DEVELOPMENT OF AN ADAPTIVE LEARNING SYSTEM APPLYING HOWARD GARDNER'S MULTIPLE INTELLIGENCES

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Abstract

This study developed an adaptive learning system applying Gardner's Multiple Intelligences. It supports adaption and reinforces individual learning. Existing learning systems provided with the same instruction content are able to show little consideration for individual learners. These learning systems do not, therefore, encourage individual learning; they fail to provide different instruction methods for differing learning styles. This proposed system provides instruction content based on an effective instruction method using Gardner's Multiple Intelligences by taking into consideration his or her individual intelligence type. We presented an adaptive learning system applying Gardner's Multiple Intelligences to social studies classes in an elementary school in Korea. Our developed adaptive learning system will contribute to effective learning which considers learner's individual differences.

Keywords

Adaptive learning system, multiple intelligences, individual learning, learning styles, personal learning

1 Introduction

Education has undergone significant changes, especially in the area of instruction strategies. The widespread use of information and communication technology allows teachers to access a larger variety of resources. Furthermore, students may use the Internet as a vast catalogue where used to complete the activities proposed by the teacher.

The variety of learning scenarios deriving from this change is breathtaking. As a consequence, students may now take a much more active role in educational experiences, and these experiences can be tailored to their preferences [1].

The biggest advantage of the computer in education lies in that it provides individualized learning [2]; therefore, the computer's individualization function must be enhanced further to increase the quality of the content. Most current courseware does not adequately consider the learner's preferential instruction methods or the learner's individual characteristics; students learn the same content, in the same manner, and in the same amount of time. Learning systems need to provide adaptive courseware that considers the individual's learning situation, learning objectives, learning history, and preferred learning style in order to maximize learning outcomes [3]. Most studies of adaptive learning systems support the adaptability of learning styles, but consider learning content in terms of learning achievement rather than the learner's learning style. In particular, when we compare web-based learning and classroom instruction, we can say that the adaptability of the learning environment is greater because the learners' backgrounds, abilities, and learning styles are much more diverse; and because it is an independent learning environment in which the teacher's support and guidance cannot be expected during the course of learning [4]. We therefore need to provide adaptive learning systems with greatly enhanced personalized education.

In past decades, researchers from different disciplines have intended to define and classify learning styles that help teachers to improve their

This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2011-327-B00527).

individualized teaching. There are many learning style theories used today, and the learning style theories have been applied widely in educational environments [5]. Currently, many researchers agree on the importance of modeling and using learning styles; however, there is little agreement in which aspects of learning style are worth modeling, and what can be done differently for users with different styles[5][6]. Moreover, the relationships between learning styles and possible interface settings are still an unclear area [5][6].

Multiple intelligence theory, which is currently newly emerging in the field of cognitive psychology learning is providing clues for new methodologies that can implement important educational criteria such as the development of human potentials, learner focused educational curricula, respect for personality and admittance of individual differences, learning motivation, and individualized lessons. Since people are born with diverse intelligences, the provision of appropriate classes and learning environments can generate a high level of achievement ability [7].

This study focuses on presenting the instruction content more individually and making it more subject to the learners' learning style. Appropriate content is presented after diagnosing the learner's intelligence through the use of Gardner's Multiple Intelligence questionnaires. The aim is then to design a system that can supply the most effective method for each learner after consideration of his or her preferred intelligence, though the ultimate goal may be the same.

