optimal resource allocation, control the whole portfolio, improve goal achievement, and reduce uncertainties (Daniel et al., 2014). A dismission of resource availabilities, unclear roles and responsibilities, non-integrated and overlapping IT projects, missing feedback, and a continuation of IT projects despite their deviations all have a negative influence on ITPPM performance (Too & Weaver, 2014; Trigo & Varajão, 2020).

Despite the need for structured processes, only limited process models for ITPPM exist in literature. They vary in their phases and activities and are sequential without the possibility of re-cycles between or within phases (Ajjan et al., 2016; Chiang & Nunez, 2013). In Karrenbauer and Breitner (2022b), we developed an integrated ITPPM process model that synthesizes and expands existing ones to address this gap. Our process model supports value-driven and objective ITPPM, provides flexibility to adapt to changes and uncertainties, integrates different stakeholders, and allows re-cycles between and within phases and activities. According to literature and our results and findings in Karrenbauer and Breitner (2022b), effective IT project evaluation, prioritization, and selection are critical activities in ITPPM. Existing methods for these activities range from financial project selections to advanced optimization models and fuzzy programming (Archer & Ghasemzadeh, 1999; Asosheh et al., 2010). Combining these quantitative and qualitative approaches, we identified commonly used IT project evaluation criteria and developed a holistic evaluation framework in Karrenbauer and Breitner (2022a, 2022b). It provides an objective evaluation method for IT projects of different sizes and types and quantifies subjective estimations.

Reliable information and appropriate tools contribute to more informed decisions (Osuszek & Ledzianowski, 2020). However, many ITPPM tools lack accessibility and transparency while decision parameters and processes are unknown or difficult to understand (Karrenbauer et al., 2023a). This black box prevents an effective analysis of critical thresholds and influencing decision parameters. In Karrenbauer and Breitner (2024), we designed, developed, and implemented a value-driven optimization model and decision support system (DSS) prototype for

ITPPM decisions to address this gap. It optimizes value contribution and considers existing interdependencies between IT projects, limited resource availabilities, and other constraints.

At the same time, the applicability of the process model, frameworks, and tools depends on the organizational IT maturity (Kock et al., 2020). The higher the maturity is, the more complex these models and frameworks can be. Using an ITPPM maturity model, companies and organizations can define their status quo of current processes and derive a roadmap to improve these. Thus, a maturity model can enhance the development and advancement of ITPPM processes. We synthesized knowledge from literature and experts and developed an integrated and value-driven maturity model for ITPPM processes in Schulte et al. (2024).

Companies and organizations tend to use tools for single project management only, despite the strengths and opportunities of ITPPM tools (Ayyagari & Atoum, 2019; Besner & Hobbs, 2012; Osuszek & Ledzianowski, 2020). Existing ITPPM tools differ in their functionalities and scope, making decisions for a suitable one difficult (Killen et al., 2020; Kock et al., 2020). However, existing literature missed a holistic and empirically validated analysis and classification of ITPPM tools to support decisions. In Karrenbauer et al. (2023a), we classified existing literature and real-world ITPPM tools, developed a taxonomy, and deduced patterns to structure the market.

On a single project level, skilled and experienced IT project managers contribute to successful project completion (Adzmi & Hassan, 2018; Gheni et al., 2017; Trigo & Varajão, 2016). However, recruitment and selection of suitable and qualified IT project managers are difficult for companies and organizations (Ahsan et al., 2013). Literature missed a framework to recruit external IT project managers and support the recruitment process, including job advertisement formulation, job interviews, and candidate selection. Therefore, in Karrenbauer et al. (2024), we classified IT project manager job advertisements, deduced archetypes, and developed a framework that assists practitioners and researchers in recruiting IT project managers.

3.2. Initial IT Project Evaluation Criteria

This section concentrates on the paper "Optimal IT Project Selection – Quantification of Critical Scoring Criteria" (Karrenbauer & Breitner, 2022a; Appendix 2). Among other results, the paper identifies initial and commonly used IT project evaluation criteria based on a systematic literature review and expert interviews. The following section only shows the identified evaluation criteria because all other results were further developed and are described and discussed in more detail in the upcoming sections.

We identified eight evaluation criteria in literature and by expert interviews. These encompass complexity, efficiency, interdependencies, risks, strategy, urgency, and politics, which all have sub-criteria (see Table 13).

Table 13. Identified IT project evaluation (sub-)categories (Karrenbauer & Breitner, 2022a)

Criteria	Sub-criteria	Literature	Experts
Complexity	Degree of complexity	x	
	General	x	
	Number of changes	x	
Efficiency	Cost and/or benefit analysis	x	x
	Economic returns	x	
	Growth rate	x	x
Interdependencies	General	x	x
	Mutual exclusiveness	x	
	Synergies	x	
	Time-dependencies	x	
Organizational Politics	Influence of executives' opinions		x
Resource Limitations	General	x	
	Human Resources	x	x
	Monetary	x	
Risk	Available experience	x	
	General	x	
	Probability of occurrence and consequences	x	x
Strategy	Competitive advantages	x	
	Increase in market share	x	
	Strategic alignment/goals	x	x
Urgency	Need for daily business		x
	Need for renewal	x	x
	Regulatory requirements	x	X

3.3. Process Model and Evaluation Framework

This section is based on the paper "Value-driven IT Project Portfolio Management: Process Model, Evaluation Framework, and Decision Support" (Karrenbauer & Breitner, 2022b; Appendix 5). It focuses on the development of a process model, an evaluation framework, and a decision support system prototype to support ITPPM processes and decisions. We used the results and findings of Karrenbauer and Breitner (2022a) as one input and extended them with more actual and higher quality literature and more expert interviews. In doing so, we addressed three research questions: (1) What activities constitute a value-driven ITPPM process? (2) How can IT projects (and proposals) be uniformly evaluated to generate a value-driven IT portfolio? (3) How can a DSS support IT project selection and scheduling? In the following, we describe and discuss the process model and evaluation framework only, as the DSS prototype is extended and discussed in more detail in Karrenbauer and Breitner (2024).

Following the DSR process according to Hevner (2007) and vom Brocke et al. (2020a), we performed several research steps in the rigor-, relevance-, and design cycles and gathered knowledge from literature and experts in several iterations. The final ITPPM process model involves eight phases with 28 activities (see Figure 3). Phase 1 *Initialize/continue/adapt ITPPM processes and policies* is about defining baseline conditions for the upcoming phases, including responsibilities, evaluation methods, resource availabilities, and the planning horizon (Alaeddini & Mir-Amini, 2020; Dewi, 2019; Gadatsch, 2009; Heidary et al., 2020; expert interviews). Thus, long-term and strategic decisions are made (Archer & Ghasemzadeh, 1999).

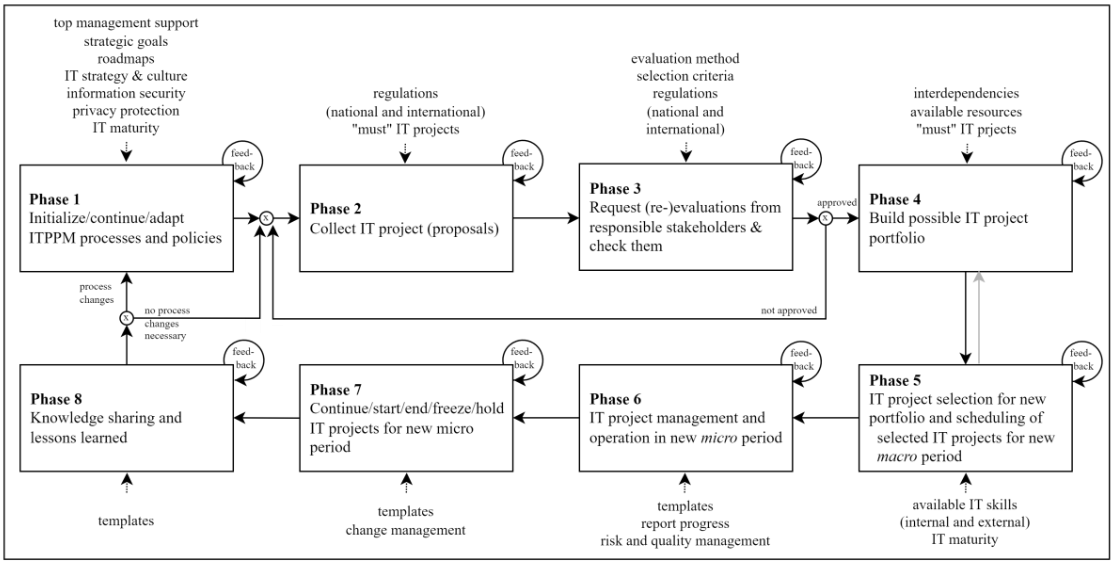

Figure 3. Cycle ITPPM process model (Karrenbauer & Breitner, 2022b)

The second phase *Collect IT project (proposals)* involves the systematic collection of (new) IT project proposals and their relevant information through business cases or pre-studies (Archer & Ghasemzadeh, 1999; Chiang & Nunez, 2013; expert interviews). The third phase *Request (re-)evaluations from responsibles and check them* focuses on the (re-)evaluation of identified IT projects (proposals) and their authorization (Ajjan et al., 2016; expert interviews). Depending on the size and scope, different entities are involved in the evaluation and authorization process and evaluations iterate between different hierarchical levels (expert interviews). Phase 4 *Build an "optimal" IT project portfolio* uses all previously collected inputs and data to determine a theoretically optimal IT project portfolio composition and scheduling based on, for example, mathematical optimization models and decision support tools (Ajjan et al., 2016; Kornfeld & Kara, 2011; expert interviews).

Results of phase 4 build a decision support and a basis for the next phase. In phase 5 *IT project selection and scheduling* the results of phase 4 are discussed. Depending on the size and importance of the IT project, several iterations between different hierarchies can be needed until a final decision for the portfolio composition and scheduling is made by decision-makers (Ajjan et al., 2016; expert interviews). In phase 6 *IT project management and operation* the actual management of selected IT projects occurs (Iriarte & Bayona, 2020; PMI, 2017; Trigo & Varajão, 2020). Once implemented, the IT projects get reviewed periodically in phase 7 *Continue/end/freeze/hold IT projects* (Beringer et al., 2012; expert interviews). Depending on the results, it is possible to freeze, change priority, hold, or terminate IT projects to adjust the portfolio and react to changes (Montgomery, 2007; expert interviews). Phase 8 *Knowledge sharing and lessons learned* occurs after the completion of an IT portfolio. Here, the real value contribution is compared with the planned one to measure success (Gadatsch, 2009; Montgomery, 2007; expert interviews). In addition, the introduction of a project database can generate knowledge to identify weaknesses and derive measures (Ajjan et al., 2016; Too & Weaver, 2014; expert interviews). Upon completion of an IT portfolio cycle, a new one starts. In case the baseline conditions require changes, the new cycle starts in phase 1, otherwise in phase 2.

Our results revealed that the phase of IT project evaluation is highly important. We derived eight commonly used criteria for IT project evaluation with several sub-criteria: Complexity, efficiency, interdependencies, resource limitations, risks, strategy, urgency, and company politics (Karrenbauer & Breitner, 2022a). We used these to develop an evaluation framework for IT projects (proposals) (see Table 14). However, we excluded the criteria interdependencies, resource limitations, and company politics and considered them in our mathematical model and DSS prototype (Karrenbauer & Breitner, 2024). The evaluation framework allows to individually evaluate IT project (proposals) using an integer one to five scale. Accordingly, each IT project must be evaluated for each sub-criterion. Applying Equation (Eq) 1 and Equation 2, it is then possible to calculate the overall IT project score, i.e., value contribution. Equation 1 defines the individual score of an IT project. The first factor $\mathrm{w_c}$ denotes the weighting or relative importance of criterion c. The second factor determines the average score of an IT project for a criterion. It can be calculated by the sum of scores of all sub-criteria s of criterion c, divided by the number of sub-criteria s for criterion c. N_c defines the set of sub-criteria for evaluation criterion c. The average score for criterion c then gets multiplied with its individual weight w_c. Summing up all weighted average scores of all criteria determines the individual score $\mathrm{a_i}$ of IT project i. Equation 2 defines an auxiliary condition to normalize the criteria's weights and assures that the sum of all weights equals one.

$$\mathrm{a_i} = \sum_{\mathrm{c} \in \mathrm{C}} \left(\mathrm{w_c} \frac{\sum_{s \in N_c} v_{isc}}{\sum_{s \in N_c} 1} \right) \qquad \forall\, i \in P \qquad \text{(Eq1)}$$

subject to

$$\sum_{c \in C} \mathrm{w_c} = 1 \qquad \text{(Eq2)}$$

Table 14 displays the final scoring table using a verbal scale. We suggest to adapt it with organization-specific values to enable a more value-driven evaluation and minimize subjective influences. Thereby, either one or a group of decision-makers can evaluate all IT projects. If multiple persons perform the scoring, we propose to calculate a mean value of the scoring results to determine the final score. It is possible to use weights corresponding to the scorer's expertise or hierarchy or discuss the results until an agreement. However, with a rising number of IT projects, this becomes less feasible because of high manual efforts. In this case, we suggest to concentrate on the most important and resource consuming IT projects only. Overall, the process model and evaluation framework synthesize and extend conceptual and empirical knowledge and ITPPM research. They allow more informed, objective, and value-driven ITPPM decisions.

Table 14. Evaluation framework for IT projects (Karrenbauer & Breitner, 2022b)

(Sub-)Criteria		Score Value 1	Score Value 2	Score Value 3	Score Value 4	Score Value 5
Complexity	Involved business departments	numerous	many	several	individual	IT department specific
	Change management impact on teams/individuals	significant changes	considerable changes	isolated changes	minor changes	no changes
	Interrelation with other IT projects	numerous	many	several	individual	none
	Ease of implementation	very complex	complex	medium	simple	very simple
	IT architecture fit	significant customi-zations	considerable customizations	isolated customizations	minor cus-tomizations	no customizations
Efficiency	Investment recovery periods	very long	long	moderate	short	very short
	Long-term cost savings	no effects	barely noticeable	noticeable	considerable	highly significant
	Impact on the growth rate	no effects	barely noticeable	noticeable	considerable	highly significant
	Employee performance improvement	none	barely noticeable	noticeable	considerable	highly significant
Risk	Risk profile	very high	high	moderate	low	very low
	Similar (un)successful past IT projects of leader/ team	in-experienced	little experienced	medium experienced	experienced	highly experienced
	Positive interrelation with other IT projects	none	barely noticeable	noticeable	considerable	highly significant
	Negative interrelation with other IT projects	highly significant	considerable	noticeable	barely noticeable	none
Strategy	Short-term business goals support	none	barely noticeable	noticeable	considerable	highly significant
	Long-term business goals support	none	barely noticeable	noticeable	considerable	highly significant
Urgency	Non-compliance with regulatory requirements	none existing	short-term disruptions	considerable disruptions	legal con-sequences	sanctions
	Needed to keep daily business processes running	no need	for few processes	for several processes	for many processes	for core processes
	Need for modernization	next 6+ years	next 5 years	next 4 years	next 3 years	next 2 years

3.4. Optimization Model and Decision Support System Prototype

This section is about the paper "Optimization Model and Decision Support for IT Project Portfolio Management" (Karrenbauer & Breitner, 2024; Appendix 11). It focuses on the developed optimization model of Karrenbauer and Breitner (2022a, 2022b) and the further development. The model served as an input to implement a DSS prototype for ITPPM decisions. We addressed two research questions: (1) How can a value-driven optimization model support IT project selection and scheduling considering resources, interdependencies, and other constraints? (2) How can this model be implemented in a DSS prototype to enable a decision-making process including strategic IT managers?

