Requirements and Prototypical Implementation of a Study Planning Assistant in CS Programs

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***Abstract*—Planning and organizing their studies by selecting modules and the order in which to attend them is an important challenge for students. Bachelor students, in particular, usually perceive this as an obstacle [1]. However, universities rarely provide tools to support students in this decision-making process. Using the method of qualitative interviews, this paper elicits requirements for a digital tool that supports the process of study planning for computer science students at the University of Bamberg, Germany. The resulting requirements are used as a foundation for a prototypical implementation. Based on this prototype, the feasibility of the collected requirements is analyzed and potential further developments are discussed.**

Keywords—study planning, requirements, web application, higher education, computer science programs

I. Motivation

Although digitization has already taken on a central role in everyday life, universities still have a lot of room for improvement in this area. While research on the digitization of universities focuses on digital teaching, systems to support students in planning and organizing their studies are rarely subject to current research projects.

The structure of a degree program at German universities is usually defined by study and examination regulations as well as module handbooks [2]–[4]. Parts of these documents have a statutory nature and are not always formulated in a way that is easy to understand for students [4]. Additionally, a current student survey [1] shows that it is in particular bachelor's students who have problems planning their studies and need more support in this area.

This paper is intended to provide an initial insight into how students of computer science (CS) degree programs at the University of Bamberg plan their studies and which requirements result from this for a digital study planning assistant. Thus, the following research questions are considered: What are the requirements for a study planning tool in CS programs from a student's perspective? How can a digital support system for study planning be designed and implemented?

This paper is therefore structured as follows. First, the characteristics of CS programs and the state of the art in study planning research are described. Second, the method applied, the resulting requirements and the prototype that has been implemented are presented. Third, the implementation of the prototype is discussed in regard to the list of the requirements that have been identified and potential future developments are addressed. The paper ends with a short conclusion.

II. Foundations

The term *study planning* is used widely both in literature and on the internet. In the context of universities, it can be used to describe not only processes related to planning courses and modules, but also relates to those that affect a student's personal life beyond that. This study focuses on study planning as a process of selection and temporal coordination of modules. In terms of coordination and selection, one might also differ between short-term and long-term study planning. In this paper, we will focus on long-term planning, which usually covers several semesters and aims at finding reasonable sequences of modules that may be interrelated in terms of content. Usually, the structure of a degree program sets the framework for study planning. This structure is defined by examination regulations, study regulations, and other regulations (e.g., module handbooks) [2]–[4].

In terms of the structure of CS programs, there is a high degree of standardization throughout programs at different German universities. The German Informatics Society (GI) has developed recommendations and suggestions for the design of bachelor's and master's degree programs, which underlie many universities' course structures [5]. The first semesters of bachelor's degree programs should therefore consist of compulsory modules to a high degree, which serve as a foundation for an individual focus with a higher amount of flexibility during the last two semesters. In contrast, few guidelines are outlined for master's degree programs. According to the GI, the consecutive, in-depth programs should offer electives to a large extent and contain hardly any restrictions regarding flexibility [6]. The GI guidelines do not give any recommendations for non-consecutive, broadening master's degree programs. These heterogeneous structures lead to differences in the flexibility of study planning between bachelor and master degree programs. However, even among master's degree programs, differences between consecutive and non-consecutive degree programs can be observed regarding the flexibility according to the respective program regulations. In general, it can be assumed that with a higher degree of compulsory modules, the focus of study planning lies on the temporal coordination of modules, while with an increasing number of electives, this focus shifts more towards the selection of modules.

One of the first systems for supporting students at German universities emerged in 2003. At the University of Ulm, a system called "Study Assistance System" (SASy) [4] was used to simplify study regulations in order to improve the comprehensibility. Recent systems and projects such as the "Information Portal for Students" (IPS2) at the University of Göttingen [7], "cmLife" at the University of Bayreuth [8] and the joint project SIDDATA [9] also address study planning and coordination. While SIDDATA focuses on the integration

2766-2144/22/$31.00 ©2022 IEEE
DOI 10.1109/ISET55194.2022.00066

of information from different sources to improve the organization of aspects around studying (e.g., stays abroad), IPS2 and cmLife are two modern systems that help students with the specific planning of their studies. However, there is no associated research on these two systems. Studies on the requirements of a study planning assistant and on further topics such as acceptance and effectiveness are not available in the context of IPS2 and cmLife.

