

What Do Academic Users Want from an Adaptive Learning System?

Martin Harrigan
martin.harrigan@cs.tcd.ie
Department of Computer Science,
Trinity College Dublin,
Ireland

Miloš Kravčik
milos.kravcik@ou.nl
Open Universiteit Nederland,
The Netherlands

Christina Steiner
chr.steiner@uni-graz.at
Department of Psychology,
University of Graz,
Austria

Vincent Wade
vincent.wade@cs.tcd.ie
Department of Computer Science,
Trinity College Dublin,
Ireland

Abstract

The academic user base of an *Adaptive Learning System* (ALS) can be partitioned in two: the learners and the teachers (encompassing both content authors and tutors). Learners come from a diverse set of backgrounds with varying abilities and motivation and hence, have very individual learning requirements [2, 6, 7]. The time and effort they can devote to learning are finite. On the other hand, teachers can create and adapt learning material to individual learning requirements. However, the time and effort they can devote to teaching are also finite. An ALS, through the virtues of adaptivity [4, 5, 3], can reconcile this mismatch by delivering individualized educational experiences to the learners while making the best use of the time and effort invested by the teachers.

The first step in developing an ALS is requirements elicitation [9]. As part of this endeavor, it is instructive to interview the user base. Interviews help crystalize the expectations of learners and teachers with respect to an ALS. They may reveal requirements not previously envisaged as being key, requirements purported to be useful but are considered otherwise by the interviewees, and requirements from different partitions of the user base that are contradictory. Within the scope of the GRAPPLE Project¹, we have elicited requirements from learners and teachers across several European academic institutions through explorative, semi-structured interviews. In this report we describe the methodology we employed while preparing, conducting, and analyzing the interviews and we present our findings along with some objective and subjective analysis.

¹The GRAPPLE Project (Generic Responsive Adaptive Personalized Learning Environment) is an EU FP7 STREP project that aims to deliver a *technology-enhanced learning* (TEL) environment that guides learners through a learning experience, automatically adapting to personal preferences, prior knowledge, skills and competences, learning goals, and the personal or social context in which the learning takes place. This functionality will be provided as a set of adaptive learning services that will be integrated with existing Open Source and commercial *Learning Management Systems* (LMSs).

1 Introduction

The development of an *Adaptive Learning System* (ALS) is a challenging task [8, 16]. 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, in particular, when these requirements are for a hypothetical system that can apply to all domains. The GRAPPLE project aims at delivering a set of adaptive learning services that will be integrated with existing Open Source and commercial *Learning Management Systems* (LMSs). Generally, LMSs have weak or no adaptive functionality whereas the prototypical ALSs lack the non-adaptive functionality that are the mainstay of LMSs [10]. Therefore, adaptive learning services must inter-operate and interface with existing LMSs [1]. The GRAPPLE project aims to correct this by providing, amongst other things, adaptivity as a service to LMSs.

To ensure target-oriented work from the beginning of the project, the needs of users (learners and teachers) with respect to an ALS were collected and aggregated in a systematic form through interviews. The concept of adaptivity was illustrated during the interviews using a hypothetical scenario involving a learner, a teacher (author and tutor), and a fully-functional ALS. A semi-structured interview allowed the interviewees to evaluate the ALS's potential merits, short-comings and usefulness with respect to their individual needs.

Prototypical ALSs are often assessed through user evaluations after the system has been developed. 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 at the end of the project.

This report is organized as follows. Section 2 details the requirements elicitation methodology. We also present the hypothetical scenario from the point of view of a learner, author and tutor. Section 3 describes the interviews themselves. In particular, we discuss responses to the hypothetical scenario, 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 suggestions made by the interviewees. Finally, we conclude in Sect. 5.

2 The Requirements Elicitation Methodology

In this section we describe the requirements elicitation methodology used when interviewing the academic users. The interviewees were divided into three groups: learners, teachers, and others. The first group consisted of students, both undergraduate and postgraduate. The second group consisted of content authors, tutors, and lecturers who are responsible for the provision and teaching of courses. The last group consisted of researchers and developers who are interested in ALSs but do not use them for learning or teaching *per se*. We produced an *interview guide and protocol* and distributed it to all our interviewers to ensure consistency across different institutions. The interviews were documented in two forms: *interview summaries* (having a narrative character) and *interview data sheets* (for quantitative and statistical analysis). The interview questions were both quantitative (closed questions with a predefined

choice of answers) and qualitative (open-ended questions that try to gather information in an unbiased manner).

We performed *content analysis* using the interview summaries and data sheets to help reduce the large body of text and data into a condensed form with essential content [15]. There are two approaches: *quantitative content analysis* employs word frequencies to deduce a systematic, objective, and quantitative description of the communication content [13]; and *qualitative content analysis* analyzes the texts within their context of communication, following content analytic rules and step by step models, without rash quantification. We used a combination of both approaches to preserve their respective advantages [12], thus resulting in a systematic and replicable analysis that is guided by qualitative text interpretation in order to get an in-depth understanding of the ideas and views of persons on the one hand, and quantitative data on the other [14].

To handle the open-ended questions we built categories of answers using [12, 14]:

- *inductive category building* – the categories are formulated *a priori* and characterized by the relevant aspects of analysis; and
- *deductive category building* – the categories are formulated *a posteriori* in terms of the gathered material.

These categories are used in Sect. 3 when summarizing the responses to the open-ended questions.

2.1 The Hypothetical Scenario

Before conducting the interviews, a hypothetical scenario involving a learner, a tutor, a content author, and a fully-functional ALS was distributed to the interviewees. This scenario illustrated the typical and possible usage of an ALS. It provided the interviewees with a basic understanding of adaptivity. The interviewees were encouraged to estimate the relevance of each use case to their own personal context and work. The scenario is briefly described in the remainder of this section.

2.1.1 Learner

Our hypothetical learner studies at a university. Together with his tutor, the learner identifies his learning objectives. Being aware of his competences and preferences, the tutor can identify a suitable learning plan for him, which is then delivered to him via the *Personalized Learning Environment* (PLE). Based on the learner's prior knowledge and the prerequisites for the selected plan, the PLE retrieves a pre-assessment for the learner to identify his knowledge gap more precisely. The PLE uses the learner's profile (including his knowledge level, skills, and preferences), pre-assessment results, and the chosen learning plan to retrieve and deliver relevant units of learning. The delivery of the content (including its selection, ordering, presentation, navigation support, choice of co-learners, method of interaction, recommendation of additional resources, etc.) is adapted to the learner's profile as well as to the current context. If the learner is following an online lecture on his desktop computer and must leave for some other appointment, he can continue to access the material via a mobile device. The material automatically adapts to the new platform. When the learner completes a unit of learning, the

PLE delivers a post-assessment. The PLE grades the learner's post-assessment and delivers the results to the learner and the tutor. If needed, the tutor can prepare a new learning plan for the learner to fill in the remaining knowledge gaps. Otherwise, both learner and tutor can set new learning objectives and follow the procedure anew.

2.1.2 Tutor

Our hypothetical tutor teaches at a university and the learner above is one of his students. Taking into account the abilities and interests of the learner, the tutor can recommend an appropriate learning plan to achieve the learner's objectives. The tutor supports his learners through supervision and guidance. His tasks include answering learners' questions, assessment of learners' contributions, monitoring and assessment of their progress, and group support. To facilitate communication with learners he uses a *Personalized Tutoring Environment* (PTE), providing him with visualizations of the learning processes and progress in order to examine social, cognitive, and behavioral aspects of learners, together with required functionality – monitoring, assessment, and learner feedback. The tutor does not have to respond to each learner question individually, as many peers with the relevant knowledge can provide answers. He intervenes only when necessary, *e.g.* no answer comes in a certain time limit or the discussion takes a wrong direction. The tutor can choose which characteristics of the learning process are relevant and his preferred means of visualization. He can set up a notification mechanism to be informed of relevant events, *e.g.* when someone has problems and needs help. If a learner finds the recommended learning plan too difficult to follow, the tutor can recognize the problem and recommend a more appropriate alternative. He may also notify the authors of problematic learning resources and learning plans.

2.1.3 Author

Our hypothetical author creates the learning resources and learning plans, *i.e.* structured learning activities referring to learning resources, for university courses. His colleagues teaching similar courses can share their plans or parts of them. He develops learning plans that can be adapted and personalized to individual learners. He composes adaptive courses using fragments of text, drawings, photos, animations, audio clips, and videos. The author can find this material through repositories or create them for himself. He uses a *Personalized Authoring Environment* (PAE), which is based on learning standards, to compose the adaptive course and enable re-usability of resources, course structure, and adaptation. The efficiency and efficacy of the authoring environment depends heavily on re-usability and interoperability. It must be possible to apply alternative pedagogical strategies over the same learning resources, *e.g.* for beginners and advanced learners, for deep study as well as quick repetition. To enable interoperability between ALSs there needs to be a clear specification of the pedagogical role of each component, and how the components relate to each other, *e.g.* prerequisite or alternative relationships. This specification should describe how the delivery of the learning experience can be adapted to the needs of individual learners, *e.g.* if a learner has high inductive reasoning then show concrete examples before conceptual material; if a learner has high social skills then offer her synchronous interaction with her peers). To create an adaptive course, various types of knowledge are required, *e.g.* domain knowledge, pedagogy, learner attributes, context, etc. Ideally the author can distinguish various types of knowledge and represent them separately as

	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.

