Intelligent and Adaptive Learning Systems:

Technology Enhanced Support for Learners and Teachers

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Chapter 4
From Europe to China:
Adapting Courseware Generation to a Different Educational Context

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ABSTRACT

Course(ware) generation is the process of assembling a sequence of learning objects that is adapted to an individual user's goals, preferences, and capabilities. This chapter investigates course generation and how it is adapted to a different educational context, an area of research that has been barely researched until now. The authors present a course generator developed within a European project and show how it was adapted to met requirements arising from the Chinese educational setting – a setting that differs from Europe being significantly more-teacher centered and whose foremost goal is to enable access to higher education to the largest amount of citizens possible.

INTRODUCTION

Course(ware) generation is the process of assembling a sequence of learning objects that is adapted to an individual user's goals, preferences and capabilities. Research on course generation started early on in the history of technology-enhanced learning. The first ideas, which formulated the basic principles today's approaches are still build on, were published in the 80s and early 90ties. Despite this long time of research, course generation has been mainly investigated by researchers from Europe and North America, which are part of the Western culture cluster according to the GLOBE framework for categorizing cultural differences (House, Hanges, & Javidan, 2004). However, teaching and learning differs in each educational context and we feel that there is

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a lack of literature describing and addressing the specific needs of teaching and learning regarding the topic of course generation. The most significant general differences are the following:

- Teaching and learning in the Confucian Asian cluster is still influenced by Confucian values, leading to more teacher-centered education than in the West (Zhang et al., 2007). This directly influences the pedagogy embedded in a course generator.
- China's education system is still developing, and facing the challenging question of how to quickly provide education to large, ever increasing numbers of learners. In China, the number of graduates at all level of higher education has quadrupled in seven years, from 830,000 (1998) to 3,068,000 students (2005) (Li et al., 2008). This raises the question how this massive increase of students can be handled effectively and leads to different research questions and solutions, also in the area of course generation, than those investigated in the West.

The objective of this chapter is to contribute to the understanding of differences in technology-enhanced learning, especially in the area of course generation. In particular, we aim at the following objectives:

- To increase awareness of how the researchers' own background influences the pedagogy embodied within a technical artifact.
- To help Western researchers understand the needs of different educational contexts.
- To help non-Western researchers understanding that it is legitimate that their research focuses on different aspects than that of their Western colleagues. While this sounds obvious, a closer look at the literature reveals that research on technology that supports "traditional" or "didactic" ways of teaching is often looked down upon, e. g, Chan et al. (2006) who state that "[t]his simplistic view [of delivering instructional content] ignores the fact that modern education and pedagogy … converge in their high valuation of active … learning methods much beyond the absorption of codified knowledge". It is not a question about ignoring facts – it is a question about constraints and possibilities. In settings such as China there is not much choice. The foremost goal is to establish an infrastructure that enables access to education. This involves participation of existing stakeholders and taking serious established, culturally embedded ways of teaching and learning.

The learned lessons are relevant for technology-enhanced learning in general, especially when taking into consideration that the challenges that China faces are shared by other countries. For instance, Nigeria's universities can accommodate only 20% of those seeking admission (Adesope et al., 2007).

The chapter is structured as follows. We start with a description of a state-of-the-art approach to course generation that distinguishes itself from most current work by its explicit modeling of pedagogical knowledge. The presented approach allows the formalization of course generation scenarios that support the learner in achieving different learning goals, such as "discover new content", "rehearse learned content" and "prepare for exam". This work was done within the European project LeActiveMath. We then describe the background of Chinese online education and the effects of these on the requirements towards course generation, such as a more teacher-based approach, ease of use, scalability, and different learning needs. The third section describes how the Western framework was adapted to the Chinese needs. The presented system is applied in large scale online learning, namely at the SJTU School of Continuing Education (SOCE-SJTU), an online college with 26000 students

RELATED WORK ON COURSE GENERATION

The existing work on courseware generation is abundant. Early research on the Dynamic Courseware Generator (DCG) by Vassileva et al. (1998) set the foundations most of today's course generation (CG) is still based on. DCG has a representation of the domain concept structure and an instructional database. Courseware is generated according to individual's learning goal and previous knowledge and can be changed according to students' progress in acquiring knowledge.