Table 1. Instructional materials and learning activities for online learning

Type of Intelligence	Instructional strategies suggested by Gardner	Instructional materials for online learning	Learning activities for online learning
Linguistic	- Read - Write - Talk - Listen	- Texts - Audio recorder/editor - Audio/video clips, players	- step-by-step lecture -discussion through email, bulletin boards, chat rooms, and teleconferences - storytelling
Logical-Mathematical	- Quantify - Think critically - Conceptualize	- Calculator programs - Math games - Simulation programs	- Computational games - Simulation games
Spatial	- See - draw - visualize - color - mind-map	- graphs, maps - video clips, players - digital cameras - image clips - simulation programs	- analyze diagrams - draw maps - create videos - virtual reality activities
Bodily-Kinesthetic	- build - act, touch - intuition - dance	- video clips, players	- show videos - follow the videos - group project activities - teleconferencing
Musical	- Sing - Rap - Listen	- Audio/ video clips, players, recorders - Instrument simulation programs	- Listen to audio or watch videos - Sing along - Play virtual instruments
Interpersonal	- teach - collaborate - interact	- role play games -teleconferencing programs	- role play activities - teleconferencing - simulations -community involvement - group project activities
Intrapersonal	- connect to personal life - make choices	-self-checking programs	- individual project activities - self-tests

2 Theoretical backgrounds

This chapter will describe Howard Gardner's Multiple Intelligence concept and adaptive learning systems as background theories.

2.1 Multiple Intelligences

Dr. Howard Gardner, a professor at Harvard University proposed the theory of Multiple Intelligences, in 1983. He suggested that traditional IQ tests were biased or too limited. In their place, he proposed that there were at least seven different intelligences to account for the broad range of human potential in children and adults. He described these intelligences as Linguistic, Logical mathematical, Spatial, Bodily Kinesthetic, Musical, Interpersonal, and Intrapersonal [8]. He later recognized the existence of another intelligence-Naturalistic and has discussed the possibility of a ninth, an existential/spiritual intelligence. In Gardner's view, traditional IQ tests were focused rather unfairly on measuring just two types of intelligences: Linguistic and Logical/Mathematical. Gardner categorized intelligence and Armstrong matched these intelligences with appropriate instructional strategies [9]. Gardner emphasized that individuals should be encouraged to use their preferred intelligence. He believed that different instructional activities and various ways of assessment for the multiple forms of intelligence needed to be designed and applied to learning [9]. Table 1 summarizes the possible effective instructional materials and learning activities for online learning by matching the instructional strategies suggested by Gardner [8] and Youngok Lee [10]. Our system applied these treatments in Table 1.

According to individual differences, online courses can offer different study guides based on learners' prior experiences and learning styles, and can offer different examples and assignments based on the students learning styles toward a goal. Learners can be required to interact with content, instructor, and peers in different ways based on their individual characteristics.

2.1.1 Limitations of Multiple Intelligence

It is undeniable that individualized attention and support enhances learning [11]. Multiple Intelligences requires thinking about types of experiences that tap into a range of intelligences as required by good teaching practice, but this is time consuming, especially in a large class [12]. Fortunately, the growth of the Internet, web tools, and access provides the perfect vehicle to drive this personalization [13]. In this light, an adaptive learning system has been proposed by many as a way to accommodate this situation in order to create e-learning content that may be used in the adaptive learning context or indeed outside such a system. It is still necessary to provide some sort of framework within which instructional designers can work to create Multiple Intelligences informed learning content. The aforementioned technologies provide a way to do this; some of these include voice tools, blogs and wikis, discussion forums, and second life.

2.1.2 Multiple Intelligence and Learning Styles

It is necessary for us to point out that the concept of Multiple Intelligences is different from that of learning styles, which is what is accommodated in current practices of ID for e-learning. Learning styles reflect an individual's preferences and choices in a learning situation and encompass a range of factors that includes cognitive styles [14], while Multiple Intelligence theory begins with a learner responding to different kinds of content [8]. In educational circles, the terms "Intelligences" and "Learning styles" are sometimes used to replace each other when in fact they refer to different quantities and fundamentally different psychological matters.

2.2 Adaptive learning

The term 'adaptive learning system' refers to educational interventions aimed at effectively accommodating individual differences in students while helping each student develop the knowledge and skills required to learn a task. Adaptive learning is generally characterized as an educational approach that incorporates alternative procedures and strategies for instruction and resource utilization and has the built-in flexibility

to permit students to take various routes to, and amounts of time for, learning [15][16].