	Frequency	Percent
Learner	8	29.6
Teacher	17	63.0
Other	2	7.4
Total	27	100.0

Table 2: Frequency of interviews per user group.

conceptual entities with explicit semantics. However, the author does not have to create all of them. He can re-use existing components available in shared repositories. If these components do not fit exactly, he can adjust them accordingly. To make the authoring process easier and more intuitive, the PAE provides automatic help and templates for specification of components, their attributes and relationships. The PAE also supports collaborative authoring, providing suitable communication and versioning support.

3 The Interviews

In this section we step through and explain the interview questions and summarize the results. There were 27 interviews in total (see Table 1 and Table 2), conducted across seven European institutions in June 2008. The learners were undergraduate and postgraduate students from various fields. The teachers were lecturers and tutors. The two remaining interviewees were researchers and developers in the field of learning systems. In the following sections, we analyze some of the answers by user group, *i.e.* learner, teacher or other, where appropriate.

The limited sample size requires that any conclusions derived from the results to be treated with care. We cannot overly generalize our results. However, there are reasons for the chosen sample size, which are predominantly due to the data collection instrument and the involved effort. Semi-structured interviews were found to be the most appropriate instrument. They were conducted in a distributed manner by different interviewers and allowed for an explorative data gathering process. Individual face-to-face conversations ensured that the interviewees understood the concept of adaptivity. However, they were quite laborious and time-consuming.

Many interviews required between one and two hours. The content analysis of open-ended answers also constituted a work-intensive process. Given these predictably high demands in carrying out the interviews (compared to other modes of data collection), a limited number of interviews was planned and realized. By distributing the interviews over different institutions, data from a broad range of users with varying backgrounds could be gathered, thereby providing some valuable insight into the general population.

3.1 Response to the Hypothetical Scenario

As detailed in Sect. 2.1, all interviewees were asked to read through a hypothetical scenario relating to ALSs prior to the interview and to rate its relevance to their personal context and work. Interviewees generally found the hypothetical scenario a useful introduction to adaptivity and also, during the interview, it was helpful when describing certain concepts of adaptivity. We briefly mention some of the interesting comments made by the three user groups with respect to the hypothetical scenario.

Unsurprisingly, the learners could relate best with the learner role. However, many found the other use cases more difficult to understand; in particular the differentiation between the tutoring and authoring roles: ‘the other scenarios were more difficult to understand, especially without a lot of background information on adaptivity and online learning applications’. One learner also pointed out that the tutor has to sufficiently understand the learner’s learning objectives in order to elaborate a suitable learning plan and he felt that they did not have the time and resources to do this properly. Other learners confirmed this viewpoint by saying that ‘authoring is a demanding task that should be done by a team’ and that ‘there is no such thing at university as individualized support’.

Teachers, in general, were more familiar with all three roles and could relate to the tutoring and authoring roles. In particular, only one teacher reported any problem in differentiating between tutors and authors. The teachers, like the learners, appreciated the difficulty in authoring an adaptive course: ‘the authoring use case does not say anything about the complexity of the process if adaptive learning is the aim’ and ‘the scenarios pre-suppose many resources in time and workforce’. One teacher cited the lack of a formal definition language for defining learning objectives as a limiting factor. Another would have liked to have seen a list of problems that have been solved and problems that remain with respect to ALSs.

The interviewees, who were neither learners nor teachers, but researchers and developers in the area of learning systems, naturally understood the scenario. One also pointed out that the three roles overlap to some degree and that this should be a factor when designing the system.

3.2 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 (see Table 3 for details). All of the teachers had experience with learning systems. Only two learners indicated that they had no experience. Questions A2-A6 were

	Yes	No
Learner	6	2
Teacher	17	0
Other	2	0
Total	25	2

Table 3: Usage of learning systems per user group.

In-House	13
Moodle	12
Blackboard	9
Sakai	3
WebCT	3
AHA!	1
ALEKS	1
BBC Course Example System	1
Dokeos	1
Educativa	1
Ilias	1

Table 4: The learning systems used by interviewees (in descending order by use).

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 4). 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 with a range from 0 to 5). 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.

A3. How often do you use a learning system? This question was initially open-ended but after the interview the answers were categorized as either daily, once to several times a week, once to several times a month, once to several times a year or hardly ever. Table 5 summarizes the results. Most teachers used learning systems daily or once to several times a week, whereas learners used them less frequently.

	Learner	Teacher	Other	Total
Daily	0	8	0	8
Once to several times a week	2	6	2	10
Once to several times a month	3	0	0	3
Once to several times a year	1	2	0	3
Hardly ever	0	1	0	1
Total	6	17	2	25

Table 5: Regularity of usage of learning systems per user group.

	Learner	Teacher	Other	Total
For years	1	13	2	16
For about 1 year	2	3	0	5
For months	3	1	0	4
Total	6	17	2	25

Table 6: Duration of usage of learning systems per user group.

A4. How long have you been using learning systems? Another indication of a user’s experience with learning systems is the duration for which they have used them. Teachers appear to have long-term experience in using learning systems, while learners have been using them more recently (see Table 6 for more details). To summarize the results of the previous four questions, the interviewed teachers are in general more experienced than the learners with respect to the use of learning systems.

A5. Do the learning systems you have used so far provide any features of adaptation to users? This question investigates the provision of adaptivity in existing learning systems. The results (Table 7) show that the majority of learning systems have no adaptive features. The weak support of adaptation by Open Source and commercial LMSs has been confirmed in the literature [10].

	Learner	Teacher	Other	Total
No	4	10	1	15
Yes	2	7	1	10
Does not apply	2	0	0	2
Total	8	17	2	27

Table 7: The presence of adaptation features in learning systems as used by each user group.

Adaptive Navigation	5
Adaptive Content	3
Personalization	3
Personalized Reminders	2
Adaptive Annotation	1
Adaptive Presentation	1
Community Personalization	1
Multi-lingual	1
Personalized Work-spaces	1
Personalized Feedback	1
Prerequisites	1
Progress Indicators	1
Resource Assignment	1
Adapted Interface	1

Table 8: The adaptation features used by interviewees in learning systems (in descending order by the number of interviewees who said so).

A6. If yes to the previous question, which adaptation features do they provide? In an open-ended question, we asked the interviewees to list the adaptation features (if any) that are present in their learning systems. Table 8 lists these features in descending order by the number of interviewees who said so. Interviewees mentioned adaptive navigation (adaptation at the link-level), adaptive content and personalization most often.

A7. For what purposes or tasks are you using (or would you use) a learning system? The answers to this open-ended question were again grouped to produce categories in Table 9. Peer support and collaboration, distribution and the material organization of a course were deemed the most important by the interviewees.

A8. What are the benefits of using a learning system? In a similar vein to question A7, the interviewees were asked to list the benefits of using a learning system. These answers would presumably reflect the actual reasons they use a learning system and, from the answers, this proved to be the case. Table 10 summarizes the results; communication, a centralized source of material and the re-usability of learning materials were mentioned most often. These reflect the top three answers of the previous question.

3.3 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? This open-ended question was the ‘adaptive analog’ of question A7. Table 11 summarizes the results. The top two answers were individualized teaching and guided, individ-

Peer Support and Collaboration	8
Distribution	6
Material Organization of Course	6
Introduction of New Material	5
Supervision and Monitoring	5
Blended Learning	3
Teacher-Learner Communication	3
Assessment and Testing	3
Calendrical Organization of Course	2
Individual Study	2
Interactivity	2
As a Supporting Tool	2
Distance Learning	1
Resource Provision	1

Table 9: The purposes for which learning systems are used (in descending order by the number of interviewees who said so).

Communication (including feedback)	9
Centralized Source of Material	8
Re-Usability of Learning Materials	6
Efficiency	5
Tracking and Progress Monitoring	5
Collaboration	4
Distribution	4
Course Overview	3
Distance Teaching and Learning	3
Persistence (<i>e.g.</i> instead of email)	3
Assessment and Testing	3
Calendrical Organization of Course	2
Synchronous and Asynchronous Teaching	2
Provision of Multimedia	1

Table 10: The benefits of learning systems (in descending order by the number of interviewees who said so).

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
Assessment and Testing	1
Basic Training	1
Calendrical Details (<i>e.g.</i> personalized deadlines)	1
Collaborative Group Formation and Guidance	1
Fast-Changing Domains	1
Formal Education	1
Consideration of Previous Performance	1
Producing Automated Summaries and Overviews	1
Recommendation Systems	1
Structured Exercises	1
Flexible Time-Constraints on the Learner	1

Table 11: The purposes or tasks for which ALSs are especially suited (in descending order by the number of interviewees who said so).

ualized learning. These can be considered the same, but from opposing viewpoints, *i.e.* the teachers’ and learners’. The provision of detailed technical material that is too cumbersome to present in a lecture or class, for example the details of the more obscure libraries and functions of a programming language, also featured quite prominently.