The WINDS project (Specht et al., 2001) focused on the authoring process of adaptive material hypermedia. Course authors can reuse material and create flexible learning objects. Teachers without programming skills have created 21 courses in the ALE authoring environment (Kravcik et al., 2004).

Later approaches in CG, such as Cristea et al. (2003), Méndez, et al. (2004), Karampiperis et al. (2004), Huang et al. (2008), all have in common that the pedagogical knowledge used in these systems is rather rudimentary (Ullrich, 2008). As a consequence, these systems cannot generate courses that target different learning goals (also called scenarios), such as "getting an overview", "exam preparation", "rehearse".

A parallel line of research is investigating how to provide adaptability in large scale web course development based on educational specifications and standard, such as IMS, SCORM (Boticario et al., 2007, Baldoni et al., 2004). However, this work does not address how to construct user-centered scenarios in LMS and does not support pedagogical scenarios.

Research on course generation and technology-enhanced learning adapted for different educational/cultural settings is few. Previous work in LeActiveMath (Melis et al., 2009) has an European focus.

To summarize, the disadvantages of most existing automatic course generation systems are (1) they only generate a single, limited type of course; (2) they implement only a restricted amount of pedagogical knowledge; (3) they have not been evaluated in large scale learning; (4) they mainly focus on the needs of the students, which differ from the needs of teachers.

The last point is of particular importance. Most existing work has focused on the learner perspective, i.e., adapting courses to an individual learner. While this is without doubt a highly relevant area of research, we found that there is also a need to investigate how course generation techniques can support teachers in doing their work. As we show later in this paper, the educational context determines the needs and requirements of its participants. In China and similar countries with a developing educational system, the foremost task is to provide access to education. In consequence, conditions for learning will not be optimal. For instance, teachers have high teaching duties and face large classes. Thus, it is important to do research that aims at supporting the teachers under these suboptimal conditions, such a simplifying the authoring/adaption of high quality courses.

COURSEWARE GENERATION BASED ON PEDAGOGICAL SCENARIOS

A course(ware) generator supports learners by on-demand assembly of sequences of learning objects. The generation takes information about learning objects, the learner and his/her learning goals into account. Course generation offers a middle-way between pre-authored "one-size-fits-all" courseware and individual look-up of learning objects (Brusilovsky, 2003).

A course generator assembles the sequences according to a set of methods that implement pedagogical knowledge. The methods determine which learning objects the course generator includes in a course, the order of these objects, the structure (sections/subsections) of a course, etc. Most of the course generators described in the recent literature incorporate a rather limited set of pedagogical knowledge and basically include a learning object together with all its prerequisites that are unknown to the learner (Keenoy et al., 2003, Mendez et al., 2004). However, this only inadequately addresses the various needs that arise during learning. For instance, a student who wants to rehearse a topic *B* needs a "course" that is different from one for a student who wants to train modeling of problems that involve *B*. Ideally, a generated course specifically addresses the user's current learning purpose and contains all learning opportunities that are required to achieve the purpose. In the following, we call this purpose or type of course *scenario*.

