Knowledge Modeling for Readiness Self-Assessment

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Abstract: Online readiness self-assessments are widely used in universities providing distant education, and they can help prospective students to understand the requirements and their readiness to study in these universities. Most of the self-assessment systems are Web-based static questionnaires. In this paper, a novel adaptive online self-assessment system AM I READY is introduced. The system is based on knowledge models, including static and dynamic user model, counseling model and self-assessment process model. It can dynamically filter questions to be asked to a specific user and adjust the contents of webpage dialog between the user and the system according to knowledge models and the user's responses. The system is more effective and helpful than the usual ones.

Keywords: E-Learning & Innovations in Teaching, Knowledge Modeling, Self-Assessment

I. Introduction

Online readiness self-assessments are widely used in universities that provide distant education service. The purpose is to help potential students to know the leaning style and requirement of studying as a distant learning student, and decide if the distant learning is the right choice for them. Most current readiness self-assessment tools are online questionnaires. By doing the questionnaires, potential students read some information and may get a final score related to their answers to these questions. The high score means high degree of their readiness. This kind of model is relatively simpler and needs to be upgraded in several aspects.

Actually, in this paper, we treat readiness self-assessment as a kind of counseling process. By doing so, we can analyze the counseling process to understand what should be done to upgrade the current model. The self-assessment system is functionally like a counselor, who needs to know the background information of his/her client (the user of the system) as early as possible and ask necessary questions to get more required information of the client until the counselor finally form an assessment about the client. During the counseling process, the counselor may also pick and/or skip some questions of all possible or potential questions according to the needs to logically understand the client by his/her answers to previous questions, and form a

more and more specific figure of the client and finally the assessment to the client about his/her readiness.

This paper describes our work to attempt fulfilling this upgrade based on this thought. As most of current systems adopted in other universities, the previous system of Am I Ready for Athabasca University is a self-assessment questionnaire: Am I ready for Athabasca University? It involves several self-test groups, including Goals, Preparation, Supports and Commitment, which are content-fixed or static (i.e. tests that do not adapt to the user's responses). Each of these groups is a Web-based questionnaire. The user can choose one of several options (Yes or No) for each question and finally get a score. The score reflects the total number of Yes and No answers, but is not objectively correlated with any measure of readiness for distance education. The students can get some information from the assessment according to the score and the meaning of Yes or No for each question. A lot of "No" answers may indicate the user needs to think more seriously about their decision before they begin their studies. The shortcoming of this system is that it does not help the prospective students very much to find out what are needed to succeed and how to get those needs met. Also, it can't dynamically alter the sequencing of questions according to user's answers in order to assess the student's readiness more precisely.

The new version of AM I READY for Athabasca University (AM I READY) is an adaptive online self-assessment tool for prospective students of Athabasca University. It is based on knowledge models of counseling process, including User Model, Counseling Model, Process Model and Assessment Model. It can choose and present most necessary questions to users by enabling, disabling and changing priority of questions according to those models, and produce dynamic question-answers dialog to a specific user. It involves better understanding of a user and effective self-assessment process with a smaller necessary question set. It can provide real time information to conduct users and show related resources to users to help them with more information. It can also find the contradictory answers of a user and give assessment according to all of the user's answers.

In the rest of this paper, the related work is reviewed right after the introduction, including adaptive questionnaires or assessments. The knowledge modeling of AM I READY system is proposed in the third section. Some details of User Model, Counseling Model, Process Model and Assessment Model are described there. In section four, the design and realization of AM I READY is

introduced. The last part of this paper is about the conclusion and future work.