B2. What are the benefits of using an ALS? Do you think adaptivity in a learning system brings added value to the user? The adaptive analog to question A8 asked the interviewees to list the benefits of using an ALS. The results, summarized in Table 12 are quite different to those for question A8. The somewhat user-agnostic benefits of non-adaptive learning systems, *e.g.* communication, a centralized source of material and the re-usability of learning materials, etc., are replaced by more user-centric benefits, *e.g.* efficiency with respect to the learner, tutor and author, user specific benefits, relevant learning material, etc.

3.3.1 Specific Features of Adaptivity

The following two sections deal with the specific features of adaptivity (what we can adapt to) and the specific dimensions of adaptivity (what we can adapt). In both cases, we first asked the interviewees to list what an ALS could adapt to and what it could adapt in an open-ended question. In follow-up questions we provided them with a comprehensive list of features and dimensions as found in the adaptive hypermedia literature [4, 5, 3, 11] and asked them to rate each feature or dimension with a score of 1 to 10 (1 being unimportant and 10 being very important). In the course of these questions we referred to the hypothetical scenario on many

Efficiency	11
User Specificity	9
Relevant Learning Material	4
Personalization	3
Re-Usability	3
Learner Motivation	3
Avoids Information and Cognitive Overload	2
Automation	1
Flexibility	1
Monitoring	1
Temporal and Spatial Relevance	1

Table 12: The benefits of ALSs (in descending order by the number of interviewees who said so).

occasions to help explain the features and dimensions to those unfamiliar with adaptivity.

B3. To which characteristics of the user or environment would you expect an ALS to adapt to? Table 13 summarizes the results. Prior knowledge, learning styles, preferences and learning goals were mentioned most often. We analyzed these results using a frequency distribution over the three user groups for the most prominent categories ($\text{mean} \geq 7$) (see Table 14, Table 15, Table 16 and Table 17). The important features remained the same when broken down by user group. The only slight discrepancy was with preferences; teachers tended to mention this feature more often than learners when compared with the three groups as a whole. Some answers near the bottom of the list are not strictly adaptive features but we include them here for completeness.

B4. I will now 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 were learner goals and tasks, learner knowledge, learner qualifications, background, experience in the hyperspace (experience with the ALS), learner preferences (*e.g.* through options or preferences menus [?]), learning and cognitive style (*e.g.* visual, auditory, kinesthetic, inductive, deductive), learner personality, interests, motivation, language, user role, platform, and location. Table 18 summarizes the results. 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 ($\text{mean} = 8.85$, $\text{s.d.} = 1.19$) and adaptation to learning goals and tasks ($\text{mean} = 8.7$, $\text{s.d.} = 1.82$). The judgment of learner knowledge is highly correlated with learning goals and tasks ($r = 0.606$, $p = 0.001$). The least importantly judged aspects, although still characterized by a mean importance of about 5, were background ($\text{mean} = 5.3$, $\text{s.d.} = 2.37$), learner personality ($\text{mean} = 5.07$, $\text{s.d.} = 2.37$), and experience in the hyperspace ($\text{mean} = 5.0$, $\text{s.d.} = 2.56$). A statistical analysis was carried

Prior Knowledge	19
Learning Style	14
Preferences	9
Learning Goals	7
Ability	5
Platform	5
Interests	4
Background	3
Learning Speed and Time Available	3
Locale	3
Group Learning Goals	2
Age	1
Gender	1
Group Achievement Level	1
Group Activity Level	1
Group Reputation	1
Experience with the System	1
Modality	1
Quality of Service	1
Reputation within Group	1

Table 13: The characteristics of a user or environment to which an ALS could adapt to (in descending order by the number of interviewees who said so).

	Learner	Teacher	Other	Total
Not Listed	2	5	1	8
Listed	6	12	1	19
Total	8	17	2	27

Table 14: Prior knowledge by user group.

	Learner	Teacher	Other	Total
Not Listed	3	8	2	13
Listed	5	9	0	14
Total	8	17	2	27

Table 15: Learning styles by user group.

	Learner	Teacher	Other	Total
Not Listed	6	11	1	18
Listed	2	6	1	9
Total	8	17	2	27

Table 16: Preferences by user group.

	Learner	Teacher	Other	Total
Not Listed	6	13	1	20
Listed	2	4	1	7
Total	8	17	2	27

Table 17: Learning goals by user group.

out in order to investigate whether there are significant differences in the importance ratings between the two main user groups (learners and teachers). Only for the adaptation criterion ‘platform’ a significant difference could be found, with learners judging the importance of this criterion higher ($\text{mean} = 8.75$, $\text{s.d.} = 0.37$) than teachers ($\text{mean} = 7.31$, $\text{s.d.} = 0.41$).

The adaptation criteria ‘learner (or prior) knowledge’ and ‘learning goals and tasks’ emerged from both questions (open question and importance rating) as the most prominent and important adaptation criteria. However, when analyzing the most frequent answer categories of adaptation criteria (question B3) and their correlations with the corresponding importance ratings of the respective criterion (question B4), a significant correlation could only be found for learner knowledge and learning style ($r = 0.545$, $p = 0.003$). This suggests that interviewees who named certain categories of adaptation criteria in question B3 did not necessarily judge them as highly important in the subsequent importance rating. This may be due to the fact, that imagining such criteria in an open-ended question was found difficult by interviewees and when confronted with the importance ratings they became aware of further criteria that they considered were even more important than those previously indicated.

3.3.2 Specific Dimensions of Adaptivity

We now proceed to the specific dimensions of adaptivity (what we can adapt). As with the specific features of adaptivity, we first asked the interviewees to list what an ALS could adapt in an open-ended question. We then provided them with a comprehensive list of dimensions as found in the adaptive hypermedia literature [4, 5, 3, 11] and asked them to rate each dimension with a score of 1 to 10 (1 being unimportant and 10 being very important).

B5. What should be adapted in an ALS and how should it be adapted? Table 19 summarizes the results. Structure of content, adaptive navigation (adaptation at the link-level) and adaptive presentation were mentioned most often. We analyzed these results by using a frequency distribution over the three user groups for the most prominent categories ($\text{mean} \geq 10$) (see Table 20, Table 21 and Table 22). It is evident, from each of the previous

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

three tables, that the teachers were mainly responsible for putting the structure of content, adaptive navigation and adaptive presentation at the top of Table 19. Perhaps, the teachers were more aware than learners of the details involved in authoring and were better able to enumerate what needs to be adapted.

B6. I will now 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 included content selection (additional explanations, prerequisite explanations, comparative explanations, explanation variants, sorting), presentation (text presentation, multimedia presentation, customization of the interface), learning activity selection, navigation support (direct guidance, sorting, hiding, link annotation, map annotation, link generation and resource recommendation, problem solving support (intelligent analysis of learner solutions, interactive problem solving support, example-based problem solving), assessment (testing and questions), service provision, and learner model matching (collaborative support, intelligent class monitoring). Table 23 summarizes the results. 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 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, learning activity selection (**mean = 8.37, s.d. = 2.02**) and adaptive testing (**mean = 8.22, s.d. = 1.63**) were considered very important. The dimensions judged to be least important, but still featuring a medium mean importance score, 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

Structure of Content	17
Navigation	11
Presentation	10
Agenda	3
Recommended Content	3
Activities	2
Exercises	2
Interface	2
Teaching and Learning Strategy	2
Feedback	1

Table 19: The dimensions that an ALS could adapt (in descending order by the number of interviewees who said so).

	Learner	Teacher	Other	Total
Not Listed	4	6	0	10
Listed	4	11	2	17
Total	8	17	2	27

Table 20: Structure of content by user group.

	Learner	Teacher	Other	Total
Not Listed	7	8	1	16
Listed	1	9	1	11
Total	8	17	2	27

Table 21: Adaptive navigation by user group.

	Learner	Teacher	Other	Total
Not Listed	6	10	1	17
Listed	2	7	1	10
Total	8	17	2	27

Table 22: Adaptive presentation by user group.

other techniques within adaptive navigation support. The learner is deprived of information in this way, which was explicitly criticized by some interviewees. A statistical group comparison of the judgments between learners and teachers yielded no significant differences in the importance ratings.

The adaptive selection and structuring of content and activities were the most prominent and important dimension of adaptation. However, when investigating the correlations between the dimensions commonly indicated by interviewees in question B5 and the importance ratings of the corresponding dimensions in question B6, a significant correlation could only be found for structure of content and content selection (which are arguably one and the same). This means, that, in general, there is no significant relation between the indication of a certain dimension of adaptation and the respective importance rating, which might stem from difficulties in freely listing dimensions (in question B5) and then being confronted with a prescribed list in question B6.

3.4 Final Questions

The interview closed with two open-ended questions.

B7. What functionality is essential for an ALS to be useful to you? In what way should it be presented to the user? Table 24 summarizes the results. There are two parts to this question. The first asks for the essential functionalities. The functionalities listed most often were authoring advice, automated evaluation of user's characteristics, automated feedback, individualized adaptation and peer-to-peer communication and collaboration. Authoring advice and authoring functionality in particular, appear to be especially important to address the concerns raised by many of the interviewees in response to the hypothetical scenario with regards to the difficulty and complexity of authoring an adaptive course (see Sect. 3.1). The second part of the question asks whether the adaptation process should be transparent or invisible to the user. An overwhelming majority indicated that this process should be transparent so that the user can 'scrutinize' the adaptation and feel in control. Further analysis by user group showed that the requirements for authoring advice and transparent adaptation were stated mainly by teachers and others (non-learners) (see Table 25 and Table 26 for details).

