Concept and Possible Impacts of a Study Planning Assistant in Higher Education

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***Abstract*—While digital study assistants (DSA) have been subject to a rising scholarly interest, the university system landscapes which they are to be integrated into are often decentralized and historically grown. In this paper, we introduce a concept of a DSA against the background of the exemplary system landscape of the University of Bamberg, Germany. We outline such a system's functionality based on a prototypical implementation, touching upon related research and discussing possible broader impact in higher education. We also address the challenges that are faced when integrating a DSA into a university context.**

Keywords—study planning, higher education, digital study planning assistant

I. Motivation

Currently, universities are facing multiple challenges that lead to disruptive changes in higher education – among them the institutions' digitalization [1]. At German universities, digitalization plays a varying role in strategy and organization, which results in different states of progress [2]. This progress is additionally hindered by varying university IT system landscapes as well as often decentralized system structures due to historical development [3]. University systems tackle many different tasks such as administrative accounting as well as student life cycle management. In the following, we will focus on those that are relevant for the process of study planning. In this context, digital study assistants (DSA) have increasingly been gaining scholarly attention, particularly in recent years [4].

Against both the background of the heterogeneity in digitalization and system landscape as well as a rising interest in DSA, following research questions arise: What might a concept of a DSA look like? How might such a new technology be embedded into an exemplary university system landscape? What are possible impacts and challenges of a DSA in higher education? The paper is therefore structured as follows: First, central aspects of study planning are described against the background of study planning (assistance) in higher education. Second, the use case of a digital study planning assistant is introduced and contextualized within the system landscape of the University of Bamberg. Third, the concept for a study planning assistant is presented. The system's potential impact as well as challenges are addressed thereafter.

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II. Study Planning in Higher Education

Study planning plays a central role in students' organizational processes. It usually refers to organizing thematically related study units (called modules), which can contain different courses and teaching forms such as lectures or seminars [5]. Module selections or module sequence selections are – depending on the degree program – settled either within or between modules. Here, a general distinction can be made between short- and long-term study planning. *Short-term study planning* includes the selection of courses and modules for the current semester, taking into account subject-specific considerations and scheduling restrictions. Long-term study planning also includes modules of future semesters, whereby learning paths and dependencies between and within modules become relevant. Table I illustrates the described forms of study planning and decisions.

TABLE I. FORMS OF STUDY PLANNING AND DECISIONS

	Selection	**Sequence Selection**
Short-term planning	choice within current semester	creating a semester timetable
Long-term planning	choice for several semesters	creating a (long-term) study plan

This study planning and decision-making process is multi-optional and complex, and sometimes leads to erratic study trajectories [6] and difficulties on the part of students [7]. Seeking to support students, various projects developing study assistants have emerged. At the University of Bayreuth, Germany, *CMlife* assists students in study planning and organization [8]. *Smart Success* at the University of Osnabrück, Germany, provides assistance for both study planning and monitoring, including an early warning system [9]. Further projects such as *Degree Navigator* or *Degree Map* target both students and advisors. *Degree Navigator* at the Rutgers School of Arts and Sciences, USA, helps managing and monitoring academic progress on both parts [10]. *Degree Map* assists students and advisors at North Dakota State University, providing information and visualization of degree planning and academic progress [11].

Karrenbauer et al. [4] introduce a structured overview of functionalities a DSA might have within the student life cycle. While other projects address the stages before and after finishing university study, we focus on the stage called 'during university study', more specifically the planning and organization of modules – short-term and long-term. Focusing on such planning processes, our system may not only be called a DSA, but more precisely a digital study planning assistant (DSPA). In comparison to the aforementioned tools, our system focuses on long-term study planning.

III. Assisted Study Planning at the University of Bamberg

The empirical foundation for the development of a DSPA at the University of Bamberg was laid in a previous contribution, which elicited requirements for such a system via qualitative interviews with computer science students and suggested a first prototype [12]. This outline has now been sharpened towards a more mature concept of a system (architecture) and prototypical implementation that is embedded into the system landscape of the University of Bamberg as far as possible.