II.   Related Works

There are some related works about the adaptive questionnaire or self-assessment, and knowledge modeling currently. An adaptive Web-based questionnaire for course survey is developed and evaluated by Chou et al in [1]. It uses the answers to certain questions, which are called Adaptive Questions, to determine the next series of questions and to skip unrelated questions. Only few questions are Adaptive Questions in their question set. Unlike other questions, they only show one by one on individual Web page for the convenience to immediately decide and lead to other related question groups in the following page. This restriction does not exist in our AM I READY system, in which all kinds of questions are combined together and priorities are used to order or control the proper presentation of following related questions. Web-based online questionnaire can also acts as an online pupil consultation system according to Milne et al [2]. Three adaptive algorithms, including Skipping, Branching and Relevance Weighting Algorithms are analyzed and compared, and Branching Algorithm is finally used in the work to make it more effective and easier to use. An interface is designed for teachers to construct the questions, response and possible path of those questions. However, it is hard to define all possible paths if there is a larger question set and relations between those questions. Nokelainen et al [3] designed an adaptive questionnaire based on Bayesian Modeling. In their paper, Bayesian statistical techniques are used to create an individual learner's profile (in Profile Creation Phase) and optimize the number of questions presented to each user (in Query Phase). It is very suitable for such surveys or test applications that we only know few about their results and categories. But it is not fit for AM I READY project, where all possible relations between questions are coded and put to the knowledge base, because it needs more controllable and user specific self-assessment process. There are also many works about knowledge modeling recently. One of them, which is related to user-adaptive interface, proposed by Rosis et al, is a visual formalism and an evaluation tool, XDM, context-sensitive dialogue modeling, to model user-adapted interface based on extended Petri nets [6]. As to other application of self-assessment, it can also act as a self-learning system according to Gayo-Avello [4]. Another related field is Adaptive Testing [5], in which testing is adapted interactively to match the ability level of the examinee by means of a statistical method called "Item Response Theory".

III.   Knowledge Modeling

Let's have a look at a real counseling process first. There are two roles involved: a counselor, who is the expert of the specific counseling field and the controller of the current counseling process, and a client, who has his/her own needs and background information that the counselor needs to know during (and maybe before) the counseling process. The more information the counselor knows about the client, the fewer questions he needs to ask while trying to understand the client and then give an assessment to him/her. Respectively, there are several models built to support the adaptive self-assessment of AM I READY, namely, User Model, Counseling Model, Process Model and Assessment Model. User Model is the knowledge about the client, including static (produced before or at the beginning of the counseling process) and dynamic ones (produced during the process). We model the counselor by Counseling Model (related to field knowledge), Process Model (knowledge about the counseling process) and Assessment Model (knowledge about the assessment). All these models are showed in Figure 1.
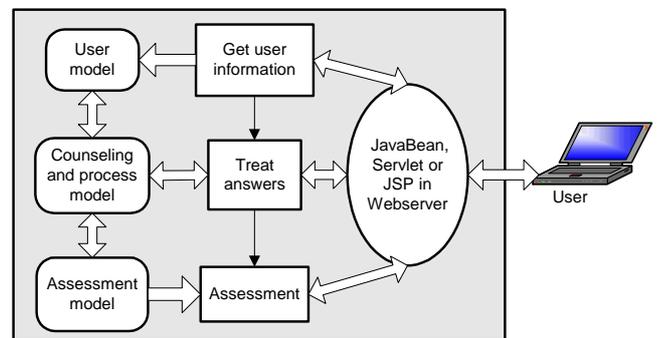

Figure 1. Knowledge Models and Architecture

User Model

There is lots of information about a user. However, we only need those that mostly affect the readiness self-assessment of the user. For this purpose, we chose several items about a user as the User Model parameters, namely:

- Highest level of education

- Work status

- Financial capability

- Computer skills

- Favorite questions groups

Users can make their choices at the very beginning of their self-assessment by clicking the options of these parameters.   Figure 2 shows the Web page for building user model. The values of those model parameters directly affect the questions the system is going to ask later. For example, if a user tells the system that he/she has graduated from college or above, the system is not going to ask any questions to assess his/her readiness of basic writing skills. Two kinds of relations have been built into the model about what *questions* or *fields* are "Disabled",   "Enabled" or   "Plus"

priority by a specific value of a parameter. This is the *static* user model – they are not going to change during the assessment after they have been set. The inner representations are the parameters and their relations in the form of *Facts* and *Rules*.