Our mixed-integer linear optimization model supports IT project prioritization, selection, and scheduling to build a value-driven portfolio. It considers interdependencies, resource restrictions, and further constraints. Table 15 shows the notation of the optimization model.

Table 15. Indices, sets, parameters, and decision variable (Karrenbauer & Breitner, 2024)

Indices and Sets			
$(i, j) \in P$	IT projects	$P = \{1, \dots, \lvert P\rvert\}$	$\lvert P\rvert \in \mathbb{N}$
$(t, \tau) \in \mathrm{T}$	Periods in planning horizon	$\mathrm{T} = \{1, \dots, \lvert\mathrm{T}\rvert\}$	$\lvert\mathrm{T}\rvert \in \mathbb{N}$
$k \in K$	Groups	$K = \{1, \dots, \lvert K\rvert\}$	$\lvert K\rvert \in \mathbb{N}$
$r \in R$	Resources	$R = \{1, \dots, \lvert R\rvert\}$	$\lvert R\rvert \in \mathbb{N}$
$c \in C$	Evaluation criteria	$C = \{1, \dots, \lvert C\rvert\}$	$\lvert C\rvert \in \mathbb{N}$
$s \in S$	Evaluation sub-criteria	$S = \{1, \dots, \lvert S\rvert\}$	$\lvert S\rvert \in \mathbb{N}$
$\varepsilon \subseteq P$	Set of excluded IT projects		
$M \subseteq P$	Set of mandatory IT projects		
$G_k \subseteq P$	Set of IT projects of group k		$\forall\, k \in K$
$N_c \subseteq S$	Set of sub-criteria of criterion c		$\forall\, c \in C$
$O_j \subset P$	Set of predecessor IT projects of IT project j		$\forall\, j \in P$
$U_j \subset P$	Set of IT projects mutual exclusive to IT project j		$\forall\, j \in P$
$U_k \subset P$	Set of groups mutual exclusive to group k		$\forall\, k \in K$
Parameters			
a_i	Overall score of IT project i		$i \in P$
$dl_i \in \mathrm{T}$	Deadline for completion of IT project i		$i \in P$
$du_i \in \mathrm{T}$	Duration of IT project i		$i \in P$
$epl_i \in \mathrm{T}$	Earliest starting period of IT project i		$i \in P$
rr_{itr}	Required resource quantity of resource r for IT project i in period t		$i \in P, t \in T,\ r \in R$
$rr_{i(\tau-t+1)r}$	Required resource quantity of resource r for IT project i in period τ which starts in period t	$t \le \tau \le t + du_i - 1$	$(t, \tau) \in \mathrm{T}, i \in P, r \in R$
ra_{tr}	Resource availability of resource r in period t		$t \in T, r \in R$
v_{isc}	Scoring value of IT project i in the sub-criterion s of the evaluation criterion c		$i \in P, s \in N_c$, $c \in C$
w_c	Weight of evaluation criterion c	$0 \le w_c \le 1$	$c \in C$
Decision Variable			
X_{it}	$= \begin{cases} 1, & \text{if IT project } i \text{ starts at the beginning of period } t \\ 0, & \text{else} \end{cases}$		$i \in P, t \in T$

$$a_i = \sum_{c \in C} \left(w_c \frac{\sum_{s \in N_c} v_{isc}}{\sum_{s \in N_c} 1} \right) \qquad \forall\ i \in P \quad \text{(Eq1)}$$

subject to

$$\sum_{c \in C} w_c = 1 \qquad \text{(Eq2)}$$

$$\max VC = \sum_{i \in P} \sum_{t \in \mathrm{T}} a_i X_{it} \qquad \text{(Eq3)}$$

$$X_{it} \in \{0, 1\} \qquad \forall\ i \in P,\ t\ \in T \quad \text{(Eq4)}$$

$$\sum_{t \in \mathrm{T}} X_{it} \leq 1 \qquad \forall\ i \in P \quad \text{(Eq5)}$$

$$\sum_{t\, \in\, T} X_{it} = 1 \qquad \forall\ i \in M \quad \text{(Eq6)}$$

$$\sum_{t \in \mathrm{T}} (t + du_i - 1)\, X_{it} \leq |T| \qquad \forall\ i \in P \quad \text{(Eq7)}$$

$$\sum_{t=1}^{epl_i - 1} X_{it} = 0 \qquad \forall\ i \in P \text{ with } epl_i > 1 \quad \text{(Eq8)}$$

$$\sum_{t = dl_i - du_i + 2}^{|T|} X_{it} = 0 \qquad \forall\ i \in P \text{ with } dl_i < \ |T| \quad \text{(Eq9)}$$

$$\sum_{i \in P} \sum_{t = \tau - du_i + 1}^{\tau} rr_{i(\tau - t + 1)r}\, X_{it} \leq ra_{\tau r} \qquad \forall\ \tau \in T, r \in R \quad \text{(Eq10)}$$

$$\sum_{t\, \in\, T} X_{it} = 0 \qquad \forall\ i \in \varepsilon \quad \text{(Eq11)}$$

$$\sum_{t\, \in\, T} \left(X_{it} + X_{jt} \right) \leq 1 \qquad \forall\ i\ \in G_k, j\ \in G_l, l \in U_k \quad \text{(Eq12)}$$

$$\sum_{t\, \in\, T} (t + du_i) X_{it} - \sum_{\tau\, \in\, T} (|T| + 1 - \tau) X_{j\tau} \leq |T| + 1 \qquad \forall\ j \in P, i \in O_j \quad \text{(Eq13)}$$

We used the IT project evaluation framework and Equation 1 and Equation 2 of Karrenbauer and Breitner (2022b) to determine an IT project's value contribution. Once calculated, Equation 3 optimizes the IT portfolio contribution by summing up the individual IT project scores. Accordingly, those IT projects that together contribute the most value are selected into the IT portfolio, considering interdependencies, resource limitations, and other constraints. Equation 4 determines that all decision variables are binary, i.e., either an IT project i is selected in period t within the planning horizon or not. If an IT project is selected, it can only be executed once (Ghasemzadeh et al., 1999) (Equation 5). Because of regulations or internal reasons, some projects need to be part of the portfolio (mandatory IT projects) (Carazo et al., 2012; Hassanzadeh et al., 2014). Irrespective of their value contribution, they get selected (Equation 6). Further, some IT projects are multi-periodic and require more periods until completion. Equation 7 ensures that these IT projects get completed within the planning horizon (Ghasemzadeh et al., 1999). Other IT projects can only start at a specific period because of preparation times or need to be finished at a certain period because they serve as input for another project. Therefore, Equation 8 considers the earliest possible starting period and Equation 9 the latest possible completion period of project i (Mira et al., 2013; Tofighian & Naderi, 2015). Equation 10 ensures that each resource type does not exceed its availability in every period (Ghasemzadeh et al., 1999). Aligned with Saltelli et al. (2006), a sensitivity analysis allows to analyze the consequences of changes in the independent variable (input) to the dependent variable (output). Transferred to ITPPM, a sensitivity analysis can determine, for example, the effect of an IT project exclusion on the portfolio contribution. Thus, Equation 11 allows to exclude IT projects from an IT portfolio (Ghasemzadeh et al., 1999). Further, IT projects can be mutually exclusive, meaning selecting one IT project (group) directly leads to excluding another (group). Equation 12 considers this interdependency. The time interdependency is also critical. In this case, one project can only start (successor IT project) once another is finished (predecessor project). Equation 13 considers this constrain (Ghasemzadeh et al., 1999; Shou & Huang, 2010).

We used the model as an input for our DSS prototype implemented in MATLAB Version 2022b. Here it is possible to insert IT project data in different tabs, while the DSS prototype considers all equations of the optimization model. We used generic IT portfolio data to perform a real-world applicability check. This included 70 IT project proposals, four planning periods, defined resource availabilities and requirements, and several interdependencies. We defined several scenarios with different resource availabilities to determine the influence of resource availability changes onto the overall IT portfolio value contribution. Table 16 shows the main results and Figure 4 the Gantt charts of two exemplary scenarios.

Table 16. IT portfolio composition, value contribution, and computing times with different resource availabilities (Karrenbauer & Breitner, 2024)

Resource availability	**# selected IT projects**	**Value contribution**	**Change in value contribution compared to 100% resource availability**	**Computing time (sec.)**
140%	28	104.2	+ 43.59%	58.9437
130%	26	96.53	+ 33.02%	50.7302
120%	24	89.3	+ 22.68%	25.9098
110%	22	80.5	+ 10.72%	46.4193
100%	**19**	**72.57**	-	**36.9372**
90%	17	64.64	- 10.93%	1.2893
80%	14	54.62	- 24.73%	1.8809
70%	12	46.5	- 35.92%	1.1499
60%	10	36.93	- 49.11%	0.84923

With a 100% resource availability, the IT portfolio consists of 19 IT projects with a value contribution of 72.57. A 20% decrease in all resource availabilities results in a 24.73% decrease in value contribution with 14 IT projects still being selected. With a 20% increase in resources, the IT portfolio consists of 24 IT projects with a 22.68% higher value contribution. In our example, the percentage of resource changes always have a slightly higher or lower impact on the value contribution. This especially applies for resource reductions. If resources are reduced by ten percent, the value contribution decreases by 10.93%. A 40% reduction in resources, reduces the portfolio value by 49.11%. Overall, a resource reduction has a greater impact on the overall value contribution than a resource increase. Further, in our example, with a higher resource availability, there are more options for the IT portfolio composition and thus the computation time to find a solution increases. The real-world applicability check shows that using our optimization model and DSS prototype it is possible to analyze the effect of changing portfolio data onto the overall portfolio composition and value contribution, before decisions are made. This allows an in-depth analysis of different scenarios and their consequences onto the IT portfolio.

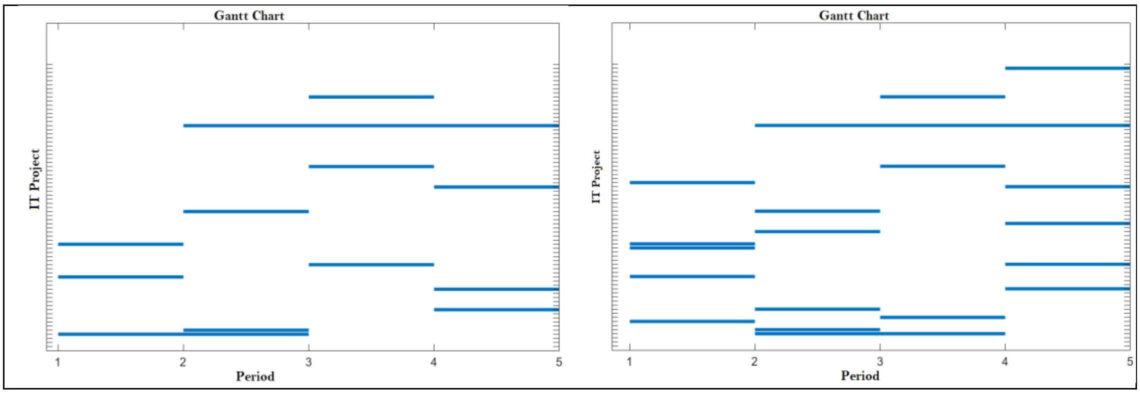

Figure 4. Gantt charts for 60% (left) and 100% (right) resource availabilities (Karrenbauer & Breitner, 2024)

3.5. Maturity Model for IT Project Portfolio Management Processes

During the analysis of ITPPM process models in Karrenbauer and Breitner (2022b), we recognized that the characteristics of the individual activities and phases are dependent on the company’s and organization’s IT maturity. More generally, the whole implementation and application of these ITPPM process models depend on the IT maturity. The higher the IT maturity is, the more mature the characteristics and activities are and the more benefits can be gained (Kock et al., 2020). For example, in the case of a low maturity, a software tool usage to support an ITPPM process is impossible because structured information and data as an input is missing, unavailable, or there are no uniform (selection) processes. To address this, we developed a comprehensive and integrated maturity model for ITPPM processes in the paper “Maturity Model for IT Project Portfolio Management Processes” (Schulte et al., 2024; Appendix 12). We used DSR and the maturity model development approach by Becker et al. (2009) to develop an ITPPM process maturity model iteratively and addressed the research question: How can a maturity model for ITPPM processes be designed and developed considering different maturity levels and criteria?

Our results and findings show that ITPPM processes can be classified within five maturity levels using the criteria IT portfolio management, IT project requirements, quality management and documentation, process participants, integrated systems, and their corresponding sub-criteria (see Table 17). For example, the IT portfolio management criterion comprises the sub-criteria business process, governance, strategy alignment, benefits, interfaces, and approvals to define the maturity levels. At the lowest maturity level, there are no defined and established ITPPM processes, governance, interfaces, and strategy alignment, and IT projects get approved ad-hoc while corresponding benefits are not recognized. At the second level, there are some defined ITPPM processes but also many workarounds, a lack of standards, no mapped processes, and irrational investment decisions. In Level 3, business processes exist, but they are sometimes inefficient. Governance, strategic criteria, and benefits are defined, an approval process is followed in most cases, and interfaces are known but only shown in parts. Level 4 represents a defined ITPPM process, a comprehensive governance structure, strategy alignment, including rational approvals based on key metrics, and mapped ITPPM processes. At the highest maturity level, ITPPM processes are optimized, include different IT project types, and continuous improvements, with an efficient IT portfolio selection process based on a rigorous approach, and updated interfaces. Table 17 shows the whole ITPPM maturity model with all sub criteria and maturity levels. Our results and findings enable companies and organizations to classify their ITPPM process and deduce value-driven and value-creating improvements considering the organizational strategy and objectives. An application enables to derive a transformation roadmap, make informed decisions, and rationalize resource allocations.