A previous overview of the system landscape at the University of Bamberg was provided by Henrich et al. [3]. Essentially, the system landscape is composed of five parts: the university website based on the content management system Typo3, identity management, an exam administration system, a learning management system based on Moodle, as well as a course administration system [3]. This initial landscape is complemented by a university data warehouse, which is currently extended by student life cycle data. Figure 1 visualizes the DSPA within the context of the current university system landscape.

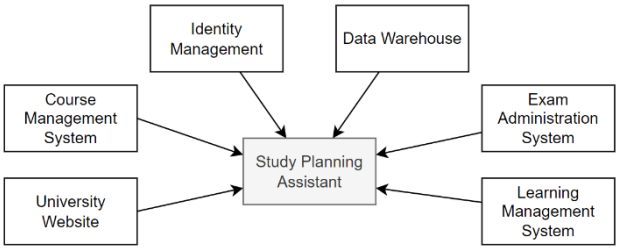

Fig. 1 System landscape at the University of Bamberg and proposed DSPA (based on [3])

Each of these depicted systems plays an essential role for the DSPA. The Corporate Design of the University Website guides the design of the web application. The Identity Management handles the login procedure for the DSPA as well as other university systems, so the DSPA does not need a separate login architecture and students can use the application without specifically registering for it. Data needed for individual study planning is provided by the Course Management System (course data), by the Exam Administration System (study program structure and individual study progress), the Data Warehouse (cohort data) as well as the Learning Management System (learning progress). It has to be noted that among German universities, this system landscape represents only one possible solution of IT architectures [2]. One current practice is to use Campus Management Systems (CMS) combining course management system functionality, exam administration and data warehouse [13]. In general, CMS can be defined as university information systems that aim to cover and support nearly all processes at a university [13]. However, the impact on the following concept of a DSPA remains small as the existence of a CMS might simplify the data access and integration but does not change the main idea of which (sub-)systems are relevant. In the long run, the functionality of a DSPA should be an integral part of a CMS, which is not yet the case for CMS known to the authors.

IV. Concept

After this introduction into the system landscape of the University of Bamberg, a concept for a DSPA is explored in the following, guided by Figure 2. First, the basic system with four pillars of core functionality is presented. Second, data sources used for this system as well as extensions are described. Last, techniques for student decision support are outlined.

A. Basic System

Four core areas of students' study planning processes that can be supported by a DSPA have been identified and implemented as core functionality in the prototype:

- *Interactive module handbook*—Information gathering and structuring.
- *Short-term (semester) planning*—Creating a timetable for a single semester.
- *Long-term study planning*—Creating a study plan for several semesters.
- *Student Dashboard*—Reflecting on individual study progress.

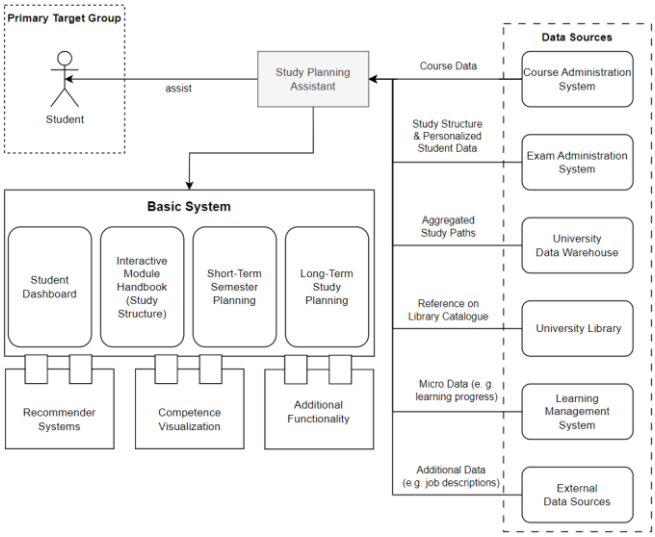

Fig. 2 Concept for a DSPA.

Interactive module handbook: Finding and gathering all information relevant for selecting courses or modules is complex and challenging for students [14]. Representing the study-program-specific study structure, the DSPA provides an overview of the modules students might choose (Figure 3). They can interact with this module overview with the provided grouping, filtering and search options that help structuring the numerous options. When clicking on a specific module, more detailed information (e.g. on learning outcomes or exams), that can support the decision process, is given.