B8. What other application areas of ALSs can you imagine? The last question of the interview asked the interviewees to list other application areas of ALSs outside of higher education. The results (summarized in Table 27) list staff training and a system that handles learning difficulties or disabilities at the top of the table. However, all of these application areas are interesting in and of themselves (*e.g.* recruitment systems that adapt to your qualifications and prior work experience and a system for learning networks of people that can adapt to your present network of friends/colleagues) regardless of how many interviewees mentioned them.

4 Analysis

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

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

Transparent Adaptation Process	7
Authoring Advice	6
Automated Evaluation of User's Characteristics	3
Automated Feedback	3
Individualized Adaptation	3
Peer-to-Peer Communication and Collaboration	3
Authoring Functionality	2
Help System	2
Recommendation System	2
Remote-Access	2
Support Learners	2
Templates	2
Accessible to All Types of Users	1
Annotation of Material	1
Automated Grading	1
Content Management	1
Localization	1
'Profit exceeds Effort'	1
Reduction of Cognitive Load	1
Standards-Compliant	1

Table 24: Essential functionalities of an ALS (in descending order by the number of interviewees who said so).

	Learner	Teacher	Other	Total
Not Listed	8	12	0	20
Listed	0	5	2	7
Total	8	17	2	27

Table 25: Transparent adaptation process by user group.

	Learner	Teacher	Other	Total
Not Listed	8	12	1	21
Listed	0	5	1	6
Total	8	17	2	27

Table 26: Authoring advice by user group.

Staff Training	9
Learning Difficulties or Disabilities	3
Distance Learning	2
Knowledge Management	2
User Manuals	2
Adaptive Testing	1
Decision Support Systems	1
Delivery of Multimedia Content	1
Digital Newspapers	1
Games	1
Interactive Lessons	1
Learning Networks (of People)	1
Life-Long Learning	1
Practice Sessions	1
Provision of Technical Detail	1
Recommendation Systems	1
Recruitment Systems	1
Reference Systems	1
Simulations	1
User-Driven Systems	1

Table 27: Application areas for ALSs outside of higher education (in descending order by the number of interviewees who said so).

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 18 and Table 23 provide a ‘most-wanted’ list of specific features and dimensions of adaptivity as ordered by their mean ratings. The most prominent features of adaptivity ($\text{mean} \geq 7$) in descending order as rated by the interviewees include adaptation to learner knowledge, learning goals and tasks, language, platform, interests, learning and cognitive style, learner qualifications, and user role. On the other hand, the most prominent dimensions of adaptivity ($\text{mean} \geq 7.5$) in descending order as rated by the interviewees include learning activity selection, content selection (especially additional explanations, prerequisite explanations and comparative explanations), problem solving support (especially intelligent analysis of solutions and example-based problem solving), learner model matching (especially adaptive collaboration support and intelligent class monitoring), and presentation. The cut-off mean values we chose are arbitrary and the list of features and dimensions of adaptivity to be implemented in a system can be contracted or expanded as resources and time afford. However, their mean ratings can be seen to prioritize their need.

We also remark on some of the main responses to the hypothetical scenario (see Sect. 3.1). Both learners and teachers appreciated the complexity of and difficulty in authoring an adaptive course. However, ‘this environment has to be very easy to use so that the teacher can do it without the intervention of specialists’. An ALS requires appropriate authoring tools with as much authoring advice and support as possible. This was again reflected in the ‘essential functionalities’ question (B7) of the interview.

Through discussions with the users, two central ideas were raised, namely, the added value of ALSs in higher education and the need for transparent adaptation. Higher education aims to create responsible learners with independent critical thinking abilities. In their academic studies, they need to be responsible for their own learning and training. They need to identify what they need to learn and to choose the best path for doing so. In some respects, this is a contradiction to the goals of ALSs. Learners are supposed to learn to learn. The creation of adaptive learning content is time and work intensive. These requirements can be difficult to fulfill in the context of higher education when the number of teachers is finite and the provision of resources is scarce.

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.

We can draw some more subjective conclusions from specific remarks and suggestions

made by the interviewees. Several interviewees² considered distance learning to be a great beneficiary of an ALS. In this context all forms of face-to-face contact are absent, and so it is crucial that the learning content and its presentation are personalized to some degree. This can, in some way, make up for the ‘human absence’.

Many considered the visualization of the various stages of learning and how they are adapted an interesting prospect³. One learner raised the question as to how he or she can know ‘if they haven’t missed anything important?’ Learners need a visual map of where they are and where they are going with important milestones clearly marked. The teachers and tutors also require visualization of the learners’ progress and the structure of the course as it currently stands.

An ALS should aim to motivate its users. For example, for some subjects that are traditionally considered ‘boring’, the material should be presented in such a way that encourages and stimulates⁴ the learners. It should do this by appealing to their interests as specified in their user profiles, and adapt the content (*e.g.* specific examples) to these interests where possible. The teachers must also be motivated and encouraged to use the system. The benefits must clearly out-weigh the simple course web page and the non-adaptive LMS⁵. The typical teacher who ‘uses the **Blackboard** learning system for logistics, **FrontPage** for authoring, wiki-software, and a blog’ must see the benefits of an ALS to consider it worth switching. The teacher must first adopt the system and find it useful before the learners can. For this to work, the authoring tools must provide simple introductory documentation and perhaps wizards, templates, and guides to get them started quickly. It must be possible for teachers to use and understand only part of the system in order to derive benefit from it. This will allow them to become gradually proficient in its workings.

In order for an ALS to be ‘teacher-friendly’ it must cater for both the bureaucracy and diversity that can prevail in some environments⁶. For example, courses designed by a teacher may have to follow strict curricula that are laid down by the university. The authoring tools should cater for this requirement. Also, it is very important that teachers can import this information from other systems. If the university changes from system to system or if the teacher changes workplace, their previous work should not be lost.

Some observant interviewees pointed out the difference between ‘global’ and ‘local’ adaptivity⁷ and the need for some formality. For example, content may be adapted locally depending on the learner’s current knowledge, but also globally depending on the learner’s learning style. It is a difficult and delicate task to correctly balance these different types of adaptation so that the output is neither pathological nor ‘overly adapted’. In places, a formal definition language of sorts may be needed to avoid ambiguity – although only advanced users may require this. The user interfaces, especially the authoring tools, may need both simple and advanced versions, themselves adaptable to the expertise of the author.

Reusable adaptive components⁸, like a grammar checker that adapts to a learner’s previous mistakes (what grammatical structures does this user repeatedly misuse?), a task manager

²82291, 00321, 57016, 58018, 07011

³81023, 74031, 64002

⁴82002, 57016, 84001, 82004

⁵60063, 58018, 73072

⁶06210, 77132, 80037

⁷79017, 64044

⁸74031, 08212, 64002, 67031

that adapts to a learners present workload and schedule and an adaptive recommendation component⁹, were deemed useful by the interviewees. It may be desirable to have an adaptive learning component employ some well-known metaphors, *e.g.* the book paradigm when organizing learning content¹⁰.

The user profile need not be a black box (*e.g.* the permanent record of a ‘school’) used only by an ALS; it can be viewed in a more positive light as a learner’s portfolio¹¹. The learner should always be able to inspect its contents to some degree. The system should be able to point out weakness between what a learner thinks he or she knows (perhaps through voluntary questionnaires) and what they appear to know from tests and exercises. It can help them identify their strengths and weaknesses. It could also point out discrepancies (if any) between an optimal learning path and a preferred learning path as indicated by the learner. To a lesser degree, it may be used to match learners with their peers who are strong in areas they are weak in and vice versa.

5 Conclusions

The foregoing interviews and their analysis form a basis for the construction of a complete set of requirements for an ALS. This appears to be the first study where the requirements for an ALS as viewed by the intended users (learners, tutors and authors) were gathered before any development work commenced. It is suggested that one indicator of the efficacy of an ALS is its provision of the ‘most-wanted’ features and dimensions of adaptivity as specified by the interviewees. Many more ‘subjective’ suggestions, as raised by individual interviewees, were presented.

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⁹80037, 82291, 58018

¹⁰00623

¹¹64042, 80037, 84001, 64002, 81023, 82004

A Interview Summaries

A.1 Learner Profile

A.1.1 Interview Code 80037

The interview with the interviewee 80037 was conducted on 3rd June 2008 in Dublin, Ireland. The interviewee was a final year undergraduate student and undertook a final year project in the area of AH. The scenarios were very familiar to him. He was already familiar with the concept of adaptivity in LMSs. The interviewee had experience with in-house e-Learning software. Furthermore, he had developed his own adaptive music recommendation system using techniques from AH. He saw the main benefits of using an adaptive LMS as being the possibility of personalized learning goals and adaptation to user preferences and locale.