III. Method

As implied in the previous section, requirements or information from previous research cannot serve as a base for the design and implementation of the prototype of this paper. To achieve the best result possible in the development of the tool, requirements are elicited by directly exploring the needs of the users – in this case the students. Qualitative interviews with potential users were therefore chosen as a method [10]. For the exploration of the requirements for the study planning support tool, the semi-structured interview was found to be particularly suitable. As the requirements for such a tool have hardly been researched so far, the semi-structured interview allows to discuss basic considerations about the tool with potential future users, ensuring structure and focus on the future system while maintaining openness to users' needs and interest [11], [12].

The structure of the interview guideline for this study is based on the four phases of guideline construction in IT projects according to Wessel [10]. Accordingly, interviews consist of an introduction, an exploration of the current situation, an exploration of the future situation and a conclusion phase [10]. The introduction briefly describes the structure and objectives of the study and provides a basic introduction into the subject area. The second part of the interview focuses on the students' current strategy of planning their studies. Due to the characteristics of CS programs, the interview explicitly asked about the temporal coordination of modules as well as the selection of elective modules. In addition to the students' current strategies, previous support options and problems encountered in the study planning process are surveyed. The third part addresses the exploration of the future situation. The focus lies on questions addressing the wishes and expectations for a digital tool that supports study planning. The final question in this section asks for exclusion criteria that would lead to the tool not being used by the students. This last part of the interview represents the conclusion of the interview.

During the selection of participants, specific subgroups of the target group were identified to ensure a high degree of variation and coverage of certain characteristics within the sample [13]. In this way, possible contrasts between the groups in their wishes regarding the support of their study planning were hoped to be revealed [12]. Based on the characteristics of CS programs, the following four types of students were identified and represented equally in the interviews: bachelor students in the beginning (1st to 4th semester) of their studies, bachelor students of higher semesters (from 5th semester onwards), master students of a consecutive master program, and master students of a non-consecutive program. For each of these types, three interview participants were surveyed. The interviewees were from the bachelor's degree program "Applied Computer Science", the consecutive master's degree program "Applied Computer Science", and the non-consecutive master's degree program "Computing in the Humanities".

Thus, a total of 12 students were interviewed. Due to the COVID-19 pandemic, most of the interviews took place virtually; in some cases, a face-to-face interview was possible. The interviews span between 12 and 40 minutes. They were transcribed for the sake of evaluation and then analyzed using the qualitative content analysis according to Kuckartz [14]. The results are described in more detail in the next section

IV. Results

The first part of this section describes the students' current approaches and strategies for study planning, the problems that have occurred, as well as missing information. It summarizes the results of the second part of the interview and presents the requirements that are derived from the result. Thereafter, the information and functionality that were requested by the students to support their study planning are described and requirements are once again elicited.

For both the timing and the selection of a module, their interest for the module as well as the required prior knowledge are important influencing factors for many of the students surveyed. Information from the module descriptions is used for this purpose. With regard to scheduling, bachelor's students and students in the non-consecutive master's program indicate that they strongly rely on existing study plans offered by the student council. Additionally, the distinction between compulsory and elective modules is a key factor in choosing the appropriate timing for a module.

It can be observed that across all groups, in addition to interest and prior knowledge, tips from fellow students (F1, F for functional requirement) as well as ECTS guideline[1] (F2) are important for half of the respondents when selecting modules. For Master's students in particular, both the semester in which the module is offered (winter or summer) and the frequency of offerings (each semester, annually, or only occasionally) are additional relevant influencing factors due to the short duration of the program. Other factors mentioned were the lecturer or chair that is responsible for the module and the selection of modules by other students. Overall, it can be observed that comprehensive information around a module should be integrated into a digital study planning assistant (F4). For short-term study planning, all groups emphasize the importance of avoiding overlaps in the timetable, keeping an eye on the number of hours per semester, and balancing studies with personal circumstances such as a part-time job. For long-term planning across semesters, it is considered to be important, among other things, to enjoy flexibility in planning while adhering to the guidelines specified by their degree program. Placeholders that allow to 'reserve' modules in the study schedule that are otherwise difficult to plan encourage such planning (F5).

