What Do Academic Users Really Want from an Adaptive Learning System?

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Abstract. When developing an *Adaptive Learning System* (ALS), users are generally consulted (if at all) towards the end of the development cycle. This can limit users' feedback to the characteristics and idiosyncrasies of the system at hand. It can be difficult to extrapolate principles and requirements, common to all ALSs, that are rated highly by users. To address this problem, we have elicited requirements from learners and teachers across several European academic institutions through explorative, semi-structured interviews [1]. The goal was to provide a methodology and an appropriate set of questions for conducting such interviews and to capture the essential requirements for the early iterations of an ALS design. In this paper we describe the methodology we employed while preparing, conducting, and analyzing the interviews and we present our findings along with objective and subjective analysis.

1 Introduction

The development of an *Adaptive Learning System* (ALS) is a challenging task [2, 3]. There exist many prototypical systems with domain-specific adaptive functionality. However, there is no established strategy for incorporating adaptivity in a system. This makes the process of requirements elicitation quite difficult. To address this problem, we have collected and aggregated the needs of users involved in higher education (learners and teachers) in a systematic form through interviews. Our approach is to illustrate the concept of adaptivity during the interviews through a hypothetical scenario involving a learner, a teacher (author and tutor), and a fully-functional ALS. A semi-structured interview allows the interviewees to evaluate an ALS's potential merits, short-comings and usefulness with respect to their individual needs.

Prototypical ALSs are often assessed through user evaluations during or after the system development stage [4, 5]. However, this can frame the user's evaluation; they comment on what has been developed and offer criticisms. Our hypothetical scenario is intentionally vague to promote a 'green fields approach'. It is the intention of this work to involve the users before any design or development commences and to later assess the utility of their input through user trials when a system is being developed.

This paper is organized as follows. Section 2 details the requirements elicitation methodology. Section 3 describes the interviews themselves. In particular, we discuss current usage of learning systems (both adaptive and non-adaptive) and ratings of the various features and dimensions of adaptivity. Section 4 analyzes the interviews subjectively by highlighting some of the pertinent and interesting

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suggestions made by the interviewees. An accompanying technical report[1] provides an expanded version of the sections herein, including the full text of the *interview summaries*.

2 The Requirements Elicitation Methodology

Interviewees are first divided into three groups: learners, teachers, and others. An *interview guide and protocol* is produced and distributed to all interviewers to ensure consistency. The interviews are documented in two forms: *interview summaries* (having a narrative character) and *interview data sheets* (for quantitative and statistical analysis). The interview questions are both quantitative (closed questions with a predefined choice of answers) and qualitative (open-ended questions that try to gather information in an unbiased manner).

Content analysis reduces the large body of text in the interview summaries and data sheets to a condensed form with essential content. There are two approaches: *quantitative content analysis* employs word frequencies to deduce a systematic, objective, and quantitative description of the communication content; and *qualitative content analysis* analyzes the texts within their context of communication, following content analytic rules and step by step models, without rash quantification. A combination of both preserves their respective advantages [6], thus resulting in a systematic analysis that is guided by qualitative interpretation in order to get an in-depth understanding of the ideas and views of the interviewees on the one hand, and quantitative data on the other [7]. To handle the open-ended questions, categories of answers are built using a combination of *inductive category building*, where the categories are formulated *a priori* and characterized by the relevant aspects of analysis, and *deductive category building*, where the categories are formulated *a posteriori* in terms of the gathered material [6, 7].

Before conducting the interviews, a hypothetical scenario involving a learner, a tutor, a content author, and a fully-functional ALS is distributed to the interviewees. The scenario illustrates typical and possible usage of an ALS. It provides the interviewees with a basic understanding of adaptivity. Respondents are encouraged to estimate the relevance of each use case to their own personal context and work. The technical report provides an example of one such scenario. We followed the above methodology when conducting the interviews reported below.

3 The Interviews

There were 27 interviews conducted in June 2008 across seven European institutions (see Table 1). The sample size was predominantly due to the data collection instrument and the involved effort.

	Learner	Teacher	Other	Total
Open Universiteit Nederland	2	6	2	10
Technische Universiteit Eindhoven	0	4	0	4
Trinity College Dublin	1	2	0	3
Università della Svizzera Italiana	1	2	0	3
Universität Graz	2	1	0	3
University of Warwick	1	1	0	2
Vrije Universiteit Brussel	1	1	0	2
Total	8	17	2	27

Table 1. Summary of the interviews.

[1] https://www.cs.tcd.ie/publications/tech-reports/reports.09/TCD-CS-2009-06.pdf

3.1 Current Usage of Learning Systems

The first section of the interview gauged the current usage of learning systems and ALSs by the interviewees. We present each question in turn and summarize the results.