An adaptive LMS for the interviewee appears especially suited to the diverse environment within a university. He would like an ALS to adapt to prior knowledge, learning goals, locale, modality, learning styles and preferences of a user. The learner should be able to indicate his/her characteristics through filling out some kind of questionnaire and by automatic system observation of the user. The system should provide an overall view of what the learner needs to do to complete a course satisfactorily. Adaptive dimensions that are judged the most important are adaptive presentation, navigation, and the structuring of content. The features that the interviewee would expect from a learning system are the provision of relevant feedback and the possibility of indicating preferences and prior knowledge/abilities. The user should always be aware of adaptation, both implicit and explicit. Application areas include intelligent recommendation systems and the delivery of multimedia content, *e.g.* for short or long biographies depending on the device.

A.1.2 Interview Code 82291

The interview with the interviewee 82291 was conducted on 14th June 2008 in Coventry, England. The interviewee is a PhD candidate in the field of computer science. The scenarios were understandable to him. The demonstration of the AHA! system was helpful to provide the interviewee with an idea of what an adaptive system is. The interviewee had some experience with e-Learning software such as Sakai. Furthermore, he had been using Sakai at university in the context of a lecture, using communication tools between learners and between learners and teacher. The main benefit of using a learning system, he sees, is the possibility for distance learning. An ALS for the interviewee appears especially suited for ‘recommendation systems’. Adaptation should be based on collaboration and users activities. He thinks the recommendation of content should be adapted. The essential functionality of an ALS is the provision of related materials via recommendation systems. He thinks other application areas of ALSs are ‘systems that are triggered by the users rather than predefined assumption’.

A.1.3 Interview Code 08212

Interviewee 08212 was a female Masters student in the field of computer science. She was of African origin, which was clearly reflected in some of her answers during the interview. English was not her native language. Nonetheless, the interview was conducted in English.

The interviewee had no prior knowledge on the topic of adaptivity. However, she was well prepared. In advance of the interview, she had read all the scenarios and she also extensively

tested an example BBC language course. In terms of the scenarios, she obviously found that the learner scenario was most relevant for her being a student. The other scenarios were more difficult to understand, especially without a lot of background information on the adaptivity and online learning applications. The example course was the most useful for her to understand the actual concept of adaptivity and the idea of making adaptive applications. Although, she did not know anything about all the different characteristics on which adaptation can happen, she could already deduce some of them (and also their intention) by just going through the hypothetical scenario.

The only online learning environment with which the interviewee was familiar was Point-Carre. This was an in-house system developed at VUB. PointCarre is based on an open source system called *Dokeos*. In the computer science department of VUB, it is not trivial to use these kinds of systems so most teachers do not use it at all or have their own personal wiki system. However, some teachers do use it but then only for uploading course documents. The interviewee did see some benefits in using the system, especially with regards to planning. It is believed that students nowadays are poor planners and have many difficulties meeting their project deadlines. If the calendar and the mailing service are effective, it would help the students in this task. For example, all the deadlines for assignments could be integrated in the calendar and personalized for each learner. Alerts could then be sent out in time to remind them of the upcoming deadlines.

The interviewees' cultural differences resulted in some criteria being more important, *e.g.* the platform and location. In her country, it is not common to have computers with high bandwidth and large fully interactive web applications are much more difficult to use. Adaptation to learning and cognitive style was deemed to be of very low importance since she already noted that it is almost impossible for people to take the time to create all this material. In contrast, she did find that having adaptive multimedia or other modalities is very important since learners like pictures and videos more than just ordinary text.

A.1.4 Interview Code 82002

This interview was done at the University of Lugano, Switzerland, at the end of course term. The interviewee was a very capable student. In his opinion, the main weaknesses of the hypothetical scenario were that the tutor has to understand the learner's learning objectives and has to elaborate a suitable learning plan. The time needed to understand the learning objectives may be too much and, sometimes, even impossible. He thinks that an adaptive system could be an improvement over traditional e-Learning tools, but that is not comparable with the face-to-face experience. He feels that adaptive systems are useful to study and review materials but ineffective in the whole learning process. He used *Moodle* for two years, more or less once a week; to find information, download materials, communicate with peers, use discussion forums, etc. The main advantage was time saving, with the possibility of finding relevant information easily. He thinks that adaptive systems are more useful for artistic fields and language learning. The main adaptation criteria could be the goals and tasks of the user, the learner's abilities and speed in acquiring new knowledge, the cognitive style and the native language or the level of foreign language that the learner has. The adaptation layer can be at the content level in an automatic way and at the presentation level under the explicit influence of the user. He thinks that the dimensions can be the prerequisite explanations, the selection of different media and the adaptive selection of learning activities. Further interesting dimen-

sions include the adaptive sorting and annotation of links, and personalized problem solving support. Key features that are necessary in such systems are problem solving support, the availability of a communication channel with peers, smart feedback and evaluation, together with a differentiated management of content at a medium level. Some other domains of applicability of an ALS are, lessons that require a large amount of experimentation, for example through simulations, and where the right level of stimulus is needed, in respect of motivation.

A.1.5 Interview Code 82004

The interview with the interviewee 82004 was conducted on 3rd June 2008 in Graz, Austria. The interviewee is a student of psychology (14th term). The scenarios were in general understandable to her, except the author scenario was not completely clear. The demonstration of the **AHA!** system was helpful to provide the interviewee with an idea of what an adaptive system is. The interviewee has experience with e-Learning software for typewriting and vocabulary. Furthermore, she had been using **WebCT** at university in the context of a lecture, where communication among learners and with the lecturer was done and homework documents were submitted using this system. Even a written exam was carried out using this system. The main benefit of using a learning system she saw is the possibility for synchronous and asynchronous communication and documentation. An ALS for the interviewee appears especially suited for learning languages and other basic knowledge, but also when doing studies of medicine. She thinks that traditional courses are boring, as the learner might be presented with contents the learner already knows, which might increase the rate of drop-outs. In the case of an adaptive system, though, the learner can be provided with contents that she is ready to learn. Consequently, the learning system should adapt to the prior knowledge, learning goals, and preferences of the learner. Adaptation should be done in a way that the learner could first indicate his/her characteristics through filling out some kind of questionnaire. The system should subsequently track learner characteristics and make the learner aware of inconsistencies (between profile information indicated in the questionnaire and tracked during system use). Furthermore, the comparison with other learners should be possible. Dimensions that were judged the most important were adaptive content selection, adaptive navigation and problem solving support, adaptive assessment and adaptive service provision. Essential features that the interviewee would expect from a learning system are the provision of feedback and the possibility of indicating preferences and prior knowledge/abilities, and adaptation according to this information. Application areas she sees are pre-university and university education, particularly for languages, vocabulary learning and mathematics.

A.1.6 Interview Code 84002

The interview with the interviewee 84002 was conducted on 3rd June 2008 in Graz, Austria. The interviewee is a student of psychology. The learner scenario was comprehensible to the interviewee; the other scenarios she deemed less relevant for her and therefore harder to understand. The demonstration of the **AHA!** system provided further insight into the notion of adaptivity. The interviewee has regularly used the **WebCT** system in the context of a university lecture. The benefits of using learning systems, she saw, included time saving for the lecturer, and the possibility of keeping a good overview of the lecture and communication therein. An ALS, she thought, was especially useful for learning clearly defined knowledge domains, but

not for very large and broad knowledge domains or for carrying out whole studies. Compared to non-adaptive systems, the benefit of adaptive systems lies in the possibility of tailoring the learning process to the abilities of individual learners. Compared to traditional teaching, where this is also possible to a certain extent, adaptive systems have to advantage of realizing adaptation much more efficiently. For the interviewee the most important adaptation criteria are learner knowledge, learner goals, and learner qualifications. Adaptation should be realized in terms of adapting the learning content and its complexity, the assessment process, and the design of the learning system. The most relevant application fields, she saw, were in learning languages and mathematics, and also for acquiring knowledge on complex theories in an interactive manner. The interviewee indicated that she would change the rating scale used for the importance ratings – in order to enable the indication of aspects of adaptivity that should not be implemented.

A.1.7 Interview Code 81023

This interview was conducted on 26th May 2008 in Heerlen, The Netherlands. The interviewee was a PhD candidate. The scenarios were in general understandable to him; just the author part seemed to be vague and too difficult to understand for people unfamiliar with adaptivity. He thought authoring is a demanding task that should be done by a team. The tutor scenario means a lot of work for the tutor initially, if he has a lot of students. He liked the idea of visualizing the learning process. From a learner point of view, he raised an interesting issue – ‘how do I know that I haven’t missed anything important?’. He considers all three scenarios as partially relevant to him. The interviewee has not used any learning system yet. He would use it as a direct help to support his work, but he prefers personal face-to-face contact. As regards the benefits of a learning system, he mentions an overview of the skills needed and guidance. An ALS for the interviewee appears especially suited for learning procedural skills, *e.g.* how to put together an engine, and to support various learning approaches, *e.g.* a holistic one. For learners, it can provide efficient learning with a reduced amount of information provided to the person. For tutors, it gives a good overview of learners’ skills. However, for authors, it generates more work. One interesting issue raised by the interviewee is a potential conflict between learner’s preferences and optimal learning. According to him, the system should adapt to prior experience, prior knowledge, and learning style of the learner. It should adapt the learning plan, selection of learning resources (appropriate media type), the learning strategy (based on prior results and choices), the assessment (based on former assignments), and also provide adaptive problem solving support. Essential features that the interviewee would expect from an ALS are ease of use and a simple, accessible user interface. Other application areas he saw were in the learning of theoretical knowledge, as he considers this difficult for practice oriented learning. The interview lasted approximately 100 minutes.