For the question about missing information, there was a high variability among the answers and no group-specific aspects could be identified. For modules in particular, information on the registration process, the feedback from students, required prior knowledge or the recommended semester was missing. Further missing information was reported in relation to the assigned courses and to guidelines of the study regulations. Thus, the requirement can be derived that users should be provided with detailed information about the module and the associated courses (F6) as well as with various tips and hints (e.g., on recommended attendance) (F1).

[1]The European Credit Transfer System (ECTS) is a European system that makes achievements in higher education more easily transferable.

A closer look at students' previous problems reveals some overlaps with the aforementioned topics in the area of missing information. The lack of information partly appears to be a trigger for specific problems in study planning. Across all groups, it becomes clear that when modules are scheduled within a particular semester, overlaps of course times are a common problem. In addition, both a high level of organizational effort and a limited offer of modules make study planning more difficult. Planning efforts could be improved with more comprehensive information (F2, F4) and a performant, reliable, and easy-to-use system (NF1, NF3, NF for non-functional requirements). The limited module offers result primarily from planning problems such as temporal overlaps of courses and missing prior knowledge. Whereas the former cannot be prevented by the students, the latter can be addressed in a preventive manner by making module dependencies and necessary prior knowledge visible (F6).

Besides the results regarding the current situation, the expectations and wishes of the students in the form of demanded functionalities for a digital study planning assistant were asked for. The following summarized results were therefore retrieved from the third part of the interviews.

One of the main wishes of the interviewees is to get an overview of their study schedule (F7) and the modules offered in their degree program (F8). These should be presented in a list-like format similar to the module handbook. In this module overview, students also request grouping, search, and filtering options in order to obtain a more focused overview (F9). The study schedule, on the other hand, should be interactively adaptable, e.g., it should be possible to place certain modules via drag and drop only in semesters which they are offered in (F10). Such error-sensitive interactivity is intended to prevent errors in planning. Furthermore, currently achieved credit points and resulting over- or underachievement in specific areas of study should be displayed. In addition, the failure and successful completion of the modules should be marked within the overview.

Students with little previous experience in CS (bachelor beginners and non-consecutive master's students), in particular, wish for recommendations of modules (F3). A broad number of possible recommendations are mentioned by the respondents such as a suggestion of modules that are similar to the modules that have been taken so far or of modules that fit together well. One respondent would also like to receive recommendations based on the study paths of other students. One of the interviewees outlines a flexible core system, which would work entirely without external data in case an automatic integration of the study structure and the offered modules is not feasible (F11). It should offer the possibility to define modules and module groups manually in order to create an individual semester plan. In this case, the main role of the application is to provide an overview.

From the answers that relate to the last question of the interview about the exclusion criteria, it is particularly non-functional requirements which can be derived. Thus, it is important to the interviewees that the application works reliably (NF1) and that it can be used across operating systems as well as platforms (NF2). The tool should also ensure easy handling, a clear structure, and comprehensibility (NF3).

Beyond the scope of these previous questions, the variety of support tools at the University of Bamberg was criticized several times, which significantly increases the effort that is required for study planning. An integration into the existing university software environment would therefore be desirable (NF4).

Concluding Table I lists the summarized requirements elicited from the interviews.

TABLE I.
FUNCTIONAL (F) AND NON-FUNCTIONAL (NF) REQUIREMENTS

F1	Show various hints (e.g., organizational changes, tips from fellow students)
F2	Display students' degree program status (e.g., achieved credits)
F3	Recommendations (e.g. based on similar or broadening modules)
F4	Advanced module information
F5	Provide planning placeholders for modules that still need to be defined in more detail
F6	Visualization of module dependencies and required prior knowledge
F7	Overview of study schedule
F8	Display all modules offered in the degree program
F9	Grouping, search, and filter options for modules
F10	Interactivity of the user interface
F11	Flexible core system
NF1	Reliability and performance
NF2	Cross-platform and multi-operating system usability
NF3	Ease of use
NF4	Integration into existing university environment

V. PROTOTYPE

Based on the list of requirements, a prototype was designed and developed. The prototype focuses on the implementation of the front-end application. The underlying database, based on a document-oriented MongoDB, was mocked and queried via a REST-API, which was implemented with Express.js and served via Node.js. The front-end application was implemented using React. The application consists of a total of three views.