A1. Do you use any learning systems? Out of 27 interviewees, 25 were using or had used learning systems. All of the teachers had experience with learning systems. Only two learners indicated that they had no experience. Questions A2-A5 were answered by the 25 interviewees with experience; the remaining questions, unless otherwise indicated, were answered by all 27.

A2. Which learning systems have you used? This was an open-ended question; we did not provide a list of learning systems to choose from. In the case of customized or heavily modified systems, we grouped these under the category 'in-house'. Other than in-house systems, `Moodle` and `Blackboard` were the most popular learning systems (see Table 2). We note that the most popular Open-Source and commercial LMSs feature. This question also provided us with information as regards the number of learning systems in use by each interviewee. On average, each interviewee used two learning systems (`mean` = 2.04, `s.d.` = 1.26). Teachers indicated that they use significantly more learning systems ($t(23) = 2.699$, $p = 0.013$), with teachers listing on average 2.5 (`s.d.` = 2.47) systems and learners listing on average 1.1 (`s.d.` = 0.9) learning systems.

In-House	13
`Moodle`	12
`Blackboard`	9
`Sakai`	3
`WebCT`	3
`Others (AHA!, ALEKS, Dokeos, Educativa, Ilias)`	6

Table 2. The learning systems used by interviewees (in descending order by use).

A3. How often do you use a learning system? The majority of the teachers used learning systems daily or once to several times a week, whereas learners used them less frequently.

A4. How long have you been using learning systems? The teachers had long-term experience in using learning systems (13 had many years' experience, 3 had one year's experience, and 1 had several months' experience), whereas learners had considerably less (only 1 has many years' experience, 2 has one year's experience, and 3 had several months' experience).

A5. Do the learning systems you have used so far provide any adaptive features to users? The responses to this question show that the majority of learning systems have no adaptive features (`no` = 15, `yes` = 10). The weak support of adaptation by Open Source and commercial LMSs has been confirmed in the literature [8].

3.2 Adaptivity – Needs and Preferences

The second section of the interview focused more on adaptivity and the purposes and benefits of an ALS (whether the interviewee had previously used one or not).

B1. What do you think are the purposes or tasks for which an ALS is especially suited? Table 3 summarizes the results. The top two answers were individualized teaching and guided, individualized learning. These can be considered the same, but from opposing viewpoints, *i.e.* the teachers' and learners'.

Individualized Teaching	6
Guided and Individualized Learning	5
Details of Technical Material	4
Clearly Defined Knowledge Domains	2
Identification of Strengths and Weaknesses in a Learner	2
Monitoring	2
Procedural and Vocational Training	2

Table 3. The top seven purposes or tasks for which ALSs are especially suited (in descending order by the number of interviewees who said so).

Efficiency	11
User Specificity	9
Relevant Learning Material	4
Personalization	3
Re-Usability	3
Learner Motivation	3
Avoids Information and Cognitive Overload	2

Table 4. The top seven benefits of ALSs (in descending order by the number of interviewees who said so).

B2. What are the benefits of using an ALS? Do you think adaptivity in a learning system brings added value to the user? The results are summarized in Table 4.

B3/B4. I list features that are reported in the literature to function as sources of adaptation, i.e. *characteristics of the learner or environment that may be considered by an ALS when adapting to the individual learner. Please indicate your opinion on the importance of adaptation to each of these features on a scale from 1 to 10 (1 being unimportant and 10 being very important).* The listed features and the results are shown in Table 5. All adaptation criteria were judged quite important; each criterion reached at least a mean importance of 5. The criteria judged to be the most important were adaptation to learner knowledge (`mean` = 8.85, `s.d.` = 1.19) and adaptation to learning goals and tasks (`mean` = 8.7, `s.d.` = 1.82). A correlation analysis showed that the judgment of learner knowledge is highly correlated with learning goals and tasks ($r = 0.606$, $p = 0.001$), and features medium correlations with language, learner qualifications, user role, background, and experience in the hyperspace. The importance rating of learner knowledge was not correlated with any other criterion. The least importantly judged aspects, although still characterized by a mean importance of about 5, were background (`mean` = 5.3, `s.d.` = 2.37), learner personality (`mean` = 5.07, `s.d.` = 2.37), and experience in the hyperspace (`mean` = 5.0, `s.d.` = 2.56).