A.1.8 Interview Code 84001

The interview with the interviewee 84001 was conducted on 9th June 2008 in Verviers, Belgium. The interviewee was in his final year of history studies. The interviewee had no experience with e-Learning software. The demonstration of WINDS and the BBC English Course were helpful to provide the interviewee with an idea of what an adaptive system is. The interviewee fears that adaptive systems make learning decisions in place of the learners while the most

fruitful result of a university training are precisely internalized abilities to make learning decisions, *i.e.* ‘the historian is not the person who knows but the person who knows where to search’. Learners develop skills by trying different methods, making mistakes or observing what works well. For the interviewee, learning must remain in the hands of the learners and if a system makes a decision, the learners should be involved. The interviewee finds the scenario document understandable but unrealistic, *i.e.* ‘there is no such thing at university as individualized support; for academics, we are no more than numbers’. According to the interviewee, personalization already exists as students are allowed to choose a growing number of options as years go by. The interviewee is in favor of choice only if it does not threaten the acquisition of a general background and the covering of inescapable notions. The interviewee could find a use of adaptive systems if such systems can automatically connect with native speakers when studying languages. He believes also that adaptive systems might be helpful to learners who are not aware of their weaknesses and are unable to ‘personalize’ their learning. For those learners, an adaptive system could identify styles and train to their best contextual use. Adaptation criteria judged as being the most important were learning goals and tasks, learner qualifications, learning styles, interests, motivation, language, and platform. However, the interviewee persisted with his view that ‘minimal personalization involving the learner is better than fully automated personalization’. The support of technologies should not infantilize but promote a learner’s responsibility in a framework and should not be too anarchic but prompt enthusiasm for learning.

A.2 Teacher Profile

A.2.1 Interview Code 60063

The interview with the interviewee 60063 was conducted on 17th June 2008 in Dublin, Ireland. The interviewee was a computer science lecturer. He had briefly used e-Learning systems when teaching courses, mainly for the delivery of notes and as a central repository for examples and links to further material. He considered the main benefits of e-Learning systems to be the ease of distribution of lecture and class notes and automated tracking and reporting. The scenarios were very familiar to him. He was also somewhat familiar with the idea of adaptivity in LMSs.

He has found e-Learning systems very useful for technical material where learners have some knowledge but require more detail. They can do this in their own time. The authoring of courses that are similar but require small changes, for instance, undergraduate and postgraduate-level courses, could be made much easier through the re-use of learning material. However, it is important that the system provides ‘more than a web page’. The profit must be greater than the effort. The user should see all forms of adaptation and always feel in control. Any type of training organization can benefit from this type of system. The system should adapt to prior knowledge and learning styles and should be able to adapt the content and navigation or link-structure.

A.2.2 Interview Code 18016

The interview with the interviewee 18016 was conducted on 10th June 2008 in Limerick, Ireland. The interviewee was a computer science lecturer. He used e-Learning systems when teaching courses, particularly Moodle. He used it mainly for the distribution of notes and as a central repository. He considers the main benefits of e-Learning systems to be the ease of

distribution of lecture and class notes and the re-usability of the content for similar courses, *e.g.* the same course the following year. The scenarios were somewhat familiar to him. He was not familiar with the idea of adaptivity in LMSs.

He thought that an ALS should adapt to prior knowledge, previous performance and ability, *e.g.* mid-term results, learning styles and preferences. The system should adapt the course content and how the learners navigate the content, *e.g.* visited links, and also the interface. Adaptation must be seamless to the user but visible on request. This type of system would be useful for any form of training or educational course, covering material that is too technical for lectures and classes or where additional practice sessions are required. A nice feature would be some sort of adaptive testing and would show a learner where their strengths and weaknesses lie.

A.2.3 Interview Code 00321

The interview with the interviewee 00321 was conducted on 11th June 2008 in Coventry, England. The interviewee is a lecturer of computer science. The scenarios were understandable to her. The demonstration of the AHA! system was helpful in providing the interviewee with an idea of what an adaptive system is. The interviewee had a lot of experience with e-Learning software. Furthermore, she used Sakai and Blackboard at the university in the context of a lecture, using communication tools among learners and between learners and teachers. The main benefit of using a learning system, she saw, is in the possibility for distance learning; teaching over greater distances, teaching both synchronously and asynchronously. An ALS for the interviewee appears especially suited for guided and individualized learning, reduction of learning space, orientation for project-based group learning and collaborative tasks guidance. Adaptation should be based on individual characteristics (*i.e.* interests, knowledge, learning and cognitive styles, preferences, background, activity level if in a group, individual reputation if in a group), group/social characteristics (*i.e.* group tasks, group goals, group achievement level, activity level, reputation, etc.), environment characteristics (*i.e.* machine type, quality of service, bandwidth, perceived bandwidth, etc.), content characteristics (*i.e.* content structure, links, etc.), provider goals (*i.e.* site provider goals, designer goals, etc.). She thinks links, content, position of items on the page (order, but also overall position), and the synchronization of items (pairing and general grouping of items) should be adapted.

A.2.4 Interview Code 06210

Interviewee 06210 was a teacher, lecturer and author. This person has been a great proponent of *technology-enhanced learning* (TEL) environments for many years. This has made him very critical on this subject. One criticism, that arose even before the interview started, was the fact that the use of these environments can be ‘suicidal’ the teachers. There is not enough time for someone to provide all the content of a particular course. The university itself imposes this restriction. The focus is so much on having to create publications and perform other academic activities that the focus is taken away from the teaching activities.

The interviewee did not have the time to go over the hypothetical scenario. After a short recapitulation of the scenarios, he could find some relevancy in both the professor viewpoint as well as the learner viewpoint. There were a lot of issues that are still not addressed in the current systems, which make it virtually impossible for the different user groups to efficiently

use the learning/teaching environments. The experience of the interviewee tells him that learners are still in favor of studying from books instead of the web. The reason for this is that from the perspective of the learner, behind one link could be more than half of the course, so learners need to click every link to see where on the website the content is. There are often too many links and all the content is not structured clearly. Therefore, the learner gets tangled in this web of information. A nice feature, which could be added to adaptive learning environments, is that the learners themselves should also have some part in specifying the adaptation. In fact, they should be able to create their own learning paths in a sense. So, the teacher enters the table of contents of a course into the system and the learner can see this table and from every part in the course can select either ‘theory’, ‘example’, ‘question’, etc. When the learner has done this, a personalized learning path will be constructed according to his/her preferences.

The implementation of such a system can be straightforward. However, finding the people to fill this system with the necessary information (the actual content) is a real problem. As soon as you are dealing with a number of different items in your course then, you have a number of different ways to explain these items and in addition, you need to create a number of different entry points to enter the course (with different backgrounds). This leads to an exponential problem in terms of the learning paths that one teacher has to create for a single course. The support for this creation of content is often lacking. Even if you succeed in creating all the content, there is the problem of maintenance. Suppose that this year you have to omit a small part of your course from last year. What happens then with all the learning paths that are using this particular part? The different relations between the parts of a course are enormous. Having an intuitive way of managing this information would enormously lower the threshold of using these systems. This environment has to be very easy to use so that the teacher can do it without intervention of specialists.

A final issue, mentioned as regards the creation of the content, is that this content needs to be specified in a form that can be processed in different ways within the learning environment. Information needs to be presented differently when someone chooses the ‘theory-first’-approach than when he chooses the ‘explain-by-example’-approach. An example presented in the first way has to be presented differently than it has to be presented in the second way. It is also very important that teachers can import this information from other systems. If the university changes from system to system, or the teacher changes university, then all his data is not lost.

A.2.5 Interview Code 53003

This interview was done at the University of Lugano, Switzerland on 3rd June 2008. The interviewee was a teacher in the field of foreign language learning. She understood the scenario but found the **AHA!** English business course too simplified a model, but useful for a student who failed in a course and needs to recall some parts of the course. She found this approach useful in industry and continuing education programs, where the learners have a strong motivation to study by themselves. She has used **Moodle** several times a week from 2005 and found almost no adaptation implemented within it. The main duties of a LMS are the support of logistical activities, *e.g.* calendar, online repository, sharing of materials, etc., and a tool to support other media like CD-ROMs. The most important benefits are sharing and facilitating coordination, and the possibility of having a common place for retrieval of materials. She thought that the main limit in the field of language teaching, for an ALS, is the oral production (especially

the dialogic form). The main adaptation criteria can be the goals and tasks of the user, their familiarity with the domain, their cognitive style and the learner's motivation; these can be reached if the system supports active learning, with an adaptation policy based mainly on the hiding and revealing of links between resources. The adaptation layer can be mainly at the content level in an automatic way and at the presentation level under the explicit influence of the user. She thought that the main dimensions are the sorting of information fragments, together with additional explanations and a high level of interactive and example-based problem solving support; adaptive testing would complete the user-based adaptation. The key for enabling such a system is the correct individuation of the granularity level of information that should act as a source for the adaptation and the user-friendliness of the whole system. She thinks that other domains that could benefit from an adaptive system are long life learning, or the health care field, for instance, training a user in medicine or for impaired people.