Table 17. ITPPM process maturity model (Schulte et al., 2024)

Criteria	IT portfolio management	IT project requirements	Quality management and documentation	ITPPM process participants	Integrated systems
Level 1 Initial process	Business process: None Governance: None Strategy alignment: None Benefits: Not seen by management Approvals: Ad hoc uncoordinated IT project approvals Interfaces: Not yet been dealt with; Departments do not talk to each other	Information collection: Information recorded unstructured and without specifications IT project selection: IT projects carried out although important information is missing (unstructed collection) Resource management: Resources are allocated unstructured, with no information about availability and capabilities	Information management: Approved IT projects and IT portfolio information not available Reporting: Nearly none, just spontaniously	Participants organization: Acting persons not clearly named, responsibilities change ad hoc Decision-making: No committee for decisions Sponsorship/Managment support: No management support	Quality: None, no tool/system support Structure: None Dashbards: None
Level 2 Repeating process	Business processes: Defined, but workarounds exist Governance: No standards Strategy alignment: No rational investment decisions Benefits: Productivity gaps due to insufficient task automation Approvals: Uncoordinated IT project approvals Interfaces: Known but not mapped in the ITPPM process	Information collection: Some business case or similar created; general information collected IT project selection: Isolated specifications are not adhered to; Dependencies are not or only sporadically taken into account Resource management: Some structures exist, but not everyone is aware of them or they are not applied	Information management: Employees cannot view information Reporting: Meetings held at irregular intervals not supporting an ITPPM process	Participants organization: Responsibilities partly defined as far as possible Decision-making: Committee without binding decisions Sponsorship/Management support: Management support of ITPPM process in parts	Quality: Poor quality, many ITPPM functions missing Structure: Departments use own lists or different tools/systems Dashboards: Rudimentary in few departments
Level 3 Organizational standards and institutionalized process	Business process: Defined, but it may be still inefficient in some places Governance: Defined standards Strategy alignment: Specific strategic criteria developed Benefits: Clearer vision and overview of projects is set in place which allows better decision making management Approvals: Approval process defined and shared with all departments and followed in most cases Interfaces: Known, but only shown in parts	Information collection: Business cases created are all structured and reviewed in the same way IT project selection: Regular meetings about requests, in which the prioritization is done; Dependencies and interactions with other IT projects or individual departments known and included in the decision-making process Resource Management: Resource utilization overview	Information management: Information used to suspend or cancel IT projects under certain conditions; Reconciliation of budget and resources Reporting: Regular reporting on time, costs and quality	Participants organization: Committee with various interest groups Decision-making: Management can override committee decisions Sponsorship/Management support: Management support of ITPPM process with many exceptions	Quality: Satisfactory ITPPM tools with various functions Structure: Several ITPPM tools or systems cover ITPPM activities Dashboards: Available, but with few ITPPM functions
Level 4 Managed process	Business process: Defined and basically lived Governance: Fully comprehensive governance structure Strategy alignment: Prioritization on the basis of key figures and criteria aligned with strategy Benefits: Management sees the benefits of an ITPPM process and understands the entire ITPPM process including the participants Approvals: Portfolio composition based on an overall balance of risk, profit, return on investment, impact on project competition and on-time project delivery, including value creation. Interfaces: Interfaces and contact persons are known and also mapped in the ITPPM process	Information collection: Information on possible future personnel requirements is forwarded to resource management and human resource management IT project selection: Flexible prioritization scheme of projects based on defined criteria to support alignment with strategic goals Resource management: Resource utilization checked regularly and adjusted, if necessary; Bottlenecks are prevented	Information managment: Status reports/information structured in the same way to make them comparable; Conclusions drawn at the end of all IT projects based on key figures Reporting: Supports management decisions	Participants organization: ITPPM process participants communicate in a structured manner Decision-making: Committee decision binding Sponsorship/Management support: Management has knowledge, skill, and abilities to comprehend and implement ITPPM process	Quality: High developed ITPPM tool, including main tasks Structure: Single ITPPM tool or system Dashboards: Dashboards and ITPPM filter options available
Level 5 Optimized process	Business process: Fully mature and considers different project types Governance: Still a fully comprehensive governance structure Strategy alignment: ITPPM process continuously optimized due to the structure and actively lived Benefits: All participants and stakeholders follow the ITPPM process as they recognize the efficiency Approvals: IT portfolio selection based on a clear, rigorous and formal approach Interfaces: Known and regularly checked for up-to-dateness; Changes are quickly incorporated	Information collection: Still full information collection system with interaction with different departments IT project selection: Still flexible prioritization based on defined criteria to support alignment with strategic goals Resource management: Resources regularly balanced and rescheduled at short notice and in an agile manner without overburdening employees	Information management: IT projects are consistently suspended or cancelled, if the benefits are not high enough Reporting: Supports management decisions; Continuous Improvement Process applied with process participants	Participants organization: Communication and decision-making structured and transparent Decision-making: A person or the committee makes a decision based on criteria cannot be overridden based on individual preferences Sponsorship/Management support: Management drives ITPPM process and ensuring regular improved	Quality: Highly developed tool, optimally selected and adapted to a company fully supporting the ITPPM process Structure: All ITPPM activities mapped on a single ITPPM tool; Interfaces to other systems available Dashboards: Dashboards and ITPPM filter options enable full analysis and reporting

3.6. Taxonomy-based Archetypes for IT Project Portfolio Management Tools

In addition to ITPPM processes, we also analyzed existing ITPPM tools. Especially when developing our own DSS (Karrenbauer & Breitner, 2024), we also looked at what knowledge is already available in literature and practice. Further, with rising complexity and number of IT projects, ITPPM tools become more important to support ITPPM processes. Therefore, this section focuses on the paper "IT Project Portfolio Management Tools: Towards Taxonomy-based Archetypes" (Karrenbauer et al., 2023a; Appendix 7). We addressed two research questions: (1) What are theoretically grounded and empirically validated elements of ITPPM tools? (2) What archetypes can be deduced based on this classification? We followed the taxonomy development approach of Nickerson et al. (2013) and Kundisch et al. (2021), classified scientific literature and 60 real-world objectives, and identified archetypes.

The final taxonomy with design elements of ITPPM tools consists of 20 dimensions and 51 characteristics within the perspectives IT portfolio structuring, resource management, IT portfolio steering, and non-functional (Kock et al., 2020; Table 18). The perspective IT portfolio structuring compromises the initial IT project evaluation, prioritization, and selection (Kock et al., 2020; Obradovic et al., 2014). The resource management perspective describes how ITPPM tools enable an efficient resource allocation and time scheduling (Obradovic et al., 2014; Stang et al., 2019). The portfolio steering perspective explains ITPPM tool functionalities that enable an IT project portfolio performance monitoring (Daradkeh et al., 2019; Obradovic et al., 2014). The non-functional perspective describes various non-functional activities not immediately connected with an ITPPM process but are essential to evaluate ITPPM tools.

Then, we used k-means clustering (Punj & Stewart, 1983) to identify archetypical patterns in the taxonomy and evaluate its applicability (Kundisch et al., 2021). We identified an optimal number of five clusters using the Silhouette and Elbow methods (Saputra et al., 2020). Identified clusters expand a taxonomy's knowledge and its descriptive nature (Möller et al., 2021). Table 18 shows the taxonomy's perspectives, dimensions, and characteristics as well as the percentage distribution for each characteristic within the five archetypes. Archetype 1 "IT portfolio overview tools with predefined parameters" includes ITPPM tools that mainly encompass functionalities to overview ITPPM processes, their status, and resources on predefined parameters. Archetype 2 "customizable evaluation and analysis tools with data extraction" compromises ITPPM tools that enable to evaluate, analyze, display, and extract data outside the specific tool. Tools within archetype 3 "customizable evaluation and analysis tools without data extraction" also allow evaluating, displaying, and analyzing IT projects. However, the data remains in the tools and cannot be extracted.

Table 18. Results of the cluster analysis (Karrenbauer et al., 2023a)

Perspective /	Dimension	Σ n=60	Cluster / Characteristics	1 n=13	2 n=11	3 n=15	4 n=12	5 n=9
IT portfolio structuring	**D_1** Financial project proposal evaluation	45%	$C_{1,1}$ None	85%	18%	27%	17%	89%
		13%	$C_{1,2}$ Single option	15%	9%	7%	33%	0%
		42%	$C_{1,3}$ Multiple options	0%	73%	67%	50%	11%
	D_2 Ranking method	10%	$C_{2,1}$ Not available	15%	0%	0%	0%	44%
		63%	$C_{2,2}$ Scoring model	0%	100%	100%	100%	0%
		27%	$C_{2,3}$ Manual ranking	85%	0%	0%	0%	56%
	D_3 Scoring criteria weighting	37%	$C_{3,1}$ No scoring model	100%	0%	0%	0%	100%
		45%	$C_{3,2}$ On a scale	0%	64%	73%	75%	0%
		18%	$C_{3,3}$ On percentage	0%	36%	27%	25%	0%
	D_4 Portfolio optimization model	8%	$C_{4,1}$ Available	0%	18%	20%	0%	0%
		92%	$C_{4,2}$ Not available	100%	82%	80%	100%	100%
	D_5 What-if scenario analysis	45%	$C_{5,1}$ Not possible	92%	0%	33%	8%	100%
		55%	$C_{5,2}$ Possible	8%	100%	67%	92%	0%
	D_6 Portfolio Gantt charts	8%	$C_{6,1}$ Not available	15%	0%	7%	0%	22%
		15%	$C_{6,2}$ Dependencies indicated	8%	45%	20%	0%	0%
		77%	$C_{6,3}$ Dependencies not indicated	77%	55%	73%	100%	78%
	D_7 Project type	55%	$C_{7,1}$ Available	15%	100%	67%	67%	22%
		45%	$C_{7,2}$ Not available	85%	0%	33%	33%	78%
	D_8 Waterline analysis	13%	$C_{8,1}$ Available	0%	45%	13%	8%	0%
		87%	$C_{8,2}$ Not available	100%	55%	87%	92%	100%
Resource management	**D_9** Resource capacity vs. demand overview	88%	$C_{9,1}$ Available	69%	100%	93%	100%	78%
		12%	$C_{9,2}$ Not available	31%	0%	7%	0%	22%
	D_{10} Resource assignment process	2%	$C_{10,1}$ Automatic assignment	0%	0%	7%	0%	0%
		23%	$C_{10,2}$ Assignment without request	62%	0%	0%	0%	67%
		12%	$C_{10,3}$ Resource request on individual level	15%	18%	13%	0%	11%
		63%	$C_{10,4}$ Resource request on individual & group level	23%	82%	80%	100%	22%
	D_{11} Time tracking	87%	$C_{11,1}$ Available	92%	100%	73%	92%	78%
		13%	$C_{11,2}$ Not available	8%	0%	27%	8%	22%
IT portfolio steering	**D_{12}** Portfolio dashboard	7%	$C_{12,1}$ Not available	23%	0%	7%	0%	0%
		18%	$C_{12,2}$ Predefined	77%	9%	0%	0%	0%
		75%	$C_{12,3}$ Customizable	0%	91%	93%	100%	100%
	D_{13} Portfolio dashboard extraction	47%	$C_{13,1}$ Possible	15%	91%	0%	92%	56%
		53%	$C_{13,2}$ Not possible	85%	9%	100%	8%	44%
	D_{14} Portfolio status reports	7%	$C_{14,1}$ Not available	23%	0%	0%	0%	11%
		18%	$C_{14,2}$ Standard	62%	9%	7%	8%	0%
		75%	$C_{14,3}$ Customizable	15%	91%	93%	92%	89%
	D_{15} Automated portfolio status report send out	18%	$C_{15,1}$ Possible	0%	55%	0%	33%	11%
		82%	$C_{15,2}$ Not possible	100%	45%	100%	67%	89%
Non-functional	**D_{16}** Software deployment	57%	$C_{16,1}$ Cloud-based	54%	0%	47%	100%	89%
		43%	$C_{16,2}$ Cloud-based and on-premises	46%	100%	53%	0%	11%
	D_{17} Pricing	12%	$C_{17,1}$ Free Version and fee-based version	31%	9%	0%	0%	22%
		10%	$C_{17,2}$ Quote based and free trial	15%	18%	0%	8%	11%
		42%	$C_{17,3}$ Quote based and no free trial	8%	45%	60%	83%	0%
		28%	$C_{17,4}$ Fixed prices and free trial	46%	18%	20%	0%	67%
		8%	$C_{17,5}$ Fixed prices and no free trial	0%	9%	20%	8%	0%
	D_{18} Integration	93%	$C_{18,1}$ Possible	92%	100%	80%	100%	100%
		7%	$C_{18,2}$ Not possible	8%	0%	20%	0%	0%
	D_{19} Access	40%	$C_{19,1}$ Desktop	23%	18%	60%	67%	22%
		60%	$C_{19,2}$ Desktop and mobile	77%	82%	40%	33%	78%
	D_{20} Customer support option	13%	$C_{20,1}$ Single option	15%	0%	33%	0%	11%
		87%	$C_{20,2}$ Multiple options	85%	100%	67%	100%	89%

n = number of tools; all characteristics are color labeled, with 100% in dark gray and 0% in white, e.g., customer support option D20 in Archetype 5 consists of 89% of multiple support options.

Archetype 4 "“In-between” IT portfolio evaluation and analysis tools" includes tools that use scoring methods to rank IT projects and a Gantt chart to display the schedule. Archetype 5 "IT portfolio overview tools with customizable parameters" compromises tools that mostly offer resource management and IT portfolio steering functionalities. Overall, the taxonomy and archetypes reduce complexity and structure the ITPPM tool market, support practitioners in choosing a suitable ITPPM tool, and facilitate the advancement of existing and creation of new ITPPM tools.

3.7. Taxonomy-based Decision Tree for IT Project Manager Recruitment

This section concerns the paper "Decision Support Framework for IT Project Manager Recruitment" (Karrenbauer et al., 2024; Appendix 9). On an IT project management level (cf. Phase 6 of the process model in Figure 3, p.16) it is essential to recruit the right IT project managers (Trigo & Varajão, 2020). Therefore, job advertisements need a precise formulation to attract the most suitable candidates (Yang et al., 2022). This led to the following research questions: (1) What are theoretically grounded and empirically validated elements of IT project manager positions and what archetypes can be deduced with this classification? (2) How can a decision tree be designed to support IT project manager recruitment? Therefore, we analyzed and classified IT project managers' required skills and benefits based on the current state of literature and 125 job advertisements in more detail (Nickerson et al., 2013; Kundisch et al., 2021), deduced archetypes, and developed a decision tree.

Table 19. Checklist for recommended archetypes (Karrenbauer et al., 2024)

Archetype	Requirements	Corporate benefits
Archetype 1: wide ranging focus	*Soft skills*: sense of responsibility, customer orientation, analytical conceptual mindset. *Certificates*: - *IT skills*: IT architecture knowledge, method and tool experience, programming skills.	Training opportunities, flexible working hours.
Archetype 2: entry-level environment	*Soft skills*: structured work, assertiveness, communication skills, team working ability. *Certificates*: - *IT skills*: agile working method.	Training opportunities.
Archetype 3: project manager-focused	*Soft skills*: structured work, communication skills, independent working skills, goal-oriented working, resilience, analytical and conceptual mindset. *Certificates*: PMI, IPMA, Scrum, and Prince2. *IT skills*: agile working method, method and tools expertise.	Flexible working hours, home office, job ticket, employee discounts.
Archetype 4: human capital investment attraction	*Soft skills*: structured work, independent working, responsibility. *Certificates*: Scrum, PMI, IPMA, and Prince2. *IT skills*: ITIL, programming skills, method and tool experience.	Home office, company pension plans, training opportunities, sport and health activities, employee discounts.
Archetype 5: experience-oriented	*Soft skills*: communication, customer orientation *Certificates*: - *IT skills*: IT architecture knowledge.	Company pension, flexible working hours, childcare, events, sport and health activities, employee discounts.

The final taxonomy with design elements for IT project manager job descriptions consists of 33 dimensions and 77 characteristics within the perspectives basic information, soft skills, IT project manager certificates, IT skills, and corporate benefits. We used the developed taxonomy as an input to deduce archetypes in IT project manager positions (Kundisch et al., 2021). We identified five clusters using the Shillouette and Elbow method (Saputra et al., 2020). Table 19 shows the archetypes, archetypical requirements, and offered corporate benefits.

We used the results and findings to develop a decision support framework for IT project manager recruitment (cf. Figure 5). We used the derived dimensions of the taxonomy as questions and the taxonomy’s characteristics as answers. Based on four questions, the framework recommends which benefits and requirements a job advertisement for IT project managers should highlight, relying on the identified archetypes. Our results and findings identify key requirements and corporate benefits for IT project manager positions. The decision framework supports the entire recruitment process, assists to create targeted job advertisements, enables to attract suitable candidates, supports conducting interviews, and assists the final candidate selection.