B5/B6. I list dimensions that can be the subject of adaptation, i.e. *methods and techniques that may be used for adapting the learning process to the individual learner. Please indicate your opinion on the importance of each of these dimensions on a scale from 1 to 10 (1 being unimportant and 10 being very important).* The list of dimensions and the results are shown in Table 6. As was the case for the features of adaptivity, all the dimensions have quite high ratings, with minimum means between 5 and 6. The dimensions judged to be most important were learning activity selection (`mean` = 8.37, `s.d.` = 2.02) and content selection (`mean` = 8.33, `s.d.` = 2.25) in general – and within this dimension, the techniques of additional explanations (`mean` = 8.37, `s.d.` = 1.04) and prerequisite explanations (`mean` = 8.19, `s.d.` = 1.98). Furthermore, adaptive testing (`mean` = 8.22, `s.d.` = 1.63) was considered very important. The dimensions judged to be least important, but still featuring a medium mean importance score,

	No.	Min.	Max.	Mean	S.D.
Learner Knowledge	26	6	10	8.85	1.190
Learning Goals and Tasks	27	4	10	8.70	1.815
Language	26	5	10	7.96	1.455
Platform	26	3	10	7.77	1.583
Interests	27	2	10	7.22	2.136
Learning and Cognitive Style	27	2	10	7.19	2.403
Learner Qualifications	26	3	10	7.15	1.974
User Role	27	1	10	7.00	2.370
Motivation	27	1	10	6.96	2.682
Learner Preferences	27	1	10	6.26	2.474
Location	27	1	10	6.04	2.361
Background	27	1	10	5.30	2.367
Learner Personality	27	1	8	5.07	2.368
Experience in Hyperspace	26	1	10	5.00	2.561

Table 5. Specific features of adaptivity as rated by the interviewees (in descending order by mean ratings).

were hiding (`mean` = 5.22, `s.d.` = 2.55) and service provision (`mean` = 5.85, `s.d.` = 2.71). Hiding is less popular and desirable in comparison with other techniques within adaptive navigation support. The learner is deprived of information in this way, which was explicitly criticized by some interviewees.

4 Analysis and Conclusions

The views of our interviewees, comprising learners, teachers and others (researchers and developers) can be summarized as follows. They require an ALS that provides individualized teaching and learning. In particular, it should be capable of providing details of technical material that cannot be covered adequately in a class or lecture. They expect such a system to be efficient with respect to the learners, tutors and authors, by providing users with relevant learning material. Table 5 and Table 6 provide a 'most-wanted' list of specific features and dimensions of adaptivity as ordered by their mean ratings.

In addition, ALSs are considered particularly suited to well explored and structured content. However, this is only one part of what a learner needs to learn. They must also learn more abstract and complex competencies, *e.g.* social and relational skills, creative problem solving (where the 'correct' or 'best' solution is possibly unknown), independent critical thinking, etc. The interviewees propose some areas where an ALS can add value in the academic context: the acquisition of basic knowledge, the acquisition of technical details that are too cumbersome to cover in lectures and classes, adaptive testing of basic knowledge, and language skills. Many interviewees insist that learners should be made aware of the adaptation; they should be able to set adaptation parameters and always feel in control. There is also a potential conflict between a learner's preferred learning style and an optimal learning strategy. It appears to be a delicate trade-off between pleasing the learner and doing what's best for them from a pedagogical standpoint. The accompanying technical report draws some more subjective conclusions from specific remarks and suggestions made by the interviewees.

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	No.	Min.	Max.	Mean	S.D.
Learning Activity Selection	27	1	10	8.37	2.022
Content Selection	27	1	10	8.33	2.253
Additional Explanations	27	7	10	8.37	1.043
Prerequisite Explanations	27	1	10	8.19	1.981
Comparative Explanations	27	5	10	7.56	1.121
Explanation Variants	27	5	10	7.44	1.625
Sorting	27	1	10	7.26	2.177
Problem Solving Support	27	5	10	7.93	1.299
Intelligent Analysis of Solutions	27	5	10	7.74	1.631
Example-Based Problem Solving	27	3	10	7.67	1.687
Interactive Problem Solving Support	27	3	10	7.37	1.822
Assessment	27	1	10	7.89	2.082
Testing	27	3	10	8.22	1.625
Questions	27	1	10	6.52	2.376
Learner Model Matching	27	1	10	7.56	1.888
Collaboration Support	27	3	10	7.78	1.805
Intelligent Class Monitoring	27	6	10	7.70	0.953
Presentation	27	1	10	7.52	2.242
Multimedia Presentation	27	1	10	7.41	2.635
Text Presentation	27	1	10	6.81	1.882
Customization of the Interface	27	1	10	6.63	2.041
Navigation Support	27	1	10	7.33	2.760
Link Generation	27	1	10	7.56	2.225
Sorting	27	1	10	7.04	2.488
Link Annotation	27	1	10	7.00	2.000
Map Annotation	27	1	10	6.96	2.244
Direct Guidance	27	1	10	6.70	2.267
Hiding	27	1	10	5.22	2.547
Service Provision	27	1	10	5.85	2.713

Table 6. Specific dimensions of adaptivity as rated by the interviewees (in descending order by category mean ratings (bold terms) and then individual mean ratings).

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