A.2.6 Interview Code 64004

This interview was done at the University of Applied Science of Southern Switzerland (SUPSI) in Manno, Switzerland, on 10th June 2008 and the interviewee was a teacher in information technologies. He was familiar with the concepts expressed, and has used many different LMSs (Moodle, Blackboard, WebCT, etc.) on a daily basis for six years. In his opinion, the main weakness of this model was an unclear distinction between different skills, such as the content expert, the pedagogical expert, the tutor and the instructional designer. To him, the lack of a formal definition language for defining learning objectives was another limiting factor of this scenario. The main tasks achieved by the use of a LMS are the provision of a repository of teaching materials, a tool to foster the collaboration and the interaction between learners and a stimulus for the creativity of the learner; its benefits are the re-usability of materials and of entire courses, the adaptation and updating of courses with a regular schedule, and the support and enhancement of learner collaboration activities. He thinks that vocational training is the most suited field for its adoption. The main benefit of using this kind of system is mainly to help teachers cope with the heterogeneity of the learners. The usability and user friendliness of the whole system are key. The main adaptation criteria are the goals and tasks of the user, their quickness and ability to acquire knowledge, their cognitive style together with their interests and motivation, and the adaptation to the user's current location. To him, the methodological approach is very important, so it is fundamental to adapt to the learning objectives but also to adapt to the user knowledge: this process should be done in both the content and (in particular) the presentation layers. This should be performed transparently to the user, and the user should be aware and in control of the whole process. He thinks that the main dimensions could be the prerequisite explanations combined with the different types of media used to present the contents; a direct guidance would allow a learner to be independent in his/her study, the use of adaptive maps and resources recommended by peers or tutor would enable better understanding. A key point is the provision of some adaptive functionality into the interactive and example-based problem solving activities, and also as a supportive technology for the collaborative activities (both from the point of view of the learner and of the teacher, *e.g.* intelligent class monitoring).

A.2.7 Interview Code 79017

The interview with the interviewee 79017 was conducted on 6th June 2008 in Graz, Austria. The interviewee is a university assistant. As the interviewee had already some background knowledge about LMSs and adaptivity the scenario document was clearly understandable to the interviewee, and the introductory definition and demonstration of an adaptive system could be kept short. The scenarios were judged as being relevant for the interviewee; she felt familiar with the described situations as she had been using LMSs and has even tried out an adaptive system in learner as well as teacher roles. Referring to the hypothetical scenario, she pointed out that she could also imagine the preparation of adaptive courses for larger, rather anonymous audiences of learners. The interviewee has experience with several learning systems, especially Moodle and Ilias and has used them for the creation of courses and organization of learning content several times a week. The ALEKS system, which she has also tried out, provides adaptivity to learner knowledge. The main benefits in using LMSs, she saw, were the automatic overview, organization, and re-usability of learning material. Contents can easily be added, modified, and re-organized. She judges an adaptive system especially suited for teaching learners of differing knowledge levels and learning achievement, and for taking into account differing learning styles. The main benefit of an ALS is the tailoring of the learning environment and contents to the individual. She thought adaptation should be done according to the learning achievement and prior knowledge of the learner, and eventually to learner's age and gender, as well as learning style and preferences. Adaptation criteria judged as being the most important were learning goals and tasks, learner knowledge, and motivation. According to the interviewee, adaptation should be realized on the level of the learning content, *i.e.* the presentation, the sequence, and the amount of content presented. Furthermore, adaptation should be done with respect to the navigation through the learning system. Another aspect that needs adaptation is the level of self-regulation, *i.e.* how much the learner can interfere with the learning system. Dimensions judged as being critical were adaptive selection of learning content and learning activities, adaptive assessment, and specific types of navigation support (map annotation and adaptive link generation). Most essential in an ALS is the adaptation of learning content in a way that the learner is neither over- nor under-challenged. Adaptation to the learning style should be done at a global level. In the interviewee's opinion adaptivity should not be overdone, *i.e.* realized in many different ways. Rather, few but clearly targeted aspects of adaptation should be implemented. The user should furthermore have the possibility to get an insight into the adaptation process and its underlying principles. A further application area for adaptive systems, she saw, was in the field of dyslexia training, as in this field highly individualized training is necessary. In general, the interviewee argued that the importance ratings were quite difficult for her to do; she always tried to compare to prior ratings and judge whether the current aspect is more or less important. As an alternative way of rating the importance she suggested to request an order of importance.

A.2.8 Interview Code 00623

The interview with the interviewee 00623 was conducted on 30th May 2008 in Eindhoven, The Netherlands. The interviewee was a teacher (author and tutor) in the Eindhoven University of Technology (TU/e). The scenario was found to be highly relevant by the interviewee. The

tutor's/author's role was found to be closest to his own. However, the interviewee does not have experience in designing an adaptive course. From the point of view of the author, the following is the main advantage of using learning systems: the author needs just to create learning material and insert it into the course, the system will automatically generate everything else for the author. However, the interviewee noticed that the author should take into account a lot of contexts during designing the learning material for (adaptive) learning system and spend more time on it. Another highlighted advantage of using an adaptive LMS is the re-use of learning material, but, again, the author in this case should specify the context for which the system is meant. There is also a necessity of keeping the book paradigm while designing the adaptive course, so that the learner could return back to the learning materials previously studied. Finally, it is necessary to provide help and guidance while taking adaptive courses. It is important that the learner is not exposed to the adaptivity.

A.2.9 Interview Code 07011

The interview with the interviewee 07011 was conducted on 12th June 2008 at University of Jyväskylä, Finland. The interviewee was a teacher (author and tutor) at University of Jyväskylä. The interviewee had experience in using LMSs in the learning process. However, she did not have any experience in using ALSs. The interviewee liked the scenario and found it clear and reasonable. There was a discussion about the different roles described in the scenario (learner, tutor, author) and corresponding functionality of the ALS. The roles of an author and a tutor were found to be closest to her own role. She said that she would be interested in the development of this type of system. Besides learning material re-use and distant access, the interviewee mentioned the possibility of storing learners' assignments as one of the advantages of learning systems. The interviewee highlighted the importance of personalization of the learning materials to the individual learning styles, learning strategies and prior knowledge of the learners. The interviewee marked out the following important functionality that should be supported by an ALS: good support for the authors, tutors and the learners; the possibility of customizing the level of adaptation; and easy access to the system.

A.2.10 Interview Code 73072

The interview with the interviewee 73072 took place on 26th May 2008 in Heerlen, The Netherlands. The interviewee was an assistant professor. Her main job is research, but she also guides PhD candidates and teaches remotely at another university. She was well informed about ALSs and did some research in this field. The interviewee thought that the use cases were short, vague, and not attractive enough; they provided just basic descriptions. As the descriptions were abstract, the benefits were not entirely clear. For her, the tutor and author scenarios were highly relevant, although the authoring use case does not say anything about the complexity of the process if adaptive learning is the aim. In the past she has used the learning systems **Educativa** and **Blackboard**. Presently, she uses **Moodle**. During term-time, she uses the system everyday. Altogether, she has used learning systems for 14 years – both as learner and teacher. She uses the learning system for learning, teaching, guiding, and research. According to her the benefits are interaction with remote people, knowledge sharing, collaboration groups, learner assessment, and learners' opportunity to create and share content. The interviewee thinks that ALSs are suited for the provision of different learning paths for various learners. Ac-

According to her, learners can benefit from a personalized learning trajectory, tutors from better support for learners, and authors from production of content fitting better to the learners' needs. Prior knowledge and learning goals she considers as important sources of adaptation for learners, together with learner's interests and their platform. For authors, the system can also recommend resources based on the topic and the target group. She considers learning styles to be an unreliable source of adaptation, as it depends on the context. According to her, the learner should control the adaptation – learning path supported by recommendations, content and adaptation strategy, etc. She mentions informal professional learning and social help support as other application areas. The interview lasted approximately 85 minutes.

A.2.11 Interview Code 67031

The interview with the interviewee 67031 was conducted on 27th May 2008 in Heerlen, The Netherlands. The interviewee was a professor at OUNL. His job includes mentoring of PhD candidates. He is very familiar with the field of personalized adaptive learning. He found the learner and tutor scenarios highly relevant and the authoring scenario partially relevant, mentioning a difficulty with distinguishing the author and tutor roles. Currently, he uses Moodle once per week, but in the past he has used learning systems for 15 years. They have provided adaptive annotations, sequencing, recommendations, content selection and presentation, as well as learning strategy selection. He uses learning systems for supervising courses and project cooperation. The benefits he sees are the automatic support of academic features, technical features relevant for education, and the structuring metaphor, *i.e.* a time schedule. According to him, ALSs are best suited for adaptive knowledge testing, usage in fast changing domains, keeping track of learning achievements, and recommending new learning paths. The benefits are in learning efficiency, understanding, ease of use, and motivation. As sources of adaptation he expects competences, knowledge level, preferences, interests, peer group, physical location, delivery device, context, learning objectives, and time constraints to feature. He thinks the task list should be adapted to the agenda and higher-level goals, recommendations to interests and current activity, and content difficulty to the perceived ability of the learner. For the interviewee, essential features are monitoring facilities, guidance, and recommendation – they all should be presented via a flexibly configurable personal learning environment, for example, utilizing Web 2.0 technologies. Other application areas are professional training, knowledge management, schools, and informal learning. The interview lasted approximately 60 minutes.