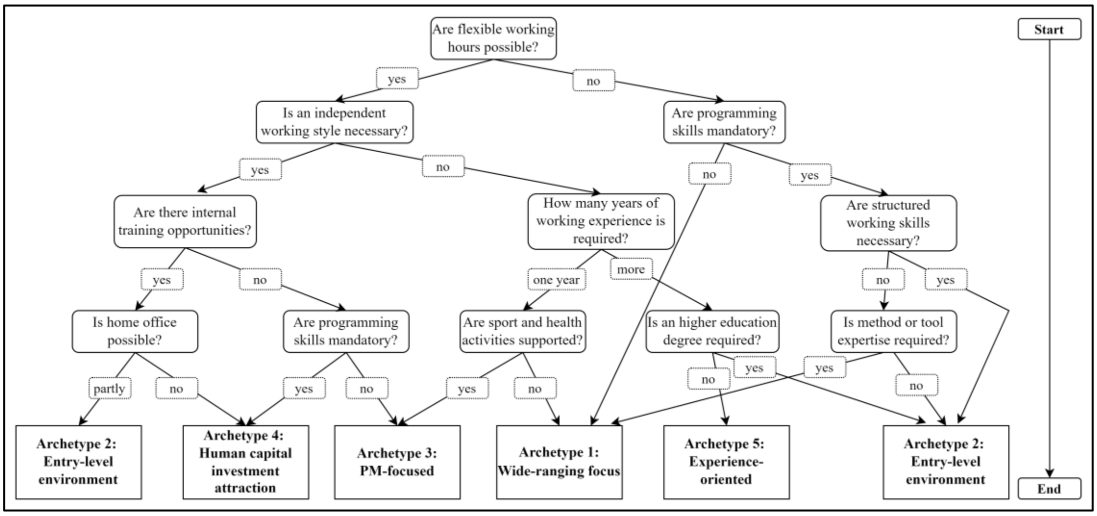

Figure 5. Decision tree for IT project manager recruitment (Karrenbauer et al., 2024)

4. Contributions to Individual Digital Study Assistants in Higher Education Institutions

4.1. Introduction and Motivation

Individualized and personalized student counseling and support became important because of rising heterogeneity among students (Clarke et al., 2013; Van der Wende, 200; Wong & Li, 2019). Relying solely on traditional counseling methods is no longer suitable (Hornsby & Osman, 2014; Marczok, 2016). Therefore, the need for self-regulation and self-organization skills increased. These self-regulation skills, encompassing data literacy and goal setting, significantly contribute to a successful HEI graduation (Wolters & Hussain, 2015). Self-regulated learning includes consciously setting and monitoring goals, following a cyclical process (Bandura, 1986; Carver & Scheier, 2011; Zimmerman, 2012). However, students perceive self-organization competencies as a challenge, while these critically influence a successful HEI graduation (Ritz et al., 2022; Wolters & Hussain, 2015).

In recent studies, smart personal assistants (SPA) have been much researched. According to Winkler et al. (2019) SPA are "agents that can automate and ease many of the daily tasks of their users by engaging with them via voice-based, natural language dialog" (p. 3). Thereby, Knote et al. (2019) identified five clusters of SPA: chatbots, adaptive voice (vision) assistants, embodied virtual assistants, passive pervasive assistants, and natural conversation assistants. They can support learning outcomes (Wollny et al., 2021), learn factual knowledge (Ruan et al., 2019), improve writing skills (Wambsganss et al., 2021a), and positively influence overall learning success (Winkler et al., 2020).

A further digital assistant to support students is an IDSA. It automates first-level support, offers individual and situation-specific recommendations, identifies learning strategies, supports study organization, and enables networking (Karrenbauer et al., 2021). Depending on an IDSA's functionalities, design, and architecture, it can fit into one of the archetypes of Knote et al. (2019). IDSA are available anywhere and anytime to answer student questions and give support through their ubiquitous access. Using them, students are no longer dependent on advisors' office hours (Weber et al., 2021). However, IDSA differ from existing PCA. The latter focus on assisting different facets of learning (Hobert, 2019; Wambsganss et al., 2021a; Wollny et el., 2021), while an IDSA aims to promote self-organized and goal-oriented study (Karrenbauer et al., 2021). Using IDSA along with human support and counseling, HEI can encounter rising student numbers, support needs, and still provide individually tailored support (Karrenbauer et al., 2023b; König et al., 2023). Thus, considering different stakeholder perspectives, there is a need to determine IDSA requirements to design, develop, and implement an IDSA in HEI.

In our research, we performed a long-term project to design, develop, and evaluate an IDSA in HEI. ADR-oriented, including researchers and practitioners from multiple disciplines, we iteratively designed, developed, evaluated, and adapted an IDSA prototype. In the beginning, part of the research team performed 28 expert interviews with lecturers form different disciplines (e.g., mathematics, criminal science, information systems; n = 9) and HEI stakeholders (e.g., study finance, library, dean’s office; n = 19) to get insights into various topics, including organizational conditions for success, added values, chances and challenges, and typical need for student support. In addition, a quantitative student survey in three German HEI (n = 570) was performed to get the target groups’ opinions about IDSA functionalities, usage incentives, and barriers. During our research process, we analyzed the interview transcripts and student survey results from different perspectives, triangulated them, and used them for our results and findings, supplemented by various literature reviews.

In a first step, in König et al. (2020) and Karrenbauer et al. (2021), we identified (non-)functionalities of IDSA to get an overview of the status quo. Next, we deduced CSF for IDSA in König et al. (2023) that support HEI stakeholders to design and develop IDSA or select a suitable one. Based hereon, we developed requirements for an IDSA design and implementation, implemented and evaluated a prototype in an iterative process, and derived guidelines for an IDSA development in HEI (Karrenbauer et al., 2023b; König et al., 2024).

One functionality within the IDSA includes open educational resources (OER) and inter-university teaching exchange networks (IUTEN) recommendations. OER are free accessible and open licensed educational materials to be used, shared, and modified for teaching, learning, and research. IUTEN refer to the exchange of courses within a defined network (König et al., 2021). Both can innovate teaching and learning within HEI. Therefore, it is essential to have knowledge about the requirements and incentives to use OER and participate in IUTEN. In König et al. (2021), we addressed this and deduced these requirements and incentives based on expert interviews. Using these results and findings, we developed two incentive models to encourage lecturers to engage in IUTEN collaborations and produce and use OER.

4.2. Non-Functionalities for Digital Study Assistants

This section focuses on the paper “Dialogue-driven Digital Study Assistants for Higher Education – A Morphological Analysis” (König et al., 2020; Appendix 1). To get an overview of digital study assistants, we first conducted a structured market research and structured literature review to analyze the current status quo, followed by qualitative and quantitative analyses. As a result, we structured identified functionalities and non-functionalities for digital study assistants using a morphological box (Ritchey, 2011; Zwicky, 1969). In the following, however, only the non-functionalities are described because Karrenbauer et al. (2021) deals with the functionalities in more detail.

Table 20 illustrates the morphological box to structure the identified non-functionalities. Digital study assistants (DSA) differ in their communication mode, i.e., how they interact with their users (Meyer von Wolff et al., 2019; Santoso et al., 2018). The intelligence dimension refers to a DSA’s knowledge base (Universität Darmstadt, 2023). Further, DSA differ in handling concerns they cannot answer (Barrett et al., 2019; Clarizia et al., 2018). The initiative dimension describes whether a DSA is proactive and starts a conversation with a student or is reactive (Choque-Díaz et al., 2018; Lebeuf et al., 2019). The interaction management dimension relates to whether a DSA can take turns in conversations, engage in discussions, introduce new topics, or combine these features (Luger & Sellen, 2016; Skjuve & Bae Brandzaeg, 2018). According to Luger and Sellen (2016), a user-assistant interaction can enhance users’ motivation to use such systems. Further, DSA can either be available through an existing platform, platform independently, or as a combination of both (Meyer von Wolff et al., 2019; Sjöström et al., 2019). Depending on the type, there are different channels. Some DSA are web-based and can be accessed through HEI web-pages or are integrated into them (Universität Innsbruck, 2023). DSA also differ in their authorization and their privacy protection.

Table 20. Morphological box for DSA non-functionalities (König et al., 2020)

Dimensions	**Characteristics**			
Communication mode	text-based	speech-based	both	
Intelligence	rule-based with	if-then sequences	intelligent, e.g., with AI	
Handling of non-answerable questions	recommendation to contact employee	employee answers automatically	no recommendation/ forwarding	
Initiative	proactive	reactive	both	
Interaction	turn taking	topic development	discussion	multiple
Platform	web-based	social media	apps	multiple
Type	standalone	platform	both	
Authorization	log in	none	both	
Privacy protection	data protection button small placed and bottom left	detailed and prominently placed	educational sensibilization	

4.3. Functionalities for Individual Digital Study Assistants

In the next step, we focused more on the functionalities and analyzed and structured them in more detail. We published our results and findings in the paper “Individual Digital Study Assistant for Higher Education Institutions: Status Quo Analysis and Further Research Agenda” (Karrenbauer et al., 2021; Appendix 3). We focused on different IDSA functionalities in the specific phases of a study life cycle (SLC) (Sprenger et al., 2010), addressing the following research question: What is the status quo of typical IDSA functionalities in HEI aligned to a SLC? Based on the results and findings in König et al. (2020), we identified the need for an individual digital study assistant. An individualized DSA allows to consider a student's individual needs, competencies, and interests instead of general recommendations. Thus, in further research, we focused on IDSA.

We identified several functionalities for an IDSA and structured our results and findings along the three SLC phases before, during, and after study (Sprenger et al., 2010) using a morphological box (Ritchey, 2011; Zwicky, 1969). The before study cycle encompasses IDSA functionalities for the recruitment, application, and enrollment. Recruitment functionalities include personal guidance in this process, degree selection systems, links to more information, or self-assessments with study recommendations and suggestions for majors and institutions (Bouaiachi et al., 2014; Lalwani et al., 2018). IDSA functionalities for the application phase guide this process or give further information and contact details (Patel et al., 2019; Santoso et al., 2018). The enrollment can be supported by giving links or direct information and proactively engage with students regarding their enrollment status (Dibitonto et al., 2018; Muangnak et al., 2020). Regarding the phase during study, IDSA offer functionalities for six dimensions. They can support exam procedures with enrollment reminders and notifications, automated enrollment, or links to the corresponding webpages (Ravikumar et al., 2017; Suvethan et al., 2019). Further functionalities concern the scheduling of classes and exams, including manual or automated entry of classes in a calendar or the possibility to optimize individual schedules (Nwankwo, 2018; Sjöström et al., 2019). With self-tests, individual checklists, or learning tips, an IDSA can assist in organizing exams and assessments (Roth et al., 2016). An IDSA can also show completed and open modules with grades and comparisons with peers as well as strengths, weaknesses, opportunities, and threats (SWOT) analysis as a performance report (Muangnak et al., 2020; Nwankwo, 2018). Regarding changing course of studies, an IDSA can provide self-assessments, major and institution suggestions, and links for further information (Fernandes et al., 2020; Jid Almahri et al., 2019). Further, IDSA can suggest OER from own HEI or others to enable distance lectures (Scheepers et al., 2018). Concerning the after study phase, IDSA mainly provide alumni activities, such as links to a list of graduates or alumni networks to connect (Universität Innsbruck, 2023; Technische Universität Darmstadt, 2023). Overall, our results and findings structure commonly used IDSA functionalities within a morphological box and serve as a knowledge base for IDSA development and introduction.

4.4. Critical Success Factors and Challenges for Individual Digital Study Assistants

This section is about the paper "Critical Success Factors and Challenges for Individual Digital Study Assistants in Higher Education: A Mixed Methods Analysis" (König et al., 2023; Appendix 6). It addressed the following research question: What are critical success factors and challenges for an individual digital study assistant in higher education? After we systematically analyzed non-functionalities (König et al., 2020) and functionalities (Karrenbauer et al., 2021), we renewed and extended the literature review on the topic of study assistants and analyzed literature for CSF and challenges for IDSA and other e-learning tools. We also used the expert interviews and quantitative study with students to provide a holistic view of CSF and challenges and triangulated the results.

We used the IS success model by DeLone and McLean (2016) to structure the CSF and challenges. Table 21 shows our results within the six IS success dimensions (DeLone & McLean, 2016; König et al., 2023). CSF and challenges in the success dimension system quality and maturity, include ease of use, easy access, and data privacy and security.

Table 21. CSF and challenges for IDSA (König et al., 2023)

IDSA CSF and challenges	
System Maturity and Quality Ease of use (intuitive, user-friendly, easy organized navigation and usage, usability and interface, self-explanatory) Easy access (no time-consuming registry process, easy registration and access) Flexibility (offline usage, flexible adaption and personalization, modular design, individualization) IT maturity (system's reliability, accessibility, guidance, timeliness, actuality) Test phase for error identification Data privacy and security (personal data protection, transparent handling, anonymous data collection, data settings, data deletion, prevent misuse of personal data) **Service Quality** Skilled personnel (technical support and maintenance, instructor training, answering of ongoing questions, contact persons) Answer quality and employee responsiveness (fair and knowledgeable, reliable, trustworthy, timely respond to requests) **Intention to use** Motivation Usefulness Willingness to be open to use Social factors (role of peers and lecturers) Self-regulation/organization Different languages Defined target groups	**Information Quality** Content (well organized, consistent, clearly written, systematic, useful, customizable to the individual needs, relevant, up to date, sufficiently available, understandable to reach a high-quality standard) No redundant information, no information overload, reliable information Data integration (portability of previous data, link existing data) **User satisfaction** Positive experiences, recommendation to others, involvement Sustainability and up-to-dateness of information, content development & maintenance Platform independence/cross-platform usability (system independence, portals and platforms used by an HEI must be integrated, prevent redundancies and overlaps) **Net impact** Learning enhancement & academic achievement Time savings Knowledge gain Empowerment University top management Added value (exciting functionalities) Credibility of relevant recommendations (meaningful, well-founded recommendations)

The dimension information quality encompasses the CSF and challenges of content, reliable and unique information, and the possibility of existing data integration. Skilled personnel, employees' responsiveness, and answer quality are assigned to the service quality dimension. The dimension user satisfaction includes, for example, CSF and challenges concerning positive experiences and involvement with an IDSA. Further, an IDSA's possibility for time saving, learning enhancement, empowerment, and added value of the functionalities influence its net impact. Social factors and self-regulation aspects are critical for the intention to use dimension. Overall, our research provides insights for the selection, implementation, and improvement of IDSA in HEI. They also benefit IDSA system developers and vendors and contribute to integrate IDSA knowledge within the established IS success model (DeLone & McLean, 2016) and advance the theoretical understanding in this field.

4.5. Requirement Analysis, Prototype Development, and Guidelines for the Design and Development of Individual Digital Study Assistants

This section is about the papers “Design, Development, and Evaluation of an Individual Digital Study Assistant for Higher Education Students” (Karrenbauer et al., 2023b; Appendix 8) and “Development Guidelines for Individual Digital Study Assistants in Higher Education” (König et al., 2024, Appendix 10). Both papers summarize the whole ADR-guided design, development, and evaluation processes. Unlike the previous papers, we did not only work conceptually but also developed and implemented a functional feasible prototype. In the end, we abstracted the learned knowledge and derived general guidelines for an IDSA development. In doing so, we addressed the research questions (1) What requirements guide a user-centric design and development of an IDSA? (2) How can an IDSA be designed based on the derived requirements?