Paigos, the course generator developed for the ActiveMath system (Melis et al., 2006), implements about 300 methods and is able to generate courses according to seven different scenarios (Ullrich, 2008). The scenarios are

- **Discover:** in the scenario *discover* Paigos generates courses that contain those learning objects that support the learner in reaching an in-depth understanding of the concepts specified by the learner.
- **Rehearse:** courses of the type *rehearse* are designed for learners who are already acquainted with the target concepts but do not yet master them completely.
- **Connect:** the scenario *connect* helps the learner to discover connections among the given concepts and other concepts and offers opportunities to train the concepts.
- **Train intense:** a course generated for the scenario *train intensively* generates a workbook that aims at increasing the competency level of the learning by presenting a large selection of exercises.
- **Traincompetencies:** a course generated for the scenario *train competency* trains a specific competency by presenting sequences of examples and exercises with increasing difficulty and competency level.
- **Exam simulation:** the scenario *exam simulation* contains exercises that can be solved within a specified timeframe.
- **Guided tour:** this scenario provides a detailed introduction of the selected topics.

Paigos' methods specify the structure of each of these scenarios. For example, the structure of the scenario *discover* is adopted from Zech (2002) and consists of several stages that typically occur in learning a new concept. For each stage, the course contains a corresponding section:

- **Description.** The course starts with a description of its aim and structure. Then, for each goal concept selected by the learner, the following sections are created:
- **Introduction.** This section motivates the usefulness of the concept using adequate resources such as examples and introduction texts. It also contains the unknown prerequisites concepts.
- **Develop.** This section presents the concept and illustrates how it can be applied.
- **Proof.** For some concepts, such as mathematical theorems, proofs or other evidence supporting the concepts is presented.
- **Practice.** This section provides opportunities to train the concept.
- **Connect.** This section illustrates the connections between the current concept and related concepts.
- **Reflection.** Each course closes with a reflection section, which provides the learner with opportunity to reflect on what he has learned in the course.

Each of these stages is further broken down by other methods until a level of primitive methods is reached. Among others, these primitive methods insert learning objects according to a set of conditions, for instance examples and exercises that are adequate in the current context. The selection of exercises and examples is highly dependent of the individual student. It takes the current competency level of the learner and competencies into account. In total, about 60 methods encode the knowledge of exercise and example selection (including specialized methods that e.g., allow selecting resources for specific competencies).

The scenarios and methods are influenced by and targeting Western learning culture, even though this was not intended during the authoring. A European team of teachers, AI experts and pedagogues formalized the scenarios and methods implemented in Paigos in the EU FP6 Project LeActiveMath. The scenarios follow constructivist learning theories (Melis et al., 2007), a widespread and popular theory in the West. The scenarios also primarily support a self-directed and independent learner who is a member of relatively small class/lecture, supported by a tutor – again, a widespread learning situation in the West. However, such relatively ideal learning situations are not the norm outside the Western educational system, which developed over a significant amount of time. The following section provides a background of the Chinese educational system (as an example of a developing and massively growing educational system), and motivates the adaption of the courseware generation system we undertook.

BACKGROUND ON CHINESE ONLINE EDUCATION

To properly asses the needs and requirements of Chinese online education, it is important to be aware of the background and context in which it evolved. The primary goal of Chinese educational policies in the last ten years was to enable and simplify access to education. Governing bodies realized that this goal could only be achieved by going online. Thus, in 1998, the Chinese Ministry of Education started large-scale deployment of distance education. Today, 66 universities are authorized to engage in online degree education. These online students mainly consist of adults and part-time learners. During the last 12 years, a total of 8.2 million students enrolled in an online university, with 3.5 million students studying online in 2009 alone. According to reports of the Chinese Ministry of Education, the number of online students has quadrupled in the last 5 years (Li et. al., 2008). The topics taught in Chinese online education cover 11 different disciplines and 299 specialties, and more than 20.000 courses have been authored at Chinese online educational institutions.

The typical Chinese education institutions provide online learners with basic services through different management systems. Regarding the content (the learning objects), teachers upload and distribute content to students and prepare assignments and tests. The majority of these materials are available only in format such as Microsoft Word and PowerPoint, not in web formats such as html. Also, most content is not sequenced in any special way, but simply made available within lists of learning objects.

This rise of online education has not come without problems, though. In recent years, employers have started to complain about the competencies of online graduates. Despite having degrees from renowned universities, the level of the online students is perceived as significantly lower than of the non-online students, partly due to questionable quality of instruction (Zhao, 2006).