The *dynamic* user model is essentially about the records of the user's choice history along the assessment, which is always changing during the assessment. The main items include the answer of each question, records of questions that are disabled, enabled, and have high priority. The increasing records will continue affecting the questions of the next page asked to users according to the same rules mentioned above.
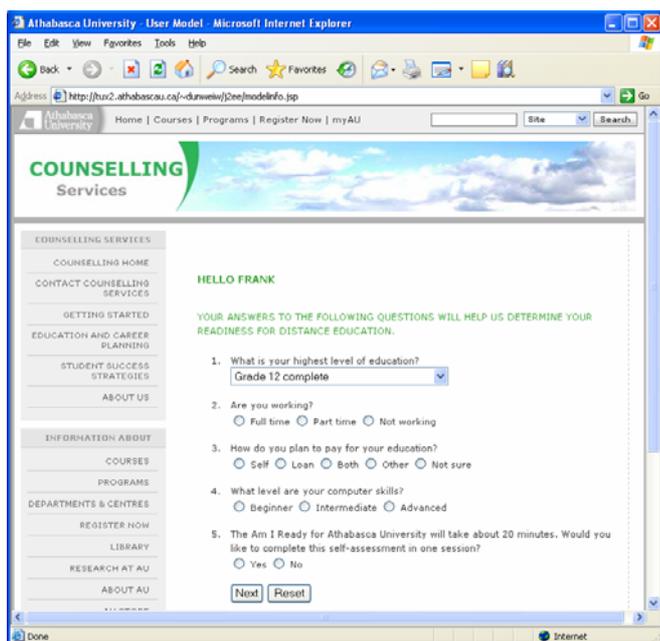

Figure 2. Static user model Web page

Counseling Model, Process Model and Assessment Model

Needless to say, counseling knowledge is always different in contents, forms and styles according to different domains and processes. However, we can still try to model the general level of the counseling knowledge, like the methods of counseling knowledge representation and resolution. In this part, we have captured five kinds of knowledge for AM I READY, which forms Counseling Model (*Questions*, *Relations*, *and Instant Information*), Process Model (*Process*) and Assessment Model (*Assessment*).

Questions are the knowledge sets about all questions of a system, its fields and sub-fields and predefined answer types. All questions are divided into eight groups (or fields) in AM I READY, e.g. Educational & Career, Financial Readiness, Academic Preparation, Course/Program Awareness, Commitment & Motivation, Computer Readiness and so on. Each field may have some sub-fields. Like that Financial Readiness includes four sub-fields, namely, General Information, Family Support, Loans and Awards. Each

question belongs to a sub-field and each sub-field belongs to a field, which forms a standard hierarchical tree structure. All questions are in plain text and can have predefined different kinds of answers. Currently, AM I READY has (1) Yes and No, (2) Yes, No and Not Clear, (3) Grade and (4) Multi-Checks. The last one can have multi-choices answers. Questions and related answer options can be seen in Figure 3. Users can choose their answers to those question by click related radio buttons. Even questions of Multi-Checks type can be represented by multi radio button pairs.

Instant Information is the additional information related to answers of certain questions. Users can see the instant information immediately after he/she click an answer button, as showed in Figure 3. The main purpose of instant information is to give users immediate response, and provide related resources (links or emails) and guidance to follow self-assessment process.
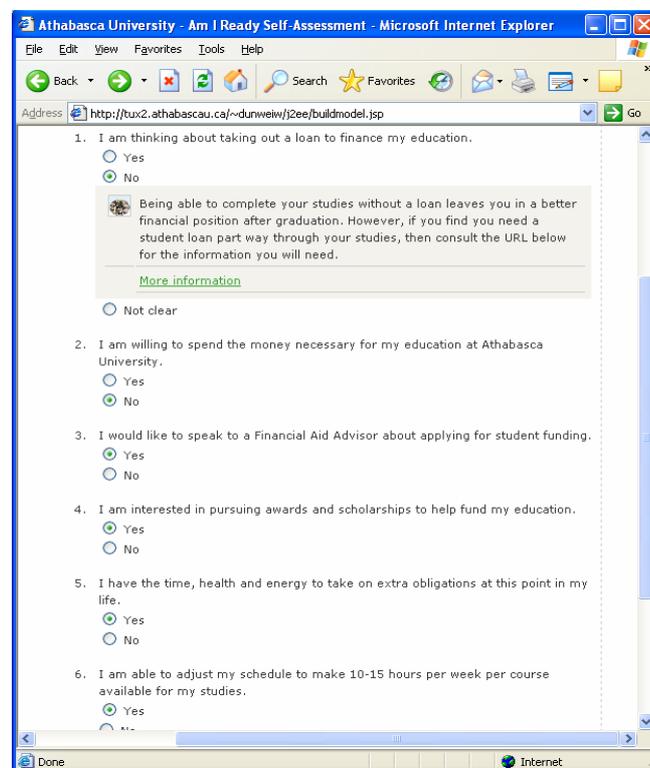