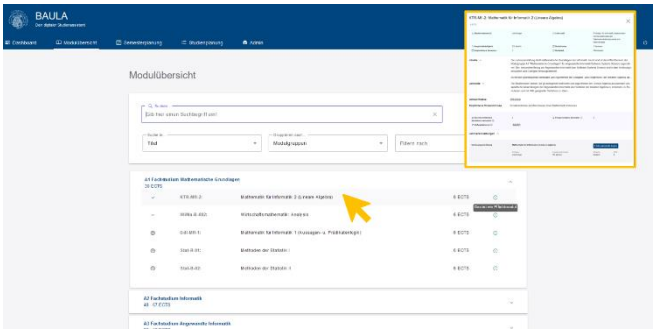

Fig. 3 Interactive Module Handbook: A list of modules that can be filtered and searched. Details for each module can be viewed on click.

Short-term (semester) planning: In order to support short-term planning, the DSPA provides a course search which allows to retrieve courses that are offered for a specific semester by selected departments (Figure 4). These can be saved to a personal list of courses, which can then be opened as a timetable via the course administration system.

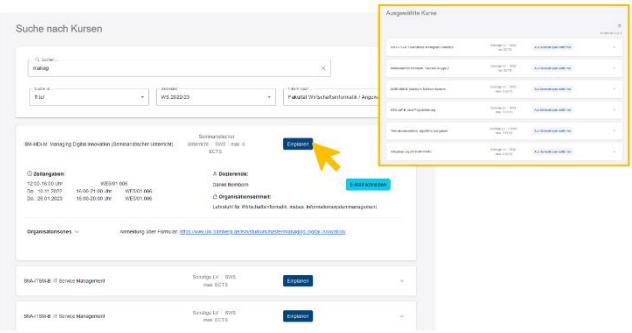

Fig. 4 Short-term planning: Searching for courses. Single courses can be added to a personal course list on click.

Long-term study planning: Apart from this short-term planning function, the DSPA allows to create study plans that span all study semesters of the student. Modules that students plan to choose in coming semesters can be added and supplemented by individual module placeholders. Due to frequent changes and constraints that may apply to the modules that are offered, long-term plans might be affected; therefore, several study plans can be created.

Student Dashboard: In order to provide students with a snapshot of their study progress, the DSPA provides an overview over the modules that have been taken, passed or failed and the current state of achieved credits. The portfolio further offers several diagrams that visualize the students' study progress (Figure 5).

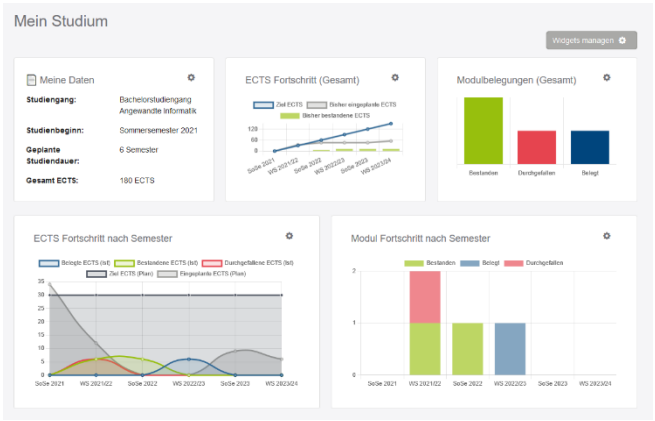

Fig. 5 Student Dashboard: Diagrams visualizing study progress.

B. Data Sources

1) Basic system:

The basic system's functionality that has just been outlined, mainly relies on the first two data sources that are depicted in Figure 2, i. e. *Course Administration System* and *Exam Administration System*. Course data is crawled via the Course Administration System's public interface and stored in the relational database of the DSPA. The data contains details that are relevant for short-term planning such as course description, instructor, department, location or time of the course. The Exam Administration System provides the study-program-specific study structures that are extracted from the system's exports created by the XML export function and stored in the relational database as well. It further provides detailed information on each module contained in a certain study program such as content, learning outcomes, or exams.