In order to improve the quality of web courses, the Chinese Ministry of Education began to curate high quality courses, the so-called National Level Excellent Web-Courses (NLEC). In 2007, 50 courses were awarded this prestigious award. Until today, 149 of such courses were authored from a total of 65 universities. While this is a highly important quality improving activity, reusing these Web courses is often not an option for lecturers due to their and their students' specific local needs and requirements. Also, authoring or adapting a NLEC course is resource intensive. It requires teams that include course teachers, instructional designers, and technicians. The developing cycle is long, expensive, and subsequent updates of content require help by technicians. As a consequence, most teachers still teach the traditional way by using their own resources, using Word documents and PowerPoint slides. For example, in our institute, the School of Continuing Education of Shanghai Jiao Tong University (SOCE-SJTU) during each semester teachers upload about 300 courses consisting of these types of learning materials. In contrast, only six Web courses were developed in the last three years and only two of these six are NLECs. These figures show that the current development process of Web courses and NLECS is not effective. We therefore investigated how course generation helps to overcome the problem of resource intensive authoring and increase re-use of existing high-quality courses and present our approach in the following section.

ADAPTING COURSEWARE GENERATION TO THE NEEDS OF A STILL DEVELOPING EDUCATIONAL SYSTEM

In this section, we present an automatic course generation system (ACGS) for large-scale education based on earlier work (especially Ullrich, 2008), adapted and extended to the specific situation in China. In this setting, the foremost requirement is that especially in degree education, the individual student is well prepared to achieve the final test, which is set by the lecturer. This means that the main aim of the ACGS at this point is to support teachers by generating courses that implement their goals regarding the outcome and coverage of the taught content. A second adaptive dimension is the targeted degree level of the students, for instance bachelor vs. master.

We are aware that this teacher-centered paradigm sounds as it runs against the more learner-centered approaches most of the current research on technology-supported learning focuses on. However, we argue that it is worth investigating the problems arising in settings where large amounts of learners get suddenly access to education, even if it amounts to support ways of teaching and learning that might not be as efficient as others.

ACGS is based on a set of design decisions described in the following that take into account the peculiarities of the large-scale education described as mentioned before.

Courseware Generation Instead of Sequencing

Brusilovsky and Vassileva (2003) give several suggestions on large-scale course generation. In particular, they suggest that the course should be fully generated before the learners start their learning process, instead of incrementally generating a course. In our setting, the objective of a course is fixed, since the courses are delivered to online learners in order to achieve a degree. Thus, all students from a class share the same teacher-given learning goal that covers a given set of knowledge. They have to learn the same material in about the same time and take exams at the same date. Therefore, in our process the teachers can assess the knowledge level of the class before the semester starts and produce an instructional plan. This instructional plan is imported into the ACGS before the semester, and the course can be generated before teaching starts. In such a setting, the courseware does not need to be generated incrementally.

Courseware Generation Based on Pedagogical Knowledge

Although in theory one should assume that online teachers have knowledge about pedagogy, in the real world, few of them actually have. In a survey we performed among Chinese online teachers, only 13% indicate to have knowledge about pedagogy. Thus, tools that incorporate some pedagogical knowledge provide a significant support to teachers. Therefore, in the ACGS, different types of pedagogical scenarios are implemented to meet the needs of the teachers. For ACGS, we developed 10 pedagogical scenarios according to the needs of different academic disciplines, such as:

1. **Learning Instruction:** this scenario is to guide the student when he/she begins to learn a new concept. The instruction includes outlines and brief explanations, information about important concepts, hints about potential learning difficulties, recommendation about learning strategies. It can be used for all kinds of subject matters.
2. **Guided Reading:** in this scenario, teachers collect introductory texts to be read by the students for initial studying of the topics. After reading the texts, students submit feedback and evaluate the texts.
3. **Video lecture learning:** in this learning scenario, students learn new concepts by watching video lectures (live and recorded).
4. **Discussions about experiments:** this scenario is for Computer Science and other engineer courses that require learning with experiments. Teachers publish the experiment content, goal, and method. Student experiment and discuss online.
5. **Case studies:** this scenario is for business courses or other liberal education domains, which need case studies.
6. **Role play:** this scenario is mainly for language learning courses. Teachers describe situations and roles for students to practice.
7. **Design Practice:** This scenario is mainly for design courses.
8. **Discussions:** after learning new concepts, teacher publish relevant discussion topics and lets student discuss these.
9. **Extra reading:** in this scenario teacher collects some extra reading articles that presents and illustrates how the concepts can be applied.
10. **Test: teachers** publish tests for student to test the learning effective.

The automatic generation process supports the teachers while designing their courses. Teachers can focus on assessing the learners' knowledge state before the lecture and on determining the general requirements induced by the degree.

Courseware Generation Based on a Knowledge Domain

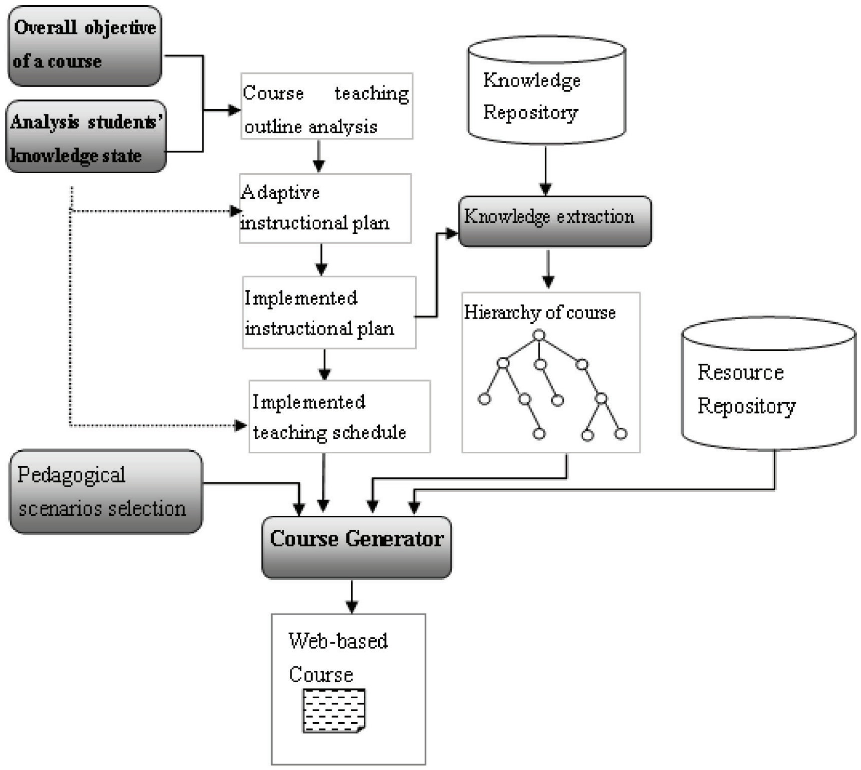
A structured knowledge domain is a prerequisite for being able to use a CG process based on pedagogical knowledge. Such a data structure, also called concept space or concept structure is a representation of the domain concepts and their relations (Vassileva, 1995). For the ACGS, we use two relationships, namely

- "consist-of", which relates a concept to its sub-concepts. These relationships represent the hierarchy inherent in the knowledge domain.
- "prerequisite-of", which specifies that a concept is prerequisite of another concept.