Figure 3. A self-assessment Web page

Relations include all relations between questions. We also regard them as rules. In AM I READY, relations can be question to question(s), question to sub-field(s), and the latter can finally become question to all questions belonging to the sub-field(s). So the relations are always one-many relations. There are four types of relations as briefly mentioned above, which are *Enable*, *Disable*, *Plus* and *Contradictory*. The first three relations are in this form:

(**Enable** (*Answer*(*i*) *of question*(*j*),   (1)

(*question list*)

(*sub-field list*)))

It means that an answer of a question will enable some questions or other questions belonging to some sub-fields if they have been disabled before. *Disable* relation can disable some questions that are no longer needed to ask the user according the user's current answer. *Plus* means to enable some questions and add the priority of those questions, which can cause those questions to be asked soon. The order to show questions is made by sorting those questions according to their priority. *Contradictory* means that some answers to certain questions are contradict:

(**Contradict** (*Answer*(*i*) *of question*(*j*),   (2)

(*list of answers of some questions*)))

Process is the knowledge of how to control the counseling process. To improve the effectiveness of a self-assessment, modeling the counseling process in a suitable way is very helpful. And it is also useful for AM I READY system to understand the process and make suitable or nature "dialog" between users and the system. To do this, we need to combine the process with other knowledge like user model and other counseling models. Just as what a real counselor is going to do, there are two critical methods: (1) *Adopting models* mentioned above, including user model and counseling model, (2) *Changing Priority* in real time and *Sort Questions* by their priority. By adopting user model and counseling model, AM I READY can filter, skip, gather questions, and by the help of priority handling, AM I READY can ask more related questions together, which is more natural to use and more friendly to interact. For example, after the user choosing Yes or Not Clear to the first financial question: "*I am thinking about taking out a loan to finance my education.*" All detailed questions about the loan are going to show on the next Web page (see Figure 4). Not like [1], in AM I READY, every question can be an "Adaptive Question" and questions on next Web page are always most related to current answers. It gives the system great flexibility and produces a kind of flexible or dynamic "Webpage-Dialog". With the flexible filtering and skipping functions, AM I READY is more effective and suitable for applications with large set of question. On the other hand, by the help of these mechanisms, we don't need to be too serious about the questions set, if only we can tell and capture the relations of those questions.
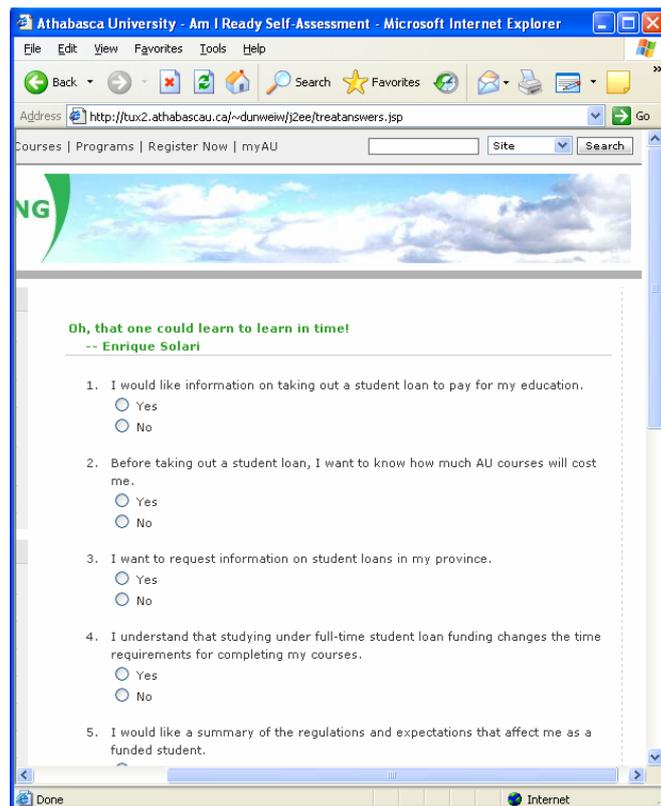