Currently, several systems providing adaptation according to users' learning styles have been created [17] [18] [19] [20][21]. Most of the adaptive learning systems that incorporate learning styles are based on the notion that matching the learning strategies with the learning styles improves learner performance. Table 2 presents some of the existing systems and the learning styles that they implement [22].

Table 2. Learning styles OF adaptive systems

System	Learning Style	Base theory
ARTHUR	visual-interactive, auditory-lecture, and text	Vark
iWeaver	auditory, visual, kinesthetic, and impulsive	Dunn and Dunn
CS388	global-sequential, visual-verbal, sensing-intuitive, and inductive-deductive	Felder-Silverman
AEC-ES	field-dependent, field-independent	
LSAS	global-sequential	Felder-Silverman
MANIC	graphic-textual	
INSPIRE	activists, pragmatists, reflectors, and theorists	Kolb
Tangow	sensing-intuitive	Felder-Silverman
MOT	diverger, converger	Kolb
OPAL	activists, pragmatists, reflectors, and theorists	Kolb

In ARTHUR [23], iWeaver [18], CS388 [24], and MANIC [25], the adaptation is achieved by providing different media representations for each learner. ARTHUR and iWeaver are very similar in choice of learning style representation. Auditory representation is achieved using sounds and streaming audio. To appeal to visual and kinesthetic learners, puzzles, animations, drag and drop examples, and riddles are used. CS388 uses different types of media such as graphs, movies, text, and slideshows. Similarly, MANIC uses graphic and textual information. In LSAS (Learning Styles Adaptive System), the sequential learners are provided with advanced organizers, maximum instruction and feedback, and more structured lessons. Global learners are guided symmetrically via overviews and summaries of lessons. In the more recent Tangow [26] and INSPIRE [27] systems, adaptation lies in presenting a different sequence of alternative content of the concepts. Our proposed system applied Gardner's Multiple Intelligences for adaptive functions instead of the general learning styles of Table 2.

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3 Development of the Adaptive learning System

In this chapter, we will describe the system structure and system operations with screen shots.

3.1 Applying principle

We will mention our base theory for the adaptive learning system framework and Gardner's treatment activities for each learning style in our proposed adaptive learning. Our system has

distinctive features when compared with existing learning systems.

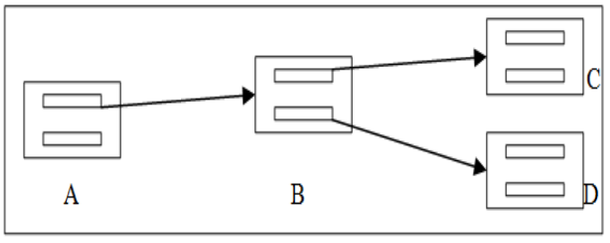

Figure 1. Traditional learning system

As shown in Figure 1, a traditional learning system presents paths of instruction for learners, nodes A, B, C, and D; but our system finds the most effective path among B1, B2, and B3, instead of using a simple node B as shown in Figure 2.

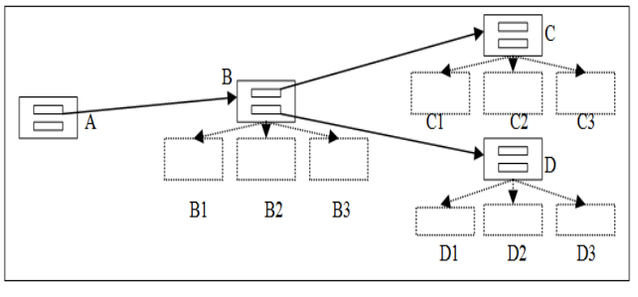

Figure 2. Adaptive Learning System

An adaptive learning system considering Learning Style is BI, B2, and B3 contains the same content, but different methods of instruction. Additionally, one of C1, C2, and C3 is presented instead of a simple node C. Thus, while the traditional learning system has provided learners with learning paths A-B-C or A-B-D without considering learning styles, the proposed system can present a wide variety of learning paths: A-B1-C1, A-B2-C2, A-B3-C3, A-B1-D1, A-B2-D2, A-B3-D3, etc., according to learning style. Our proposed system applied these features using Gardner's Multiple Intelligences.