The General Framework of the Automatic Course Generation System

The main aim of the ACGS at this point is to support teachers by generating courses that implement their goals regarding the outcome and coverage of the taught content. In brief, the teacher decides about the content of a course and designs a schedule, which gets filled by reusing learning objects stored in a resource repository. The detailed process flow is illustrated in Figure 1. It starts with the teacher determining the overall objectives of

Figure 1. ACGS process flow



a course and the current knowledge state of the students. These results in a broad course outline, which the teachers then refine into a detailed instructional plan, taking into account the degree targeted by the students. These documents follow a given, easy to use syntax. Teachers write these documents as an Excel file and upload them to the system. We decided to use Excel sheets instead of a specific authoring tool because most teachers have used and are comfortable using this format.

An instructional plan is represented by a table with the fields "Unit name, learning goal, emphasized concepts, difficulties, recommended learning time". Table 1 contains an example of an instructional plan. Sometimes an instructional plan for one course is fixed. While teachers begin to instruct one course, they can adjust it slightly according to their evaluation of the target students group. This results in an implemented instructional plan.

In each semester, teachers arrange the teaching schedule and plan the learning content and learning activities for each week according to their implemented instructional plan. A teaching schedule is represented by a table with the fields "No. of week, recommended learning time, learning content, emphasized concepts, main learning activities".

Following Karampiperis (2004), we consider an instructional plan as connecting two different spaces. The first one is the knowledge space, which includes the concepts and the relationship among them – actually a network of concepts, stored in the Knowledge repository (KR). The second is the resource space, stored in the Resource Repository (RR). The learning objects in the RR link to the concepts in KR via their metadata. Based on the uploaded documents, the knowledge extracting process generates the hierarchy of the concepts used in the course using the overall concept

Table 1. An example of an instructional plan

unit name	learning goal	emphasized concepts	difficulties	recommended learning time
Linear List (LL)	1. Master the relationship among the elements in Linked Lists (LL); 2. Be familiar with two storing structures of LL: Sequence storing LL (SLL) and Chain storing LL (CLL); 3. Understanding the basic operation of SLL and CLL:delete, insert, … 4. Unstanding the basic structure character of circulation chain LL, double direction chain LL.	1. the relation between data elements; 2. the format of SLL; 3. Main algorithms such as insert, delete, etc. for SLL; 4. the format of CLL; 5. Main algorithms such inset, delete, etc. for CLL;	1. Comprehension of relation of data elements in LL; 2. construct algorithms of CLL, and the algorithms of other operation.	1. two weeks for this unit; 2. attendance lectures for 8 periods; 3. experiment 2 hours to implement the algorithms

structure defined in the Knowledge Repository. The knowledge extracting process uses the implemented instructional plan produced by the teacher and retrieves the concepts used in the plan, called CKR (Course Knowledge Domain).

Based on the CKR and the resources available in the RR, the course generator selects the specific resources of the course, according to the scenario chosen by the teacher.

The Application of ACGS

The first version of the system was completed in August 2009 and used by two computer science teachers at SOCE-SJTU for their course on Data Structures (DS). The two lecturers developed two courses for different target audiences (a 5 credits course in a 18-weeks class, and a 3 credits course in a 12-weeks class). The teachers authored the courses within three weeks, without requiring help by instructional designer or technical experts. The courses are accessible online at http://jpkc.onlinesjtu.com/CourseShare/Courses/Theme1/Default.aspx?courseid=701018 and http://jpkc.onlinesjtu.com/CourseShare/Courses/Theme1/Default.aspx?courseid=601018.

The authoring process happened as follows, Firstly, the two DS lecturers jointly decided on the knowledge structure, that is, the concepts and their relationships. In the end, the knowledge structure consisted of 158 interrelated concepts. Based on this, two teachers construct two different DS courses. The differences of these two DS courses are:

- **Different implemented plans:** due to the different target audiences, the two lecturers developed two different implemented instructional plans.
- **Different Knowledge Space:** Different implemented plans and the different knowledge levels of the two target groups resulted in different subsets of the KR being selected for the CKD. The first course contained 119 knowledge concepts, second course contained 78.
- **Different pedagogical scenarios:** according to different learning content, teachers can choose different scenarios to support different learning activities. One lecturer selected five scenarios, namely “learning instruction”, “reading guiding”, “video lecture learning”, “discussion about experiments” and “test”. The second lecturer only selected three scenarios, like “learning instruction”, “experimentation discussion” and “test”.