A.2.12 Interview Code 74031

The interview with the interviewee 74031 was conducted on 12th June 2008 in Liège, Belgium. The interviewee was a university assistant in charge of mandatory and optional Dutch language learning programs. The interviewee was a teacher/tutor and an instructional designer, delivering and providing extra learning material to pupils via WebCT. The introductory definition and demonstration of an adaptive system could be kept short since the interviewee had already some background knowledge about aspects of adaptivity. Though the interviewee found the scenario document clearly understandable and highly relevant, she thinks that the scenarios pre-suppose many resources in time and workforce, which is not the case in her institution. With approximately three to four hundred students, no one in her team can practice close

personalization. Differentiation takes place at a group level. She has, for example, set up on **WebCT** an automatic feedback system regarding the most common grammatical mistakes. She mentions also that the **WebCT** tool ‘Voiceboard’, creates a one-to-one teacher/learner private learning space. Using ‘Tell Me More’, learners can learn at their own pace. However, for the activities on **WebCT**, the time frame is the same for all learners in order to allow the creation of discussion forums based on common readings. Learning styles are not a guiding idea when the interviewee develops learning objects but a variety of the offered resources are. And she, of course, takes account of prior knowledge (provided by an initial test which sorts learners in ability level A, B or C). Occasionally, and only on demand of individuals, she tries to personalize learning material based on interest. Though she deplors the lack of resource localization possibilities, the absence of interaction with peers and teacher and the narrow drill and practice orientation in ‘Tell Me More’, she is envious of its dashboard which allows teacher/learner to see all available activities and resources and which displays clear indicators about their level of completion. She would like to rely on a similar comprehensive view with the material she develops on her own. The benefits of using a learning system are visualization facilities, the ability to communicate effectively with learners, and tracking facilities. Adaptation criteria judged as being the most important included learning goals and tasks, learner interests, language and platform. According to the interviewee, adaptation should be realized on the level of additional information, interactive problem solving support, example-based problem solving, and adaptive assessment/testing/questions. However, the interviewee considers that her ratings must be treated with caution because she has not necessarily figured out the details involved with each of them.

A.2.13 Interview Code 57016

The interview with the interviewee 57016 was conducted on 2nd June 2008 in Heerlen, The Netherlands. The interviewee was a teacher and researcher at OUNL. According to him, the scenarios do not indicate which issues have been already solved. For OUNL students, the scenario is more relevant than for normal university students. For him the learner scenario is non-relevant, but the tutor and author scenarios are highly relevant. The interviewee uses **Blackboard** a few times a week. He has used learning systems for 25 years but without any personalization or adaptive features. He uses it for information offering and as a portfolio where learners can upload their products. The benefits are the provision of up-to-date course content and the possibility of getting feedback. He thinks an ALS can provide alternative learning paths based on different starting points and background knowledge, based on the context and intention. The benefits for the learner are efficient learning and improved motivation. For the other two roles, there are indirect added values. According to the interviewee, a learning system should adapt to prior knowledge and current intention (goals and tasks). He thinks the content (presentation, ordering, selection) and the teaching strategy should be adapted. He considers an overview of learners’ performance, adaptation to learners’ intentions, and templates for authors and tutors as essential functionality for an ALS. He sees distance education, learning networks, training of skills, and competence development as possible application areas. Finally, he considers the problem to be unresolved since research data is lacking. The interview lasted approximately 100 minutes.

A.2.14 Interview Code 58018

The interview with the interviewee 58018 was conducted on 3rd June 2008 in Heerlen, The Netherlands. The interviewee is a tutor of distance learning courses and an author of learning materials at OUNL. For her, the scenarios were clear, but do not reflect her practice with distance education, which is without any adaptivity. From a tutor perspective, she considers monitoring of learner's progress important. All three scenarios were partially relevant for her. She uses the **Blackboard** learning system, but also **FrontPage** for authoring, **Drupal**, a wiki, and a blog. She uses them regularly for the past ten years. Her learning systems provide some adaptive features, but they use them in a limited way – *e.g.* notification according to user profile (using **MySpace**), adaptability, notification of tutors regarding the discussion forum, etc. She uses learning systems for flexible delivery of content, communication with learners, and progress monitoring. Regarding the benefits, she says that in distance learning a LMS is essential – new forms of communication and a more efficient development process. According to her an ALS is suited to more efficient learning providing a limited amount of material to a learner, recommendation of successful learning paths, and monitoring of learning progress. The main benefits she sees include notification and monitoring. As sources of adaptation, she would expect learner's background, prior knowledge and preferences, *e.g.* language. She thinks that content and instruction should be adapted (fixed basics and flexible parts), which should be done by different presentations, considering the quantity of text and modality. For the interviewee, the essential functionality is notification (instead of a changing environment), non-obtrusive forms of adaptation and suggestion. The interview lasted approximately 100 minutes.

A.2.15 Interview Code 64002

The interview with the interviewee 64002 took place on 5th June 2008 in Heerlen, The Netherlands. The interviewee was a teacher in distance education at OUNL. He thought the scenarios were clear. From the learner's perspective, a personal learning goal has to fit into the curriculum and there should be room for surprise and discovery. Learners can also author materials, but a quality check is needed. For tutors it is difficult to get relevant information on learners. He has raised the issue of freedom versus control of tutors, which can be addressed via peer reviewing and reflection. The learner and tutor scenarios were highly relevant for him, in particular the authoring role. He uses the **Blackboard** learning system, but also a special examination system, course evaluation system, progress monitoring system and email. He uses these on a daily or weekly basis for the past year. He does not use any adaptive features. The purpose is to give assignments to learners, to provide learning content, communication, and collaboration. According to him the benefits include correcting his own errors, communication with learners, logistical benefits, and monitoring of learning activities. The interviewee thinks an ALS provides temporal and content flexibility and the identification of weaknesses and strengths. According to him, a learning system should adapt to the learner performance, preferences, goals, wishes, considering also user role and location. Content (learner and teacher as designers, teacher as approval), pace (according to progress, time, place) and task (contextualization and personalization) should be adapted. He considered the essential functionality to be the automatic planning of tasks (supported by visualizations) and progress monitoring (shared and controlled). He can also imagine other application areas, for instance education

for special groups (disabled people) and the management of learners in learning networks. Finally, he thinks that personalization has to meet certain standards in learning assessment. The interview lasted approximately 90 minutes.

A.3 Other Profile

A.3.1 Interview Code 77132 (research assistant)

The interview with the interviewee 77132 took place on 9th June 2008 in Heerlen, The Netherlands. The interviewee was a PhD candidate at OUNL. He was very familiar with ALSs as this is his area of research. He had not read the hypothetical scenario. He uses learning systems, namely **Moodle** and **Drupal**, approximately every two days for the past three years. The systems do not provide any adaptation features. He uses them for university study and sees their benefits in interactive tests, integration of multimedia, communication, and sharing of digital materials. According to him, ALSs are useful for recommending learning materials, different media, and supporting learning groups. Other uses include the adaptation of content to prior knowledge and adaptation to changing curricula. The main benefits are effectiveness and efficiency of study, learner's satisfaction, and reduced drop out rates. The interviewee expects the following sources of adaptation: prior knowledge, learning goals and tasks, interest, motivation, and study time. He thinks curricula should be adapted via adjustment of learning activities and time schedule, then media type according to current preferences. The course should be adapted to the learner's preferences (including language), needs, competences, study time, and hardware device. For him the essential functionalities are the recommendation of interesting materials, explanation and control of adaptation, recommendation of peer learners, a question answering tool (from a peer learner or tutor), as well as the ability to rate and tag learning materials. As application areas, he proposes informal learning, open educational resources, and knowledge management systems. The interview (without discussing the hypothetical scenario) lasted approximately 40 minutes.

A.3.2 Interview Code 64042 (research/developer)

The interview with the interviewee 64042 took place on 9th June 2008 in Heerlen, The Netherlands. The interviewee was an educational technologist at OUNL. She was familiar with ALSs as her research is related to this area. She had read the hypothetical scenario and thinks that the motivation to adapt learning could be clearer and asks whether different environments are necessary, as the roles can overlap. All three scenarios are highly relevant for her at the conceptual level. She uses the **Blackboard** and **Moodle** learning systems; the former twice a week, the latter once a month. She has been using learning systems for the past eight years. The systems she used provided adaptive learning paths and an adaptive interface. The interviewee uses the learning systems for learner's guidance, self-tests, and general information to perform the study tasks, collaborative tasks, and learner portfolios. ALSs can generate personalized learning paths and content, but she is skeptical as regards learning styles and how to respond to them. She sees the benefits of ALSs as being improved efficiency and enhanced motivation for learners. The interviewee considers the following characteristics as sources of adaptation: learner performance and preferences. She thinks the learning path and content (presentation) can be adapted according to past performance and prior knowledge. For her, the essential functionality of an ALS includes learner path and content adaptation, an overview of the

learner's progress and state in the domain based on assessment. Adaptive assessment should be presented with clear feedback. Adaptivity should be transparent to the learner. With respect to application areas, she mentions workplace learning with shared learning paths and informal learning. The interview lasted approximately 75 minutes.

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