2) Extended System:

In the context of the extension of this basic planning functionality towards a more sophisticated DSPA, more data sources as depicted in Figure 2 are drawn upon. A first source is the *University Data Warehouse*, which stores aggregated student cohort data consisting of demographic data such as gender or background as well as study paths (= taken modules, attempts and grades). The data can be provided offline or via a dedicated interface. Second, the *Exam Administration System* may provide individual study path data via an interface. A third source which also provides student-specific success data but focuses more on the course level than the study path level is the *Learning Management System*. The system that is based on Moodle can provide individual learning progress data via plugins. Apart from these student-success-related sources, further sources are of interest. An interface by the *University Library* allows for referencing data in the Library Catalog. Last, *external resources* such as job descriptions may also be helpful to students as will be described in Section IV-C2.

C. Techniques of Supporting Student Decisions

Based on data provided by these various data sources, certain techniques can assist students' selections and sequence selection decisions in short-term and long-term study planning as introduced in Table I. Moving beyond a 'simple' delivery of information relevant for study planning in the basic system, the fields of *Competence Orientation* as well as *Recommender Systems* become particularly relevant.

1) Competence Orientation and Visualization:

Competence is understood to be a disposition that is context-specific and functionally tied to a certain domain according to Klieme et al. [15]. Accordingly, competences within the DSPA are always visualized in relation to the student's specific degree program. Competence visualization can play an essential role for module or course selection processes in short-term planning. Competence descriptions may be translated into visualizations that represent the competence composition of the selected item (course or module) and can help the students assess whether the item is suitable. Competence visualization also becomes helpful in the context of competence orientation, which, by definition relates to long-term orientation or study planning, i.e. visualization techniques can represent to which extent competence aim(s) are fulfilled by taken courses (e.g. BilApp [16]). Besides visualization, competence orientation might also be supported by a competence-based system that recommends fitting learning material [17], which leads us to the field of recommender systems.

2) Course or Module Recommender Systems:

The overall research area of Recommender Systems (RS) is rooted in the field of Artificial Intelligence (AI). Correspondingly, the subarea of course recommender systems belongs to the subfield of artificial intelligence in education, which has been gaining rising interest [18]. Course recommender systems support students in their navigation towards their learning goals [14] by recommending items that suit their personal state of knowledge or preferences. Likewise, within the DSPA, module recommendations can be

provided that support students in their study planning decision processes of navigating through their study path and towards their individual goals. The DSPA may provide recommendations on group or individual level by (i) cohort data analysis and (ii) matching modules with the current state of the individual learner model.

(i) Groups of study paths provided by the University Data Warehouse can be analyzed using statistical and machine learning techniques commonly used in academic performance prediction [19] such as logistic regression, key factor analysis or clustering. Thereby, a DSPA may assist students in their module sequence selections by identifying module dependencies *('You should choose module X before module Y'),* but also in their short-term selection *('Other students in your program chose...')* by identifying common module successors based on frequency analysis.

(ii) The assistant can further provide recommendations based on a student's individual learner model, which, apart from usual contents such as knowledge or skills (competences) [20], also consists of data such as personal interests or preferences, a student's individual study path (extracted from the Exam Administration System) or their belonging to a certain student group or community. Students' short-term selection decisions can be supported by suggesting a personalized ranked module or course list according to the current and desired state of the model, for instance, while their sequence selections can be assisted by the identification of a (non-)fulfillment of previously acquired competencies (e.g. via Learning Management System data) needed for passing a particular module. Recommendations can also consider desired competences or thematic goals defined by the students themselves based for example using external resources (e.g. job descriptions). Recommended items can be modules or courses, but also resources such as e-books or further educational resources.

This section has introduced the concept of the DSPA by first, introducing the main components of its core system; second, outlining the data sources that a study assistant can be built upon within the university system landscape; third, exploring the two exemplary fields of competence orientation and module recommender systems. Based on this concept, the next section will explore the system's possible impact, while the section VI will call attention to challenges and current limitations.

V. Impact and Possibilities

Drawing on the previous section, a DSPA can be impactful in many ways beyond its function as a tool for study planning. Its core functionality which has been introduced, in particular the interactive module handbook as well as the student dashboard, allows for easier access of information that is required for study planning and increased transparency of the students' current study progress.