The module overview (Fig. 1) shows a list of all modules available in the degree program. The modules are divided into compulsory and elective modules and are subdivided by default according to the further degree program structure within these categories. When selecting a module, the user is directed to a detailed view (Fig. 4), which displays all known information of this module. In the last view of the application, the user has the possibility to plan the study semester by semester. For this purpose, the planned modules are listed for each semester (Fig. 3).

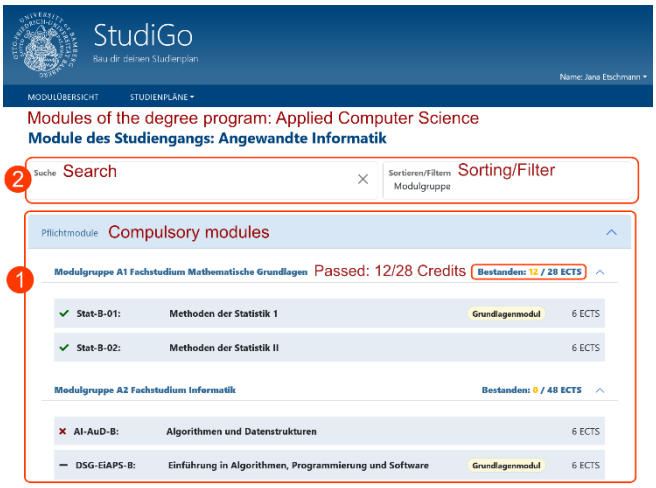

Fig. 1. Overview of all modules within the developed tool

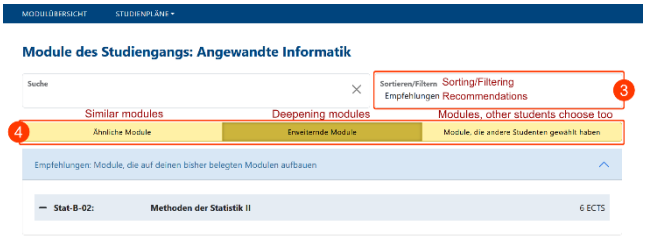

Fig. 2. Different groups of recommendations are offered to the user in tabs.

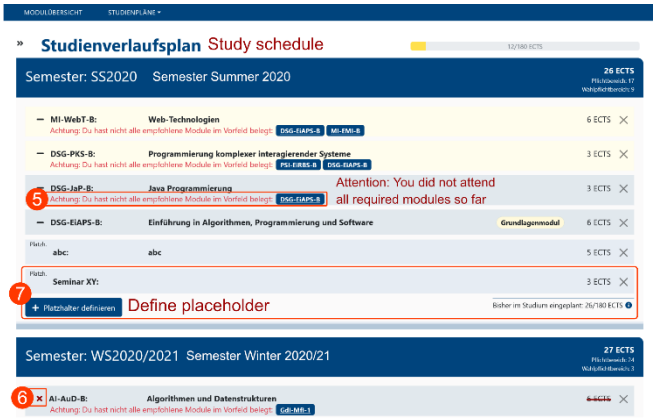

Fig. 3. Study plan which allows the students to plan their modules semester by semester.

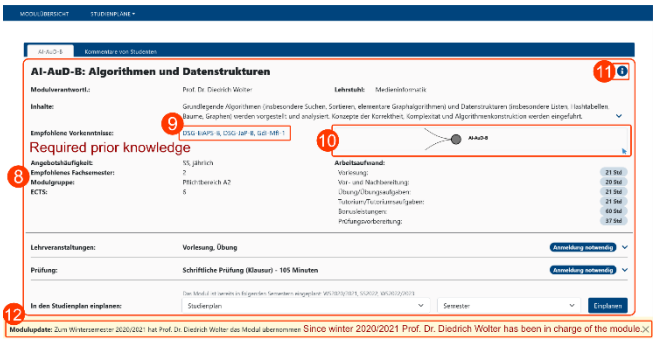

Fig. 4. Detailed information for the selected module.