Figure 6 shows the whole ADR research design. We started with all project participants and a kick-off meeting and concluded with the tasks to develop a back-end system and start a requirement analysis of diverse stakeholders.

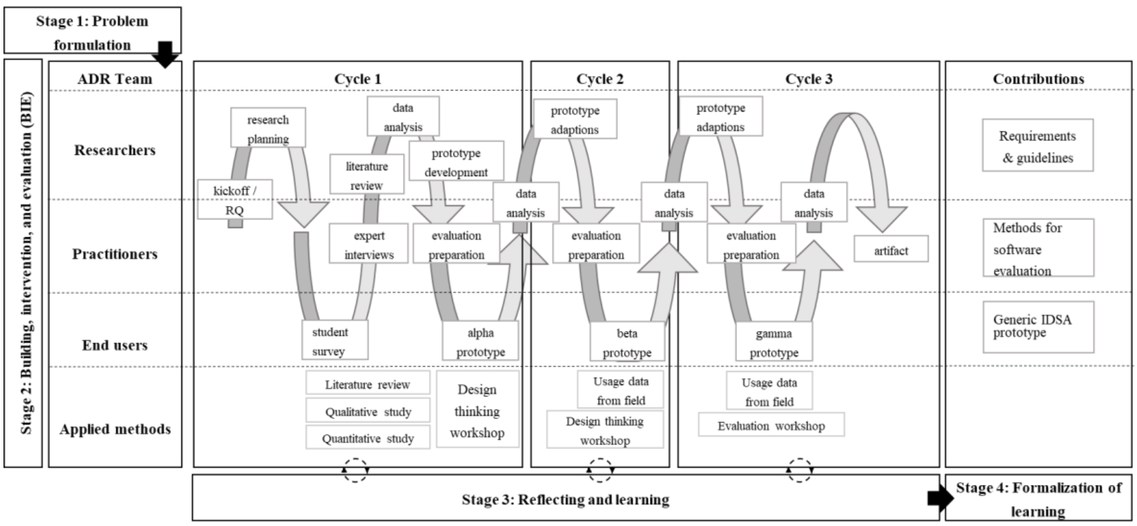

Figure 6. ADR research cycles for IDSA design and development (König et al., 2024)

Based on our qualitative and quantitative analysis and the literature, we identified seven requirements with several sub-requirements for an IDSA design and development, see Table 22.

Accordingly, different functionalities, contact options, data-based responsiveness and individuality, well-tested system, marketing strategies, data protection and security, and usability are important to consider.

Table 22. IDSA (sub-)requirements (Karrenbauer et al., 2023b)

(Sub)-Requirement
R.1. Different functionalities
R.1.1.: Learning organization
R.1.2.: Self-regulation
R.1.3.: Goal-setting and achievement
R.1.4.: Course recommendations
R.1.5.: Recommendations for OER and teaching networks
R.1.6.: Recommendations and suggestions based on interests, competencies, and strengths
R.1.7.: Self-autonomy
R.1.8.: Networking and exchanging experiences
R.1.9.: Study abroad
R.1.10.: Added value
R.2.: Contact options
R.2.1.: Opportunity for feedback
R.2.2.: Technical support
R.3.: Data-based responsiveness and individuality
R.3.1.: Possibility for individualization
R.3.2.: Knowledge of a student's academic course
R.3.3.: Interdepartmental information
R.3.4.: (Semi-)automatic import of existing data
R.3.5.: Minimize manual effort and low changeover costs
R.3.6.: Timeliness of data, content, and dates
R.4.: Well-tested system
R.4.1.: Intensive test phase for fault identification
R.4.2.: Error correction
R.4.3.: New updates
R.4.4.: Involve students and incorporate their feedback
R.5.: Marketing strategies
R.5.1.: Pricing policy
R.5.2.: High awareness
R.5.3.: Target-group-oriented communication and wording
R.6.: Data protection and security
R.6.1.: Transparent data handling
R.6.2.: Anonymous data collection
R.6.3.: No misuse of data
R.6.4.: Detailed privacy settings
R.7.: Usability
R.7.1.: Intuitive and easy usability
R.7.2.: Modular design
R.7.3.: Simple and clear as possible
R.7.4.: Optional introduction tutorials

Based on the requirements and developed concepts, the developers within the ADR team implemented a first prototype and incorporated selected functionalities (alpha prototype). It was rolled out in three German HEI and more than 700 students tested it. Further, the practitioners of the ADR team performed four focus group discussions using design thinking (Plattner et al., 2011) and personas (Lübcke et al., 2020). Based on the feedback, together with the developers, we designed and implemented new functionalities and evolved existing ones (beta prototype). In general, users could decide whether or not to select a functionality and its recommendations.

Again, the beta prototype was rolled out in three German HEI to evaluate it with target users. We used the usage data and the results of the questionnaire in the functionality Evaluation (5-point Likert scale, 1 (*don't agree*) to 5 (*fully agree)*). In total, 1,036 users tested the IDSA and of that 643 shared their data for research purposes, with 135 had no data stored. Overall, the functionalities *Organization of Learning*, *Interests*, *OER*, and *Personality* were used the most and *Get-Together* and *Data Sovereignty* the least. Thereby, an added value through the functionalities was not always perceived (M = 2.79, σ = 1.6), and not all could imagine to use the IDSA regularly (M = 3.1, σ = 1.6). However, the prototype encouraged students to reflect and think about their study goals (M = 3.1, σ = 1.71), they enjoyed using it (M = 3.75, σ = 1.79, R.7), and perceived it as intuitive (M = 3.44, σ = 1.65). Some students still discovered errors and pointed these out. In addition, the practitioners of the ADR team performed four design thinking workshops with 31 students to evaluate and improve the current prototype (Schurz et al., 2021). The workshops highlighted further improvement needs for the current IDSA prototype. In general, students asked for more individualization, information, and instructions but also questioned the value of some functionalities. Based hereon, the developers merged functionalities to avoid redundancies and overlaps, refined and expanded others, removed those without a value, and implemented new ones (gamma prototype) to increase the added value. Table 23 shows all realized functionalities within all prototypes.

Table 23. Developed IDSA functionalities in our ADR cycles (adapted from Karrenbauer et al., 2023b; König et al., 2024)

Functionality	**R.**	**Description**	**Alpha Prototype**	**Beta Prototype**	**Gamma Prototype**
Study Abroad	R.1.9	Information and guidelines for planning a semester abroad	x	x	x
Interests	R.1.4, R.1.6	Recommendations for learning resources based on interests	x	x	x
Learning Organization	R.1.1, R.1.3	Students can explore their learning behaviors, strengths and weaknesses, and receive recommendations	x	x	x
Get Together	R.1.8	Networking with other users based on study data, interests and/or status of planned stay abroad		x	x
Memory & Attention	R.1.2	Personality, long-term memory, short-term memory and task switching ability tests and personal feedback		x	x
Data Ethics	R.1.7, R.6	Education about data ethics to strengthen data sovereignty		x	x
Evaluation	R.2.1, R.4.4	User survey to collect feedback about the IDSA		x	x
Study Financing	R.1.2	Information about financing studies, semesters abroad, etc.		x	*
OER	R.1.5	OER recommendations based on study data and interests		x	**
Scientific Career	R.1.2	Information to achieve scientific goals, e.g., a Ph.D.		x	
Study Orientation	R.1.1, R.1.2	Information for first-year students sorted by topic			x
Study Goals	R.1.3	Clarification of individual goals			x

* Integrated in Study Orientation functionality; ** Integrated in Interest functionality

Again, the adapted prototype was rolled out in the local learning management system (LMS) of three German HEI. More than 1,000 students from various majors used the prototype and 274 provided usage data, of whom 106 shared their study data for analyses. The *Study Goals* and *Memory & Attention* functionalities had the highest number of interactions, followed by *Interests, Study Abroad*, and *Learning Organization*.

In addition, the practitioners performed evaluation workshops with four students again. Overall, the students perceived the IDSA prototype as useful and valuable to support study planning and organization. We did not receive much suggestions for further improvements, so we transitioned the prototype into an active system. Table 24 includes the derived guidelines for IDSA development based on our results and findings and gained knowledge during our design and development process. Our results and findings contribute insights and knowledge about IDSA in HEI and provide requirements and guidelines for the design and development of IDSA.

Table 24. Guidelines for IDSA design and development (König et al., 2024)

Guidelines		
1. Framework	1.1	Check HEI IT and IS for maturity, choose one LMS that all stakeholders use, and ensure top HEI management commitment to support openness.
	1.2.	Carefully determine all target groups.
	1.3.	Build a team for core tasks depending on the fields of expertise.
	1.4.	Define specific, attractive, and reachable goals of an IDSA.
2. Project Management	2.1.	Build a team of mainly experienced software developers.
	2.2	Choose one environment and (virtual) place, if possible, and use hybrid/agile project management methods.
3. Content	3.1.	Consider internal data and privacy protection challenges and barriers.
	3.2.	Ensure efficient and visible IT project management also for content.
	3.3.	Create an easily useable and inviting, up-to-date design, including mobile devices.
	3.4.	Ensure user-centered IDSA development.
	3.5.	Have testers of all target groups reliably available.
	3.6.	Pay attention to appropriate and user-oriented language.
	3.7.	Ensure that content is structured in a pedagogically efficient way.
	3.8.	Redefine and enrich target groups, if necessary.
	3.9.	Build a team for all content tasks depending on the fields of expertise.
	3.10.	Redefine specific, attractive, and reachable goals of an IDSA.
4. Team selection	4.1.	Group members must have time capacity, professional competence, and social competencies.
5. Team development	5.1.	The desired performance and synergy effects can be achieved by supporting team development.
6. Marketing	6.1.	Begin marketing efforts, both internally and externally, at an early stage.
	6.2.	Top management – the board of directors – must be involved as soon as possible.
7. (Team) Communication	7.1.	A good mix of online and face-to-face meetings strengthens team communication.
8. Student habits	8.1.	Ensure that students are well organized in their virtual support environment

4.6. Requirements and Incentives for Open Educational Resource Usage and Inter-university Teaching Exchange Network Participation

This section focuses on the paper “Incentives for Lecturers to Use OERs and Participate in Inter-University Teaching Exchange Networks” (König et al., 2021; Appendix 4). It promotes requirements and incentives for OER usage and IUTEN participation and introduces two inventive models. We identified early on that an IDSA must support the use of OER and participation in IUTEN. This has been continuously confirmed throughout our research. Therefore, OER must be produced and made accessible, and exchange collaboration networks must be available. We addressed the following research questions: (1) Which requirements are necessary to encourage lecturers to use OERs and participate in IUTENs? (2) How can an incentive model for lecturers be conceptualized to use OERs and participate in IUTENs?

Table 25 illustrates the main requirements and incentives of our expert interviews. As for requirements for OER usage we identified four different categories: the OERs' preparation, their content relevance, general legal aspects, and their need to be target group focused. Regarding incentives to participate in IUTEN, we identified performance certification, the availability of a technical framework, and a balanced distribution as essential requirements.

Table 25. OER and IUTEN requirements and incentives (König et al., 2021)

(Main) Categories	Explanation	# Mentions
OER requirements		
Preparation	OERs must be prepared with high quality (didactically, professionally and up-to-date).	6
Content relevance	OERs must be relevant to the topic of the course in terms of content.	3
Legal aspects	Legal issues such as copyright, publishing law, etc. must be clarified and evident.	2
Target group focus	The level of demand varies depending on the target group and must be taken into account by OERs.	2
OER incentives		
Digital format	Digital format makes OERs more readily available, easier to modify, offers the ability to link them together.	4
Supplementation of lessons	OERs offer the opportunity to add your own teaching content and materials.	4
IUTEN requirements		
Performance certification	Uniform regulations for the crediting of academic achievements (for students as well as lecturers)	3
Technical framework	Technical support and technical infrastructure must be provided.	3
Distribution	Balanced exchange of materials, lectures, students.	2
IUTEN incentives		
Variety of offers	IUTENs provide the opportunity to expand one's own curriculum (portfolio of offerings) and to cover different areas of focus.	7
Discipline specificity	The professional specialization of the different universities can be supported by exchange models.	4
Collegiality	Collegial collaboration is seen as an incentive.	4
Quality standards	Exchange between universities ensures a certain level of quality	2
Networking	Inter-HEI networking is stimulated by IUTENs (joint publications or research projects)	2

We used the model of Porter and Lawler (1968) as a basis to derive our incentive models. In previous research, it was already applied in the IS research context (vom Brocke et al., 2010). We made little adaptions regarding the wording to transfer the original model from management motivation to the HEI context. In general, the model consists of nine variables that have a motivational influence, see Figure 7. We used the identified incentives and requirements to develop one incentive model for OER usage and one for IUTEN participation. To incentivize OER usage, lecturers need to be convinced of the value of familiarization (1) of OER. Together with the expectation of rewards for the engagement (2), the willingness to engage with OER (3) increases. Individual performance depends on individual competencies and personality traits (4) combined with a proper understanding of their role as a lecturer (5). Performance increases when

HEI support OER integration (6). Lecturers get intrinsically motivated to engage with OER to enhance their materials (7A) and to learn technically (7B). Providing adequate rewards leads to satisfaction and finally to the motivation to further engage with OER (8, 9).

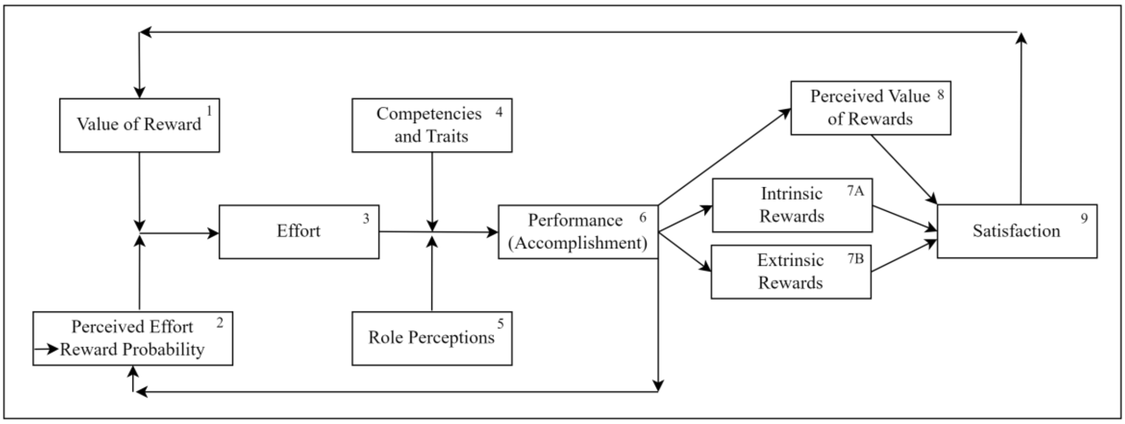

Figure 7. Incentive model (König et al., 2021)

Regarding IUTEN participation, lecturers must be convinced of the value of familiarizing themselves with IUTEN (1). They expect to be rewarded with increased distribution possibilities (2) which increases their willingness to participate in IUTEN and modify lectures to make them more online compatible (3). The personal competencies and traits in the discipline specificity (4) and the role perception within the HEI (5) influence the lecturer's performance. Participation in IUTEN enables lecturers to develop courses matching their research interests and import others from the network to increase their performance (6). Participation enables lecturers to enhance courses, expand offerings, and collaborate with colleagues (8). The opportunity to network, intrinsically motivates participation (7A) and they are satisfied by offering students an added value (7B). Lecturers feel rewarded and satisfied by offering expertise not available at other HEI. Our incentive models provide opportunities for HEI to improve OER usage and IUTEN participation. They contribute knowledge on how to implement measures to enhance collaboration and usage.