Figure 4. A dialogic Web page after Figure 3.

Assessment is information about the assessment sentences, which are going to show at the last page of the self-assessment. As mentioned in introduction section, we don't use a single score to assess the readiness of a user. Actually, some assessment information plus remedial suggestion are more useful to users, which can help them to understand how to make it happen if he/she is not so readiness in some aspects. We've designed two kinds of assessment information: *Question Related* and *Question Group Related*. The latter has more than one conditions coming from different fields and questions:

(*Assessment* (*i*)   (3)

　　　　$\leftarrow$

(*answer*(*i*) *of question*(*j*),

… …))

The final assessment information is in Figure 5. Users can browser, download and print the assessment information in AM I READY system.
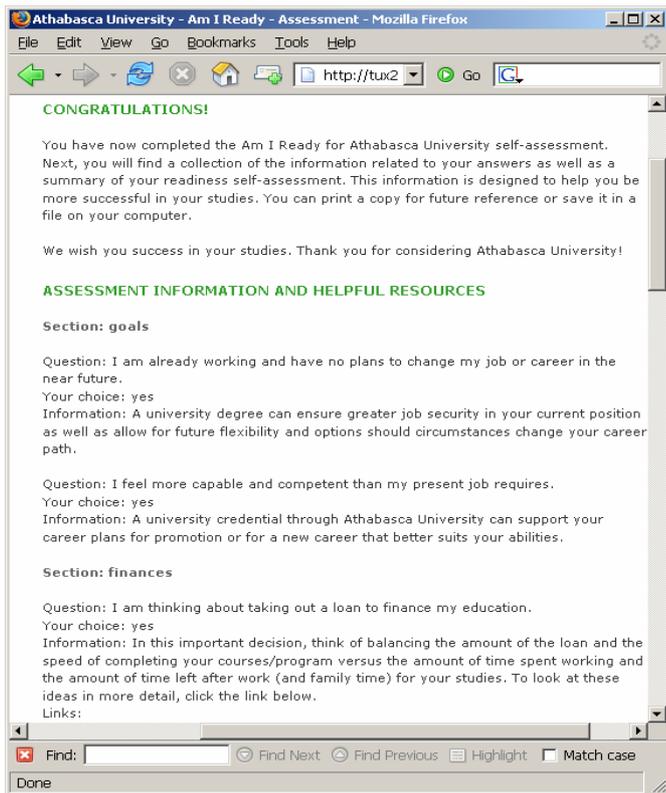
Figure 5. Assessment information