The courses were used in a class with 320 online students and another one with 78 students.

After these initial test runs, the platform was used by 41 lecturers in SOCE-SJTU. 48 Web-based courses have been generated from ACGS in three months. About 5800 online students used these courses in the autumn semester 2009.

We collected feedback from these 41 teachers via a questionnaire including question such as:

“Is the system convenient?”

“Do you need any technical support?”

“Does the function of ACGS meet your needs?”

“Do the pedagogical scenarios design reasonable?”

40 teachers answered the questionnaire: All of them indicated that ACGS is very convenient (35) or convenient (5). 38 teachers did not need technical support while using the system. Only two teachers encountered difficulties. Almost all the teachers thought the ACGS met their needs for teaching. Only one teacher gave an advice on the functionality. All the teachers were satisfied with the pedagogical scenarios and said that they like the designed scenarios and like to use them in online teaching.

We also collect some suggestions about the format of the instructional plan and the teaching schedule, and some new learning scenarios.

LESSONS LEARNED AND CONCLUSION

We were surprised by the degree to which the concepts implemented in the course generator Paigos had to be transformed in order to be of practical use in a different educational context. We designed Paigos to be flexible and adaptable to a variety of educational settings and supported this claim by implementing scenarios based on different pedagogical paradigms. However, the requirements that arose in the Chinese context differed substantially and required substantial research and redevelopment:

- **Teacher centered vs. learner centered:** While the original target group of Paigos consists of students, in the Chinese setting, it consists of teachers. This is due to the whole teaching/learning process being more teacher-centered at the current time in the development of the Chinese education system.
- **Adaptivity dimensions:** Courses primarily needed to be adapted to the target degree and group knowledge, not individual content items. While Paigos allows selecting individual concepts that determine the content of a (possibly very short) course, this feature is not highly relevant in the Chinese context. A course will always include a large number of concepts given by the subject matter and the degree targeted by the students. In addition, the individual knowledge of a student is considered less important than the knowledge of the whole group as a generated course will be for the complete class.
- **Different scenarios:** Not all of Paigos’ scenarios could be reused, for instance some required too detailed metadata (Train Competency). We also had to develop additional scenarios to cover subject matters not yet represented in Paigos (language learning).
- **Authoring of content vs. outlines:** we designed Paigos to run in an environment in which it is easy to add new learning objects and where this frequently happens. In contrast, ACGS assumes that high quality content has been authored previously, and that teacher author outlines that specify the learning objects that their course uses. This authoring process has to be as easy as possible, and for that reason we are using

Excel, a tool most teachers are comfortable with.

These requirements and our solutions result in a system that reuses existing high-quality courses and makes it easy to adapt these courses to the specific situation, primarily defined by content matter and degree.

Several fundamental concepts of Paigos are still visible in ACGS: Scenarios consist of rules and methods that formalize pedagogical knowledge of how and when to select specific types of learning objects.

Future work will research an increased automatization, e.g., how to extract concepts from the instructional plans uploaded by the teachers. More significantly, we want to investigate to what extend we can make CG accessible to students. This includes pedagogical issues (how can this more learned-focused approach be integrated in the teaching), but also technical issues (can ACGS be optimized sufficiently to handle course generation requests by more than 20.000 students).

Finally, we want to stress that by no means is constructivist teaching and learning only for the West. Actually, significant efforts are being undertaken to modernize Chinese teaching with the aim of integrating a more student-centered approach—efforts that face their own difficulties, such as resistance from teachers, parents and learners (Zhang, 2007). However, once these efforts have proven successful, course generation will need to adapt, again.

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