5. Overall Discussion, Implications, Recommendations, Limitations, Further Research Agendas, and Conclusions

The digital transformation with new technologies leads to new chances and challenges (Vial, 2019). Within companies and organizations, it critically influences ITPPM structures and can support automatized decisions. For HEI, digital assistants enable to automatize first-level support and provide students with ubiquitous advising as an addition to personal counseling. Independent of the research focus, applying our artifacts requires a stable and reliable IT infrastructure that allows flexibility for adaptions. Different data from various sources need to be accessed, analyzed, and processed. This data access leads to challenges. Getting good recommendations, for example, for an IT portfolio composition or suitable OER, requires good data quality, availability, and integrity. A recommendation can only be as good as its underlying data quality. Existing shadow systems (Kopper & Westner, 2016), such as Excel to document IT project evaluations instead of corporate ITPPM tools, mean this information and data is unavailable for further analysis. Without reliable data, a reliable recommendation is impossible (garbage in, garbage out; Kilkenny & Robinson, 2018).

However, data access and its use often lead to interface problems. During the IDSA design and development, some functionalities were limited in their scope or were not possible because of missing interfaces. When implementing a DSS for ITPPM, interfaces to other programs and departments are crucial to consider. For example, extracting data from a DSS to use it for PowerPoint presentations is critical. Considering interfaces applies to smaller department-specific solutions and especially to organization-wide ones. Thereby, interface availability and data quality often indicate organizational and HEI IT maturity. Good data quality and interface availability often imply a higher IT maturity; at a lower IT maturity, data is often unstructured and interfaces are unavailable (Schulte et al., 2024). Our models, frameworks, and tools mostly address organizations and HEI with a higher maturity. For example, the IDSA prototype (Karrenbauer et al., 2023b; König et al., 2024) has many interfaces to access OER platforms and integrate HEI internal data. Also, the DSS prototype in Karrenbauer and Breitner (2024) requires structured data to compose a value-driven IT project portfolio.

Besides missing interfaces, data protection and security are common reasons for constrained data access and availability. To support individual and user-centric recommendations, personal data and information is indispensable. There is a trade-off between having as much user data as possible to allow individualized recommendations and using this data for software improvements against having high privacy standards and only collecting as little data as possible. This must be considered during a tool development.

The proof of use (Nunamaker et al., 2015), the actual system's usage, depends on its usability, trust, and acceptance of end users. In the ITPPM context, users include, for example, decision-makers and departments while in the IDSA context they include students, lecturers, and HEI stakeholders. It is crucial to involve different stakeholders early in the design and development of tools, models, and frameworks to include their opinions and needs. Early involvement might also increase users' acceptance (Bhatti & Qureshi, 2007), as models, frameworks, and tools must be used and applied to unleash their added values.

In our ITPPM research, we introduced models, frameworks, and classifications to further advance value-driven ITPPM, automate this process, and make decisions more objective. Our comprehensive and integrated ITPPM process model comprises eight phases and 28 activities (Karrenbauer & Breitner, 2022b). We address the non-routine of IT projects integrating feedback iterations and allowing re-cycles between and within activities and phases. The involvement of stakeholders from different departments, systematic consideration of interdependencies, and a criteria-based evaluation address an IT project's cross-functionalities and complexity. The evaluation framework (Karrenbauer & Breitner, 2022a, 2022b) includes critical IT project criteria and allows a uniform IT project evaluation based on these criteria to increase comparability. It applies to IT projects of different sizes and scopes. We encourage multiple stakeholder scoring to reduce subjective influences. Companies and organizations can adapt our process model and evaluation framework to their needs to increase transparency and strategy aligned decisions. Using the process model and evaluation framework enables value-driven and objective decisions, reducing subjective manipulations in ITPPM processes. Results serve as a rational basis for decisions and increase comprehensibility. Applying our artifacts contribute to organizational learning, reporting, and data collection. In general, we extend and contribute to the ITPPM knowledge base and provide new research opportunities. The process model and scoring framework are Level 2 artifacts (Gregor & Hevner, 2013) that provide mature and abstract ITPPM knowledge that can be transferred to other portfolio types.

Our DSS prototype combines our scoring framework and optimization model within one solution and enhances previous research (Mohagheghi et al., 2019). The DSS prototype provides a Level 1 artifact that is still limited in its functionalities and scope (Gregor & Hevner, 2013). The value-driven optimization model maximizes the total value contribution and schedules the portfolio while considering many constraints. In our model, we synthesized and extended current literature and systematically considered different IT project interdependencies, scheduling aspects, and enable scenario and impact analyses. With rising number of IT project proposals, a manual portfolio composition is no longer possible, as resource restrictions and interdependencies are too complex to consider. Using our DSS prototype improves and automatizes these decisions leading to better quality results (Caniëls & Baken, 2012). Applying the DSS prototype, decisions are based on objective criteria, while sensitivity and scenario analysis allow to assess the effects of changing inputs to minimize uncertainties. Optimization results, i.e., the theoretical optimal portfolio composition, are not to be seen as fixed but rather offer a basis for decision-making (cf. phase 5 in Karrenbauer & Breitner, 2022b).

Our empirical and conceptual analyses revealed that ITPPM processes can differ in their maturity in five criteria and 17 sub-criteria within five maturity levels (Schulte et al., 2024). While literature focuses more on decision-making (Hoffmann et al., 2017), IT portfolio prioritization (El Hannach et al., 2016), evaluation (Archer & Ghasemzadeh, 1999), and selection (Pennypacker, 2005), practitioners highlighted IT project requirements, interface representation, data collection and provision, and integrated systems as critical. Our maturity model enables companies and organizations to classify their ITPPM process and deduce value-driven and value-creating improvements considering the organizational strategy and objectives. It enables to derive a transformation roadmap, make informed decisions, and rationalize resource allocations. A uniform application allows organizations to share best practices and define generalized standards.

Classifications are applicable to various topics and areas. They enable structure and provide insights into the status quo, similarities, and differences. Again, reliable data is needed as an input. Based on the classification, patterns can be identified through a cluster analysis (Kundisch et al., 2021; Nickerson et al., 2013). Our taxonomy and archetypes in Karrenbauer et al. (2023a) showed a shift from rather easy to complex ITPPM tools. Further, there are differences between literature and practice. Literature focused much more on interdependencies and optimization models (e.g., Bathallath et al., 2016; Linhart et al., 2020), which are scarcely considered in existing tools. Our taxonomy provides a knowledge base for theory building (Kundisch et al., 2021; Muntermann et al., 2015). Together with the archetypes, they structure the current ITPPM tool market and show differences and similarities between the tools. This can serve as a checklist for tool selections, as a basis for further developments of existing tools, or the introduction of new ones.

Analyzing IT project manager job advertisements, we identified that most organizations searched for experienced IT project managers with higher education backgrounds. They favor employees with communication, independent working style, and analytical and conceptual thinking skills. Thereby, certifications are advantageous but rarely mandatory, even though they get increasingly popular (Soroka-Potrzebna, 2021). Our results and findings show differences and similarities in IT project job advertisements and provide decision support for recruiters. The decision framework enables the formulation of specific job advertisements (Yang et al., 2022), can be used throughout the recruitment process, and reduces existing complexity (Alvarenga et al., 2020).

Literature about digital assistants has increased in recent years, including chatbot requirements (Meyer von Wolff et al., 2019) and archetype and taxonomy development for PCA (Knote et al., 2019; Weber et al., 2021). Within our HEI research, we performed multi-perspective analyses and included stakeholders and literature reviews with different focuses. We identified various CSF and requirements for IDSA in HEI. There was much agreement among faculty, organizational units, and students in what they perceived as essential. Nevertheless, there were also differences. Students perceived flexibility, qualified employees, no redundant information, and data integration as important, while lecturers and faculty experts mainly focused on top management support, the recommendations' reliability, and self-organization and regulation. Also, findings from literature comply with our quantitative and qualitative results, making them more nuanced, valid, and reliable.

Integrating multiple stakeholders in the design and development process had various advantages. The requirement analyses allowed to get different perspectives from target stakeholders and those that an IDSA is intended to support and relieve. We could consider these requirements during the implementation to meet the demands of later users and thus increase the IDSA's added value and attractiveness. During our IDSA implementation, the different perspectives of the stakeholders were invaluable to design functionalities, identify interfaces, and implement the IDSA from different points of view. However, this can also lead to challenges because of these different views. Further, assembling the IDSA team requires to include sufficient developers with experience in addition to conceptual employees.

Before an IDSA deployment, it is essential to test it comprehensively, identify and improve existing errors, and check the IDSA's maturity to provide a reliable assistant. Marketing activities are essential to make the IDSA known and increase the number of users. Although thousands of students tested our IDSA, it was only a small share of more than 60,000 students as potential users in the underlying HEI. This must be strengthened in further developments. A higher usage rate is important for general success and individual functionalities. For example, the *Get-Together* function only achieves its added value, if the number of users is high. Lecturers are also a multiplier to make the IDSA known. They are probably more willing to promote an IDSA and produce content if it reaches many students. In general, multi-functionality must not compromise the depth and content of single functionalities (Hobert, 2019). For other HEI, it is possible to adapt and transfer our results and findings to their needs and create a refined IDSA. For example, selecting and modifying single functionalities to address specific target groups is possible. Thus, our requirements, CSF, prototype implementation, and evaluation serve as a basis for conceptualizing a multi-functional IDSA.

One limitation of our research is the restricted data access. Our literature reviews mostly focused on English and partly on German literature from international conferences and journals in IS, ITPPM, Education, and related fields. Literature written in other languages or fields may not have been considered, while others may have been missed because of licensing regulations. Also, in Karrenbauer et al. (2023a) we were restricted by full access to ITPPM tools. Thus, used data is based on freely available information on the vendor’s website, demo videos, brochures, and information sheets. This led to possibly missing out on information about (non-)functionalities not explicitly described in public information.

Moreover, our data analyses may be subjectively biased. The literature to include in our reviews depended on what we considered relevant. To mitigate this, we used systematic and structured procedures and employed inclusion and exclusion criteria combined with different search methods, including forward, backward, author, and similarity searches using Google Scholar. Also, the expert’s individual experiences and knowledge might have influenced our results from the qualitative studies. Again, we used structured data analysis methods and interview guidelines to reduce this subjectivity. We analyzed transcripts independently and discussed the results until we reached an agreement and made adaptions, if necessary. However, there still might be some subjectivity. We performed interviews with German experts in their native language. As Van Nes et al. (2010) suggested, we coded and analyzed the transcript in German to remain in the interview language as long as possible to prevent translation errors and limitations. For quotes, we used the committee-based parallel translation (Douglas & Craig, 2007), with, where possible, two authors independently translating the statements and comparing and refining them (Douglas & Craig, 2007; McGorry, 2000). Translation errors still cannot be completely eliminated.

All our results and findings are time-bound snapshots and reflect the current state of research and experts’ knowledge. However, research and knowledge evolve, resulting in new knowledge to advance our results and findings. Therefore, the following proposes further research directions and topics, building on our results and findings and addresses further limitations. These topics do not attempt to be complete but rather offer examples for further directions.

For the ITPPM field, seven research directions with 24 concrete research topics emerged. As already mentioned, all our results and findings are time-bound snapshots and reflect the current state of research and expert knowledge. We only considered literature until 2023 and conducted all expert surveys and interviews between 2019 and 2023. We could not consider new insights from more recent literature or expert knowledge outside this time frame. Newer data and information can lead to adaptions, improvements, renewals, or expansions of our artifacts. It is critical to regularly update and refine our results and findings to include this new knowledge and ensure rigorous and relevant results in the dynamic IS field (further research direction (**FRD) 1**).

In Karrenbauer and Breitner (2022b), we identified evaluation criteria and ITPPM process activities that can enhance with new findings. Thus, there is a need to identify and analyze new results and findings systematically. Changes in these are likely to be accompanied by changes in the maturity model for ITPPM processes (Schulte et al., 2024), which also need to be identified and analyzed. Relying on the extendable nature of taxonomies, it is possible to extend the classification in Karrenbauer et al. (2023a) and Karrenbauer et al. (2024) anytime with new insights (Nickerson et al., 2013). Changes in the market in general or the ITPPM tool market in specific as well as in IT project management requirements and benefits, can lead to changed classification results. Refinements and re-analyses by deleting or adding dimensions and characteristics can result in changed or new archetypes and modifications in the decision support framework. Kundisch et al. (2021) recommend to compare current results with newer ones to identify patterns and trends leading to valuable insights into current market changes.

In general, we included experts from different countries (e.g., Germany, France, Canada, United States) to allow a generalizability of our results. Nevertheless, most experts came from Europe and North America, while countries from Asia or Africa are not represented. Thus, our expert sample can be geographically and culturally biased. Cultural differences between individual countries and continents (Hofstede, 1984) potentially influence organizational structures and procedures and their requirements. For example, the skills and corporate benefits for an IT project manager position identified in Karrenbauer et al. (2024) might differ between countries. Likewise, for example, power distances or uncertainty avoidance (Hofstede, 1984) can impact the overall ITPPM process and evaluation methods from Karrenbauer and Breitner (2022b) or influence the maturity levels of Schulte et al. (2024). Therefore, **FRD 2** focuses on the cultural influences on ITPPM processes.

With a few exceptions, we evaluated our artifacts using applicability checks (e.g., Karrenbauer & Breitner, 2024), expert interviews (e.g., Karrenbauer & Breitner, 2022b), or expert surveys (e.g., Schulte et al., 2024) and all were applicable. According to Nunamaker et al. (2015), we showed our artifacts' proof of concept. However, we cannot make a general claim regarding their successful implementation in a real-life company or organization and their influences and impacts there. Thus, **FRD 3** addresses the actual proof of value and proof of use of our artifacts (Nunamaker et al., 2015). Further research can analyze the decision-quality improvement and the impacts on decision-makers' behavior when using the process model and evaluation framework of Karrenbauer and Breitner (2022b). It is further possible to research the influence of these models and the DSS prototype of Karrenbauer and Breitner (2024) on the IT project portfolio's performance, using, for example, case study research or laboratory experiments with real-world data. In addition, we evaluated the added value of the decision support framework in Karrenbauer et al. (2024) with expert interviews only. Using the decision tree in recruitment or case studies can evaluate its proof of value.

Companies and organizations are heterogeneous and differ from each other in many areas. For example, the size, industry, culture, and regulations influence the behavior and the ITPPM. A one fits all approach is not possible and different conditions require different approaches and models. This limits the applicability of our artifacts and besides generalization, specialization is also necessary. It requires further research that focuses on different types of organizations, adapts our artifacts accordingly, and identifies their differences and similarities (**FRD 4**). In addition, we did not analyze the organizational cultural dimensions' influence at the team and organizational levels. Further research can examine their impact on ITPPM processes, IT project evaluation, and organizational IT maturity. Understanding the different organizational and cultural dimensions' influence on ITPPM can lead to valuable insights into its role in shaping ITPPM processes.