IV. System Structure And Realization

As mentioned above, AM I READY is a knowledge intensive system. We have modeled different knowledge with different representation. We can then use different expert or reasoning tools and methods to realize the self-assessment process. As it should be a stable and sustainable system serving to online users, and should be compatible with current information infrastructure of Athabasca University, we've tried to put the knowledge, including rules, relations, facts and text information, into PostgreSQL database, and to reason the questions to ask next by SQL and Java/JSP. The system structure is depicted in Figure 6, and the overall counseling or self-assessment process is depicted in Figure 7.
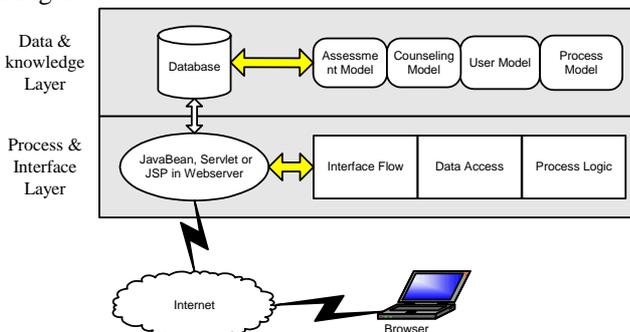

Figure 6. System structure

The system can be functionally divided into two layers: Data & Knowledge Layer, and Process & Interface Layer. All the data and knowledge are stored in the first layer with the help of database and SQL reasoning, while Java/JSP on the second layer handles the interface and interaction between the system and users. Users can online access the system by the Internet.
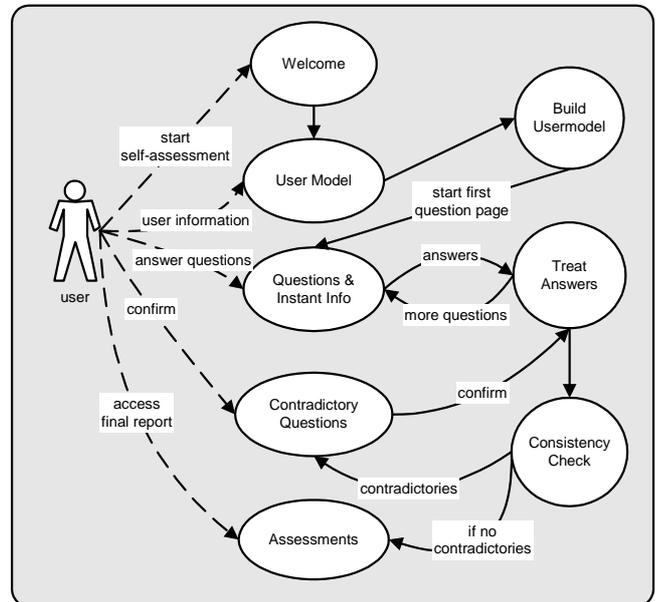

Figure 7. Information interactions among components

As you can see in Figure 7, a user can input user information at the beginning of the self-assessment. The system then builds the user model according to the inputted information. Based on the first filtered or arranged question sets, the system starts to ask questions and the user starts to answer those questions in turn. The system can ask new questions to the user after it accepts the user's answers and selects questions to ask by reasoning and sorting all currently available questions which are always changing to follow the direction to "model" or "understand" or "assess" the user. If there are no more questions to ask, the system is going to check answers to see if there are some contradictions among them. If yes, related questions are going to be sent back to the user for double check. After the contradictory questions has successfully confirmed, the final assessment information displays on the last page.

V. Conclusion and Future Works

Knowledge modeling in AM I READY project has captured different kinds of counseling knowledge and several models of self-assessment process, and has brought new features to traditional self-assessment online questionnaire system. Those features include flexible questions designing, user oriented or user specific questioning, dynamic and adaptive self-assessment process. Knowledge modeling, representation and reasoning have been proposed and implemented

in this project. Functionally, it provides a more effective and natural process to understand and assess its users. It can also provide real time guidance and remedial information to the users, which can be very helpful for the prospective students not only get to know their readiness, but also know how to improve the readiness.

The system is currently running and providing online services. However, we still have some work to do in the future. A knowledge editor is needed to improve the knowledge modeling and modification. A new change for improving the final representation of users' readiness by statistical information is on the way. A Formal knowledge description and a SQL based reasoning method for AM I READY are going to be reported in another paper. Data mining can also be done to analyze the questions and their relations and provide some information to improve the knowledge base. Readiness self-assessment is only the rudimentary step to a general counseling system, which we expect to intake more Psychology and Artificial Intelligence technologies to pursue the research and development on it.

Acknowlededement

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