VI. Discussion

This section examines the prototypical implementation against the background of the elicited requirements. Since the focus of the prototype lies on the implementation of the front-end, the requirements were mainly implemented with regards to the user interface.

The non-functional requirements (NF1, NF3), in particular, can therefore not be discussed in depth but require more targeted investigations, e.g. in the form of a usability study. More complex functionalities were integrated into the implementation in a simplified manner and required data was mocked. The integration of data from existing applications within the university context (NF4) is therefore also not provided by the prototype. Currently, the integration of various university systems is being discussed with stakeholders. Since the tool is designed as a web application, cross-platform and cross- operating system use can be ensured (NF2).

The module overview (Fig. 1) displays all modules that can be taken in a degree program in a module handbook-like structure (F8) ❶. A click on one of the modules leads the user to the detailed view of the module. Currently, the overview is limited to modules from the module handbook; sections in which any modules from other degree programs can be added have not yet been considered. Modules can be grouped by chairs using the sorting function. Further grouping options can be integrated additionally here. A filter and search function is also implemented (F9) ❷. The result of the search is currently displayed within the sorting or filtering instead of a separate module. This allows for additional information such as a module's allocation to subcategories or filtering. The recommendation of appropriate modules is realized via the filter function ❸ (F3).

As the recommendations can be based on different criteria and various wishes of students have emerged in this respect, the selection of different tabs allows the display of different groups of suggestions (Fig. 2). In the prototype, the user is offered recommendations based on similar modules, deepening modules – i.e. modules that build on modules already taken – as well as modules that other users with a similar selection history have completed ❹. For all groups of recommendations, only modules that have not yet been passed are displayed.

Finally, the module overview also offers the display of a banner to provide information about changes in the module offering (F1). The banner is displayed as soon as new modules are added or existing modules are removed.

The study schedule (Fig. 3) shows a semester-by-semester view of the planned modules over the period of study (F7). Both past semesters and future semesters are displayed. The overview contains hints in case the suggested order of the modules is not followed by students (F1) ❺. In addition, it is marked whether a module was passed or failed in a particular semester ❻. Again, a click on the module leads to the detailed view of the module. Furthermore, the function to define placeholders for modules that are difficult to schedule has been implemented (F5). A button within the respective semester opens a popup window in which the user enters the most important information (abbreviation, name, credits, notes). The placeholder is then placed in the selected semester and considered in the calculation of credits per semester and in the study path ❼.

The detailed view of a module (Fig. 4) contains all important information about this module in a table-like overview ❽. It collects the data for a module from the module handbook and also displays further desired information (F4). The prior knowledge of the selected module is represented by a link to the corresponding modules (F6) ❾. These dependencies are visualized additionally to the user as a graph, making it easier to see how several modules are linked ❿. Useful tips related to the selected module are displayed using an info button next to the title of the module (F1) ⓫. Hovering over this info button reveals the tips for the module. Moreover, dynamic changes within the structure of the module such as lecturer changes are displayed as a banner in the bottom part of the view (F1) ⓬.

A flexible core system (F11) as well as enhanced interactivity i.e. drag and drop (F10) was not implemented in the prototype. The flexible core system might facilitate the extension of the tool to a larger number of degree programs. Enhanced interactivity may have a positive impact on the usability and reduce errors in the planning process. The implementation of these two functions and a proper evaluation should be next steps in the further development of the prototype.

VII. Conclusion

This paper presented a list of requirements that has been elicited from interviews with students from different CS programs as well as a first implementation of these requirements. Besides an evaluation of the user interface and functionality, a more comprehensive study should be conducted to investigate whether the developed prototype provides helpful support to students in planning their studies. The target group of our research was limited to students of CS programs. In order to develop an assistant that will assist students of a broad range of different degree programs, further research is required. Nevertheless, the prototype and the list of requirements can be used as basis for this further research that aims at making study planning more digital, modern, and – above all – easier for students.

Acknowledgment

This research was conducted as part of the project “Developing Digital Cultures for Teaching (DiKuLe)” and was financed by “Stiftung Innovation in der Hochschullehre (Foundation for Innovation in Higher Education)”.

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