In our research, we did not focus much on emerging technologies. However, they can impact general ITPPM processes, including our results and findings. **FRD 5** addresses the potential of emerging technologies in ITPPM. Further research must focus on their application areas, chances and challenges, CSF, reasons for failure, and acceptance in ITPPM, using, for example, literature reviews, qualitative analyses, and market research. More precisely, it is possible to analyze the emerging technologies' impact, like artificial intelligence (AI), on evaluating and selecting IT projects and ITPPM processes (Karrenbauer & Breitner, 2022b, 2024). Especially how and which phases or activities can be simplified, supported, or automated. Further, when classifying ITPPM tools for Karrenbauer et al. (2023a), we did not find much information about the usage of emerging technologies in the tools. Further research must investigate these technologies' possible application potentials and areas in ITPPM tools, using an updated taxonomy analysis, design thinking workshops, literature reviews, or qualitative analyses. In Karrenbauer et al. (2024), we used a manual classification of 125 IT project manager advertisements as a database. Further research can use web scraping and web mining techniques of different job portal websites and text analysis tools to increase the database and significantly strengthen our results' robustness.

FRD 6 addresses the research focus of ITPPM tools. In Karrenbauer et al. (2023a), we developed a taxonomy and performed an archetype analysis to identify patterns between ITPPM tools. We evaluated the taxonomy with five practitioners and a cluster analysis (ex-ante evaluation; Kundisch et al., 2021). However, an evaluation of the clusters is still missing. Further research can perform, for example, qualitative studies to proof the patterns' usefulness and applicability (Kundisch et al., 2021; Szopinski et al., 2020). During the classification, we recognized variations in the depth and scope of functionalities among classified ITPPM tools. Aligning with Kock et al. (2020), a higher organizational maturity leads to more advanced requirements and benefits.

There is an opportunity for further research to categorize existing ITPPM tools according to their maturity and develop a comprehensive maturity model for ITPPM tools based on our taxonomy and archetypes. As our taxonomy and archetypes show, existing solutions differ in their functionalities, scope, and complexity. This complicates the selection of a suitable ITPPM tool for a company or organization. Further research can develop a decision tree to assist in ITPPM tool selection using our taxonomy and clusters. In addition, trust in ITPPM tools is crucial for its usage. Companies and organizations rely on the tools to provide reliable results based on their inputs. Thereby, decision processes in commercial tools are not always comprehensible and tools lack transparency, making the decision process a black box with limited traceability of the underlying algorithms. This enables new research opportunities to investigate the factors influencing trust in ITPPM tools and how to make them trustworthy. Further research can also focus on how to open the black box to increase transparency. We analyzed the (non-)functionalities of ITPPM tools. It is possible to analyze CSF for ITPPM tools and reasons for failure using expert interviews or a re-classification of the tools. New tools or those that no longer exist can give valuable insights into the CSF and reasons for failure (Kundisch et al., 2021). Further, systematically analyzing positive and negative ratings of existing tools with web scraping, web mining, and text analysis tools (FRD 5) can lead to further CSF and reasons for failure. Websites such as Gartner.com or Capterra.com provide many ratings of different ITPPM tools and might be used as a database.

The further development of our optimization model and DSS prototype of Karrenbauer and Breitner (2024) is focus in **FRD 7**. We used a scoring approach in combination with resource constraints, interdependencies, and other restrictions to make value-driven IT portfolio decisions. New findings from literature or practice (FRD 1) and emerging technologies (FRD 5) must be integrated into our existing optimization model and implemented in our DSS prototype. The objective function in the optimization model (Eq1) aims to optimize the value contribution by summing up individual IT project scores. It neglects interdependencies and synergies between single IT projects. For example, implementing one project may positively or negatively influence the value creation of one or more other IT projects. It offers the possibility for further research to include synergies and interdependencies within the objective function. Further, our DSS prototype is implemented in MATLAB version 2022b, limiting its availability, usability, and applicability for researchers and practitioners. Further research can design, develop, and deploy our DSS prototype as an open-source web version to improve usability and applicability. Care must be taken to evaluate it throughout the development process with core stakeholders by performing focus-group discussions or design thinking workshops and incorporating the feedback. Table 26 shows the research agenda for further ITPPM research.

Table 26. Further research agenda for ITPPM research

Further research directions	Research topics	Exemplarily research methods
1. Update and refinement of results and findings	1.1 Analysis of changes in IT project evaluation criteria and ITPPM process activities and phases 1.2 Analysis of changes in the maturity model for ITPPM processes 1.3 Re-classification of ITPPM tools 1.4 Re-classification of IT project manager job advertisements	Literature review, qualitative interviews, taxonomy development, archetype analysis, decision tree development
2. Examination of cultural influences on ITPPM	2.1 Examination of the cultural influences on IT project manager skills and benefits 2.2 Examination of the cultural influences on IT project evaluation, ITPPM processes, and their maturity	Cross-cultural and international - qualitative interviews - job advertisement analysis - case-study research
3. Analysis of our artifacts' proof of value and proof of use	3.1. Examination of the decision-quality improvement and behavior of decision-makers when applying the IT project evaluation framework, ITPPM process model, DSS prototype, and maturity model 3.2 Examination of the IT project's portfolio performance when applying the IT project evaluation framework, ITPPM process model, DSS prototype, and maturity model 3.3 Performance evaluation of the decision support framework for IT project manager recruitment	Laboratory experiments with real world data, case study research
4. Influence of different types of organizations	4.1 Identification and adaptation of our artifacts to the specific needs of different types of organizations 4.2 Analysis of the differences and similarities of the different types of organizations on the IT project evaluation framework, ITPPM process model, DSS prototype, and maturity model 4.3. Examination of the organizational and team culture on ITPPM	Qualitative interviews, case study research
5. Analysis of the potential of emerging technologies in ITPPM	5.1 General analysis of application areas, chances, challenges, acceptance, and failure 5.2 Examination of application potentials and areas of AI in ITPPM processes 5.3 Examination of application areas and potentials in ITPPM tools 5.4 Use of web scraping, web mining, and text analysis to increase database for IT project manager job advertisements	Technology acceptance model, unified theory of acceptance and use of technology, web scraping, web mining, market search, taxonomy development, design thinking
6. Expansion of ITPPM tool research	6.1. Evaluation of the usefulness and applicability of the ITPPM tool artifact 6.2 Development of a maturity model for ITPPM tools 6.3 Development of a decision support framework for ITPPM tool selection 6.4 Examination of factors that influence trust in ITPPM tools 6.5 Examination of CSF and reasons for failure of ITPPM tools	Qualitative interviews, decision tree development, maturity model development, web scraping, web mining
7. Further development of the optimization model and DSS prototype	7.1 Integration of new knowledge and emerging technologies within the DSS prototype 7.2 Incorporation of synergies and interdependencies within the objective function 7.3 Implementation and evaluation of an open-source DSS	Literature review, Operations Research methods, applicability check

For the IDSA field, 18 research topics within six research directions emerged. We used qualitative interviews and a quantitative student survey with German participants, all performed before the COVID-19 pandemic. Therefore, **FRD 8** addresses the update and expansion of the data. Online and distance learning during the COVID-19 pandemic with the need for more self-organized and regulated learning likely influence our results and findings. Further research must focus on how IDSA functionalities, CSF, and requirements have changed post-pandemic and analyze the differences and their impact on the IDSA design and development. All surveys were conducted with German experts from mostly one HEI. This might have biased our results and findings. German HEI already have major differences in their requirements, regulations, goals, and approaches, assuming even more global differences (Hofstede, 1984). We tried to minimize the German perspective by conducting international literature reviews. The narrow perspective still limits our results and findings. Further research can analyze the transferability to other German HEI not involved in the project, using, for example, qualitative studies and applicability checks. More globally, research can analyze the cultural influences on IDSA to gain knowledge about how different countries and cultures shape IDSA functionalities, CSF, requirements, and the design and development. To update and expand the survey with a broader range of experts and cultures enables a comprehensive understanding of similarities and differences to adapt the IDSA accordingly. Further, our literature reviews are time restricted until 2023. Further research must renew the reviews, expand and adapt current research results, including the CSF and requirements, and incorporate the new results to adapt our prototype to maintain rigor.

In König et al. (2023), we analyzed CSF and in Karrenbauer et al. (2023b) requirements for IDSA. Considering them during the implementation process does not necessarily lead to success. **FRD 9** addresses the focus on a long-term perspective to assess an IDSA's overall success. Identified CSF and requirements served as a basis for the IDSA prototype development. It requires a long-term perspective to analyze the long-term effects and success and whether and how IDSA can enhance, simplify, and support self-organized and self-regulated studying. Another research topic concerns the applicability of IDSA and their usage assessment. In case they are not used, it is critical to determine the reasons for failure, using, for example, field-studies or cross-sectional studies. The extend of OER usage and IUTEN participation among students and lecturers reveals another research topic. Understanding usage rates and their corresponding effects on teaching and student success is crucial. It requires research on how OER usage and IUTEN participation improve or hinder learning outcomes and experience.

FRD 10 focuses on the trust and acceptance of IDSA and OER usage and IUTEN participation. IDSA users must trust that the information and recommendations are accurate and reliable. Therefore, transparency and explainability are essential and comprehensible explanations of how an IDSA works and what the results are based on. Data privacy and incorporating user feedback can further enhance trust. The acceptance and trust of students towards OER is another research topic. It includes the assessment if students perceive OER as a trustworthy information source, whether as a standalone resource or as supplementary material for lectures. Analyzing these topics provide knowledge about the factors that influence students' trust and acceptance of OER. Knowing preferences and concerns, acceptance rates can be improved, potentially also leading to more trust. Besides the student perspective, trust and acceptance of lectures in OER are also relevant to understand. They act as multipliers who recommend OER in general or specific OER documents to students. It requires further research to determine the trust and acceptance of lecturers in OER. The same applies to IUTEN participation to promote engagement as well.

Data privacy and security emerged as an IDSA CSF, challenge, and requirement (Karrenbauer et al., 2023b; König et al., 2023). Therefore, **FRD 11** addresses this topic. Implementing a privacy-friendly IDSA faces many challenges and restricts functionalities. Further research must define and establish common guidelines to ensure data privacy and security in IDSA. To define and promote ethical standards it is essential to prevent manipulations, especially when IDSA can adapt to a user's personality (Spiekermann et al., 2022; Wambsganss et al., 2021c).

Developed prototypes in Karrenbauer et al. (2023b) and König et al. (2024) provide enhancement opportunities (**FRD 12**). During our analysis, we recognized that there are different support and information needs between different student groups. It requires research to identify these needs and how they differ between different study groups, including students from mechanical engineering, management and economic, and foreign countries. Understanding the differences and similarities allows to develop tailored IDSA for different student groups. Moreover, different study phases (Sprenger et al., 2010) require different IDSA support (Karrenbauer et al., 2021). We showed the actual status quo of these functionalities (Karrenbauer et al., 2021). Further research can investigate how IDSA can address these study phase specific support needs. Through student surveys and expert interviews, it is possible to identify new support needs within each phase, develop functionalities that address these activities, and gain insights into the study phase specific optimal IDSA usage and corresponding functionalities. Because of limitations in the LMS, we were restricted in the IDSA implementations and could not use voice-based language, even though it is much researched. Further research can include it, especially increasing the IDSA's usability and user experience.

An HEI's maturity level influences an IDSA's complexity and functionalities (**FRD 13**). For example, a chatbot-based IDSA requires a high IT maturity. Further research can analyze the HEI maturity's influence on an IDSA and understand its influence during the design and implementation processes. Based hereon, it is possible to develop a maturity model for IDSA design, development, and operation. Such research provides valuable insights into the relationship between IT maturity and IDSA design, development, implementation, and operation. Table 27 provides an overview of the IDSA research directions and topics.

Table 27. Further research agenda for IDSA research

Further research directions	Research topics	Exemplarily research methods
8. Expansion and update of data	8.1 Examination of the pandemic's impact on IDSA functionalities, its CSF, and requirements 8.2 Analysis of the transferability of our results to other German and global HEI 8.3 Examination of how cultural influences shape IDSA requirements, functionalities, and CSF 8.4 Analysis of changes in IDSA CSF and requirements based on new insights and integration in prototype	Literature review, qualitative interviews, design thinking workshops, applicability check
9. Examination of a long-term perspective to evaluate the overall IDSA success	9.1 Analysis of the long-term effects of IDSA and their influence on self-regulated learning and organization 9.2 Examination of failure reasons of an IDSA 9.3 Analysis of OER implementation and IUTEN participation on learning experience and outcomes	Qualitative interviews, quantitative survey, field studies, cross sectional studies
10. Analysis of acceptance and trust in IDSA, OER, and IUTEN	10.1 Examination of trust and acceptance in IDSA 10.2 Examination of OER as a trustworthiness source of information 10.3 Analysis of trust and acceptance in OER and IUTEN	Technology acceptance model, unified theory of acceptance and use of technology
11. Examination of data privacy and security in IDSA	11.1 Development of data privacy and security guidelines for IDSA 11.2 Analysis of ethical aspects in IDSA	Qualitative interviews, literature review, student workshops
12. Further developments of IDSA prototype	12.1 Analysis of support needs of different target groups 12.2 Implementation of these needs into an IDSA 12.3 Exploration of study-phase specific requirements 12.4 Integration of voice-based language systems	Qualitative interviews, literature review, student survey
13. Analysis of IT maturity	13.1 Analysis of HEI IT maturity during the design and implementation process 13.2 Development of a maturity model for IDSA design, development, implementation, and operation	Qualitative interviews, literature reviews

Overall, this cumulative dissertation contains 12 publications dealing with various topics in ITPPM and IDSA in HEI. The research focus on ITPPM contains research about how to improve value-driven ITPPM. Within our papers, we introduced an evaluation framework for IT projects, developed a process model for ITPPM, as well as a value-driven optimization model and a DSS prototype to support ITPPM decisions. In further papers we classified existing ITPPM tools and requirements and benefits of IT project manager job advertisements and discussed a maturity model for ITPPM processes. The research focus on IDSA in HEI introduced a functional feasible IDSA to support self-regulated and self-organized studying. After identifying critical (non-)functionalities, we deduced CSF, challenges, and requirements of an IDSA, developed and evaluated an IDSA prototype and finally deduced guidelines for an IDSA design, development, and operation. Our results and findings provide scientific contributions and enhance the ITPPM and IDSA knowledge base. Practitioners can use the results and findings of our ITPPM research to increase transparency in their ITPPM decisions, contribute to the strategy, and reduce failures. The IDSA research serves as a knowledge base for decision-makers in HEI when introducing an IDSA. The derived research agendas address further research directions and topics in the two important fields of studies. They can be used as a foundation for initiating discussions and conducting tailored research in the continuously changing ITPPM and HEI environment.