The extended functionality, relying on several data sources that have been addressed previously, allows for more individual assistance of students. Therefore, a major part of the research on the DSPA can be rooted in the rising field of techniques of artificial intelligence in education [18]. In the context of the DSPA however, the potentials of individual assistance not only refer to group and individual recommendations of modules or educational resources as previously explained, but also to support students in their personal study goals, which is a central idea of a DSA [4]. Therefore, students are to be encouraged to set their individual goals and to follow a study path that suits their own interests as far as their study structure allows. The higher goal here is to enable students to study autonomously and make conscious decisions. Therefore, an important part is enabling them to access and monitor their current state of studies, for example via the student dashboard, which may be extended towards an open learner model [20]. Students performing poorly can be offered information on study guidance or additional helpful resources. As has become evident, a DSPA has the potential to assist students in various ways – further ways are to be explored in the future.

Aside from assisting students, research in the context of the DSPA is also highly relevant to other university groups such as study monitoring or study program administration. For instance, measures for further curriculum development or study guidance may be derived from techniques of (educational) process mining such as bubble chart analysis and others [6]. Closely related to this aspect of revealing potential improvements in the study structure, the DSPA naturally raises further organizational and structural questions on a higher level as it draws upon a variety of resources of variable quality and, as depicted in Figure 1, as it is highly embedded into the university system landscape. This leads us to the challenges.

VI. Challenges and Current Limitations

The potential impact such a DSPA might have regarding all the aspects that have been mentioned is closely tied to the existence of good quality data and its provision. Due to the decentralized system structure and the absence of standardized guidelines for the creation and distribution of such material (i.e. study structure reference, module and course descriptions) with respect to format, naming or details, the quality of the resources that the DSPA at the University of Bamberg draws upon is inconsistent and partly poor [3]. This represents a major challenge regarding the limitations of automatic information extraction and text mining / analysis, and thus, providing students with all the relevant information and recommending modules or courses to students. An exchange of data, ideally in a shared format, between these systems to prevent such problems caused by decentralized maintenance would facilitate data quality [3].

Another major challenge is the provision of data. A DSPA's system sustainability is highly dependent on its embedment into the university system landscape. Therefore, interfaces provided by the relevant university systems such as the Data Warehouse or the Exam Administration System are essential to the lasting impact such a DSPA can have. Relying on the current infrastructure, data can hardly be exchanged between the systems' decentralized parts, which impedes the introduction of a new technology such as the DSPA. Currently, the lack of a central digitalization or system sustainability strategy hinders the progression in this respect.

Furthermore, the issues of data privacy and protection are a challenge. In the context of artificial intelligence in higher education, large amounts of personal student data are usually collected [18], which is (not yet) the case for the DSPA at the University of Bamberg. However, the analysis of (pseudonymized) cohort data also must consider and negotiate data protection guidelines. Data utilization within the DSPA application must be regulated correspondingly – stated explicitly and consented by the students. This issue, however,

must be addressed not only on the level of a DSPA, but must be supported by clear regulations and guidelines provided by the university in the first place.

All these challenges of insufficient data quality, the lack of interfaces regarding data provision, and data privacy issues emerging from decentralized systems and the overall organization lacking clear guidelines may be overcome by investing in a holistic strategy for a sustainable digital progression that respects data privacy and autonomy and is strongly supported by the university management.

VII. Conclusion

This research has introduced a concept for a DSPA against the background of an exemplary complex university system landscape. We have outlined a prototypical implementation as well as related research and have discussed possible impact and challenges that come with such an integration. Throughout the coming months, the system's benefit and functionality will be evaluated. Its user interface and functionality are to be thoroughly tested in a think-aloud user setting, while the overall benefit of the DSPA will be assessed by a pre-post research design with respect to specific study-planning-relevant parameters, i.e. complexity, time, and support by resources and systems. Thereby, the fulfillment of the aim to provide a useful application with a core functionality that is helpful to students can be appraised. Further functionality regarding the research areas that have been introduced in this paper is then also built upon a more stable core.

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