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Appendices

Appendix A1: Dialogue-Driven Digital Study Assistants for Higher Education – A Morphological Analysis

Authors: Claudia M. König, Christin Karrenbauer, Nadine Guhr, Michael H. Breitner

Outlet: Proceedings of the 13th International Conference of Education, Research and Innovation

Link: https://doi.org/10.21125/iceri.2020.0681

Abstract: Students want to receive information quickly, individually tailored to their needs and easily. Individual educational biographies and an increasing number of students mean that an individual provision of information becomes the focus of interest. On the one hand, we want to support students with targeted information through a digital study assistant (DSA), and on the other hand, we want to motivate them to study in a self-active way. Our analysis process has a student-centered perspective. The basis is an international literature review – including backward, forward, author and similarity search (Google Scholar) – and data collected from students and other stakeholders. Based on our results and findings, we develop a morphological box for a DSA development. In particular, we focus on requirements important for students in terms of equipment characteristics. One result is that many attractive applications are already available on the conventional market and that students already use these regularly. A challenge is to develop, adapt and adopt a successful DSA for a higher education institution (HEI).

Keywords: Digital Study Assistant, Morphological Box, Study Individualization, User-centric Design

Appendix A2: Optimal IT Project Selection – Quantification of Critical Scoring Criteria

Authors: Christin Karrenbauer, Michael H. Breitner

Outlet: Projektmanagement und Vorgehensmodelle 2022 - Virtuelle Zusammenarbeit und verlorene Kulturen?

Link: https://dl.gi.de/server/api/core/bitstreams/effe7877-cac3-49a4-a3e7-8e4adf031b46/content

Abstract: The management of IT project portfolios is challenging because of IT projects’ complexity, dynamics, unknowns, and uncertainties. IT projects account for a large IT budget proportion and significantly influence value contribution, strategic development, goal achievements, and competitive advantages. Many IT projects still fail, exceed time and resources, and do not reach their planned goals because of wrong decisions, unsatisfactory evaluation, and missing selection criteria. Thus, a continuous IT project scoring and selection is crucial to enable an optimal portfolio composition. We conduct a systematic literature review and 14 semi-structured qualitative expert interviews to develop a uniform and holistic scoring approach. Our findings show that IT projects’ urgency, strategy, efficiency, risk, and complexity are critical IT project scoring criteria. Our scoring approach increases objectivity and quality in evaluating planned and running IT projects and allows more convincing and transparent decisions.

Keywords: Information Technology Projects, IT Project Portfolio Management, IT Project Evaluation, Scoring Model, Scoring Criteria

Appendix A3: Individual Digital Study Assistant for Higher Education Institutions: Status Quo Analysis and Further Research Agenda

Authors: Christin Karrenbauer, Claudia M. König, Michael H. Breitner

Outlet: Proceedings of the 16th International Conference on Wirtschaftsinformatik

Link: https://link.springer.com/chapter/10.1007/978-3-030-86800-0_8

Abstract: Today, digital assistants can support students during their studies. A quick and easily useable and accessible information transfer, individually tailored to the students' needs is required. Individual educational biographies and an increasing number of students require individual information provision and advice. Research on digital assistance systems has increased dramatically over the past decade. We focus on the individual digital study assistant (IDSA) field with its functionalities embedded in a typical student life cycle (SLC). In order to determine the status quo of DSA, we conduct a literature review with a focus on their functionalities. One research finding indicates that the DSA field generates a wide range of DSA functionalities. We structured them developing a morphological box. Finally, we discuss a further research agenda for the development, adaption, introduction, and success of IDSA.

Keywords: Literature Review, Student Life Cycle, Individual Digital Study Assistant, Morphological Analysis, Further Research Agenda.

Appendix A4: Incentives for Lecturers to Use OERs and Participate in Inter-university Teaching Exchange Networks

Authors: Claudia M. König, Carla Reinken, Paul Greiff, Christin Karrenbauer, Uwe Hoppe, Michael H. Breitner

Outlet: Proceedings of the 27th Americas Conference on Information Systems

Link: https://aisel.aisnet.org/amcis2021/is_education/sig_education/13

Abstract: Concepts of inter-university teaching exchange networks (IUTENs), i.e. the exchange of courses at different universities as well as the import of Open Educational Resources (OERs) offer potential for innovative teaching-learning scenarios in higher education. Students experience collaborative teaching from different universities. Lecturers benefit from synergy effects and knowledge exchange with national and international colleagues, e.g., OERs enable to share a pool of international educational materials, often of high quality. Today's lecturers have decreasing time for innovative teaching formats due to increasing student numbers and student expectations. Thus, incentive models for higher education lecturers are necessary to foster IUTENs. We explore requirements conducting interviews with 19 university lecturers about their OERs usage (intention) and about participation (intention) in IUTENs and design an incentive model. The interviews support our model and show that some lecturers are interested in IUTENs and OERs, but more attractive incentives are often needed.

Keywords: Open Educational Resources, Inter-University Teaching Exchange Networks, Requirements, Incentive Model, Lecturer Interviews, Higher Education.

Appendix A5: Value-driven IT Project Portfolio Management: Process Model, Evaluation Framework, and Decision Support

Authors: Christin Karrenbauer, Michael H. Breitner

Outlet: Proceedings of the 43rd International Conference on Information Systems

Link: https://aisel.aisnet.org/icis2022/is_design/is_design/9

Abstract: Companies must optimize their information technology (IT) project portfolio to achieve goals. However, IT projects often exceed resources and do not create their promised value, for example, because of missing structured processes and evaluation methods. Continuous IT portfolio management is thus of importance and a critical business activity to reach value-driven goals. Guided by Design Science Research with literature reviews and expert interviews, we develop, evaluate, and adjust an IT project portfolio management process model, a holistic IT project evaluation framework, and implement a decision support system prototype. Our results and findings synthesize and extend previous research and expert opinions and guide decision-makers to make more informed and objective IT project portfolio management decisions aligned with optimal value creation. Furthermore, we deduce new research opportunities for IT project portfolio management process models, decision tools, and evaluation frameworks.

Keywords: IT Project Portfolio Management, Process Model, Evaluation Framework, Decision Support System, Value Contribution, Design Science Research.

Appendix A6: Critical Success Factors and Challenges for Individual Digital Study Assistants in Higher Education: A Mixed Methods Analysis

Authors: Claudia M. König, Christin Karrenbauer, Michael H. Breitner

Outlet: Education and Information Technologies

Link: https://doi.org/10.1007/s10639-022-11394-w

Abstract: During the COVID-19 pandemic, the availability of online higher education programs and tools has grown rapidly. One example is an individual digital study assistant (IDSA) for students, which provides functionalities to train self-regulation skills, to engage with own educational goals and to offer automated, first-level support to higher education institution (HEI) units and employees. An IDSA further can guide students through HEI and their administration. But, what are the critical success factors (CSF) and challenges for an IDSA? We deduce these using a mixed methods approach with one quantitative student survey, two rounds of interviews with various HEI experts, and a literature review. We classified our results according to the information system (IS) success model of DeLone & McLean (2016). Our results and findings show, e.g., that skilled and reliable HEI personnel, well-organized and useful content, cross-platform usability, ease of use, and students' social factors are essential. Attractive IDSA functionalities are a major challenge because students use many apps, daily. Based on our CSF and challenges, we deduce theoretical and practical recommendations and develop a further research agenda.

Keywords: Individual Digital Study Assistant, Critical Success Factors and Challenges, IS Success Model, Technology in Higher Education, Mixed Methods, Research Agenda.

Appendix A7: IT Project Portfolio Management Tools: Towards Taxonomy-based Archetypes

Authors: Christin Karrenbauer, Florian Bergmann, Michael H. Breitner

Outlet: Proceedings of the 56th Hawaii International Conference on System Sciences

Link: https://hdl.handle.net/10125/103402

Abstract: To achieve organizational goals and remain competitive, evaluating, selecting, and managing IT projects and proposals to build a value-driven portfolio is a critical activity. IT project portfolio management (ITPPM) tools assist these portfolio-related activities, support strategic decision-makers, and help complete more IT projects successfully. Despite existing research on this topic, knowledge about the characteristics and design elements of ITPPM tools is still limited. We develop a taxonomy based on scientific literature and 60 real-word ITPPM tools with four perspectives, 20 dimensions, and 51 characteristics. Subsequently, we perform a cluster analysis and identify five ITPPM tool archetypes. Our results and findings contribute to the knowledge base and integrate scientific and practical knowledge to build the basis for further research on ITPPM tools. Further, we structure the ITPPM tool market, guide practitioners in selecting an appropriate ITPPM tool and support the development of new solutions or develop existing ones further.

Keywords: IT Project Portfolio Management Tools, Taxonomy, Design Elements, Cluster Analysis, Archetypes.

Appendix A8: Design, Development, and Evaluation of an Individual Digital Study Assistant for Higher Education Students

Authors: Christin Karrenbauer, Tim Brauner, Claudia M. König, Michael H. Breitner

Outlet: Educational Technology Research and Development

Link: https://link.springer.com/article/10.1007/s11423-023-10255-8

Abstract: The growing number of students in higher education institutions, along with students’ diverse educational backgrounds, is driving demand for more individual study support. Furthermore, online lectures increased due to the COVID-19 pandemic and are expected to continue, further accelerating the need for self-regulated learning. Individual digital study assistants (IDSA) address these challenges via ubiquitous, easy, automatic online access. This Action Design Research-based study entailed designing, developing, and evaluating an IDSA that aims to support students’ self-regulated learning, study organization, and goal achievement for students in their early study phase with limited knowledge of higher education institutions. Therefore, data from 28 qualitative expert interviews, a quantitative survey of 570 students, and a literature review was used to derive seven general IDSA requirements, including functionalities, contact options, data-based responsiveness and individuality, a well-tested system, marketing strategies, data protection, and usability. The research team incorporated the identified requirements into an IDSA prototype, tested by more than 1,000 students, that includes functionalities as recommending lectures based on individual interests and competencies, matching students, and providing feedback about strengths and weaknesses in learning behaviors. The results and findings compromise a knowledge base for academics, support IDSA theory building, and illustrate IDSA design and development to guide system developers and decision-makers in higher education. This knowledge can also be transferred to other higher education institutions to support implementing IDSAs with limited adaptations. Further, this research introduces a feasible functional system to support self-organization

Keywords: Individual Digital Study Assistant, Higher Education Institution, Requirement Analysis, Prototyping, Evaluation, Action Design Research.

Appendix A9: Development Guidelines for Individual Digital Study Assistants in Higher Education

Authors: Claudia M. König, Christin Karrenbauer, Michael H. Breitner

Outlet: International Journal of Educational Technology in Higher Education

Link: https://link.springer.com/article/10.1186/s41239-024-00439-4

Abstract: Increasing student numbers, heterogeneity and individual biographies lead to a growing need for personalized support. To meet these challenges, an Individual Digital Study Assistant (IDSA) provides features to help students improve their self-regulation and organizational skills to achieve individual study goals. Based on qualitative expert interviews, a quantitative student survey, and current literature we derived requirements for an IDSA. Based on them, we designed, developed, and implemented a first IDSA prototype for higher education institutions (HEI). We continuously evaluated the prototype within different workshops and analyzed the usage data to improve it further in three enhanced prototypes. Based on this iterative process, we derived guidelines for an IDSA design and development. Accordingly, the framework, project management, content, team selection, team development, team communication, marketing, and student habits are important to consider. The guidelines advance the knowledge base of IDSA in HEI and guide and support practitioners in the design, development, and implementation of IDSA in HEI.

Keywords: Individual Digital Study Assistant, Development and Diffusion Guidelines, Higher Education Institution, Action Design Research, Student Life Cycle

Appendix A10: Decision Support Framework for IT Project Manager Recruitment

Authors: Christin Karrenbauer, Jana Gerlach, Michael H. Breitner

Outlet: Heliyon

Link: https://www.cell.com/heliyon/pdf/S2405-8440(24)00716-3.pdf

Abstract: Information technology project managers (IT PM) have a critical influence on IT project success while attracting and selecting the right IT PM is challenging. We followed a four-level research design and firstly developed a taxonomy as an input for a cluster analysis to identify patterns in IT PM job advertisements. Based hereon, we developed a decision support framework for IT PM recruitment. We evaluated our findings in an online survey. We identified multiple design elements for IT PM job advertisements within five perspectives and deduced five IT PM archetypes. The decision support framework uses five questions to assist IT PM recruitment. We expand the knowledge base and consider not only IT PM requirements but also benefits. Our decision support framework is the first to holistically support IT PM recruitment, supports recruitment managers in structuring job interviews, identifies potential matches between applicants and recruiters, and assists in the final selection.

Keywords: Recruitment, IT Project Manager, Taxonomy, Archetypes, Decision Support Framework

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Appendix A11: Mathematical Optimization Model and Decision Support for IT Project Portfolio Management

Authors: Christin Karrenbauer, Michael H. Breitner

Outlet: Submitted to Journal of Decision Science

Link: https://seafile.cloud.uni-hannover.de/f/c247fc7026bf4e098357/

Abstract: Information Technology (IT) projects are critical to achieve organizational goals and remain competitive. Nevertheless, IT project portfolio management decisions are often unstructured and subjective, leading to unsatisfactory performance, i.e., value creation and high failure rates. IT project portfolios are characterized by complexities, interdependencies, cross-functionalities, and resource restrictions, that make IT project portfolio management challenging. Several optimization models already support IT project portfolio management decisions. These mostly focus on IT projects selection and resource restrictions and not on scheduling, IT project exclusions, or sensitivity analyses. Further, visualizing IT project portfolio information can improve the quality of decision-making. Using Design Science Research and building on existing knowledge, we developed a value-driven optimization model and decision support system prototype to support the evaluation, selection, and scheduling of IT project portfolios considering interdependencies, resource limitations, and other constraints. We implemented our model in a MATLAB decision support system prototype for computational benchmarking, evaluated it with four experts, and added a real-world applicability check. Our results and findings enable guidance for strategic IT decision-makers to make informed and impartial decisions aligned with maximal value creation. Further, we infer new research avenues for decision-making in IT project portfolio management.

Keywords: IT Project Portfolio Management, Decision Support, Optimization Model, Decision Support System Prototype, Design Science Research, Value Creation.

Appendix A12: Maturity Model for IT Project Portfolio Management Processes

Authors: Fenja Schulte, Christin Karrenbauer, Michael H. Breitner

Outlet: Submitted to International Journal of Information Systems and Project Management

Link: https://seafile.cloud.uni-hannover.de/f/8c84fa6272f841bc83c2/?dl=1/

Abstract: Information Technology project portfolio management (ITPPM) rapidly increase in importance and complexity. Value-driven ITPPM with efficient resource allocation and scheduling enables competitive advantages. ITPPM criteria and processes are often unstructured in practice and theoretically underdeveloped. Maturity models can improve ITPPM processes and can analyze and classify their status quo to identify strengths and improvement opportunities. However, existing maturity models in the ITP(P)M domain are either too loose or too specific, which impedes their application. Further, these models often focus on single project management, without an IT focus, and often miss a rigorous methodical foundation. To address this, the paper outlines a maturity model for ITPPM processes using a holistic maturity model design process with knowledge and know-how from an extensive literature review and qualitative expert interviews. The developed maturity model classifies ITPPM processes in five maturity levels, based on the five criteria IT portfolio management, IT project requirements, quality management and documentation, ITPPM process participants, and integrated systems with several sub-criteria. The results and findings extend ITPPM knowledge and allow a generalized classification of ITPPM processes. Applying the ITPPM maturity model enables informed decisions about future roadmaps to improve ITPPM processes driven by corporate’s or organization’s business strategy and objectives.

Keywords: IT Project Portfolio Management, Maturity Model, Value Creation, IT Transformation Roadmap, Decision Support.