3.2 Environment of Implementation

The environment of implementation is indicated in Table 3. We implemented the adaptive learning system by using Flash and PHP. In addition, we used Mysql as database management system used Apache as sever system.

Table 3. Environment of courseware implementation

Division	Environment of Implementation	
Server	O/S	Red Hat Linux 9 kernel 2.4.32
	WebServer / DB	Apache / Mysql
	Programing	PHP / Flash Action Script
Client	O/S	Windows 9X, 2000, XP
	Brower	Above Internet Explorer 5.5
	plug-in	Flash running plug-ins are needed

3.3 User Registration

An adaptive learning system that applies Gardner's Multiple Intelligences evaluates the particular intelligence of the learners and must attain the relevant value. In order to store multiple intelligence evaluation and learner information on a database and to approach an adaptive learning system with the application of Multiple Intelligences, a table structure is formed into 13 fields and specifies for generation in the same way. In the user confirmation process, if the learner is not identified as a user, he or she must proceed to the user registration screen and insert personal information. This is to identify the members' particular intelligence evaluation and to store the evaluation value on the web database. In the log-in, if the value resulting from the evaluation of existing particular intelligence is stored in the database in the same way, the three outstanding multiple intelligence domains are introduced in order at the same time as the log-in. Scores can be seen for each intelligence. If one is registered, but has no data value regarding the particular intelligence evaluation results, then guidance should be provided so that the learner can receive multiple intelligence inspection.

3.4 Multiple intelligence evaluation

In the multiple intelligence evaluation to provide the most appropriate intelligence instruction, there are seven questions for each of the seven domains.

Evaluation is conducted by using the forty-nine questions as indicated in Figure 3. Evaluation time is somewhat different for each learner; but it usually takes about 15 minutes, and the questions are mixed for each intelligence. After reading the evaluation content in order, a button for the relevant five-staged checklist scale table is pressed in order for the evaluation to take place.

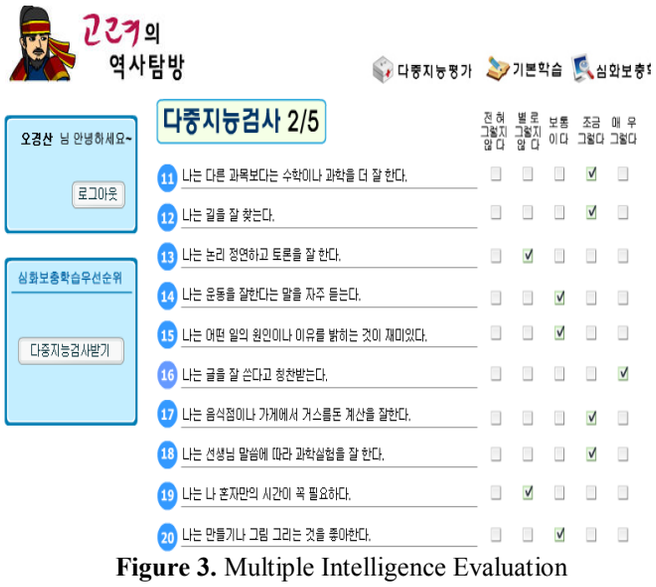

Figure 3. Multiple Intelligence Evaluation

As shown in Figure 4, after the evaluation sequences are completed, the three outstanding intelligence types with highest scores among the multiple intelligences are guided in order that selected learning may be generated. In addition, scores can be seen for each intelligence area, and learning is conducted in the basic learning area after the multiple evaluations are complete.

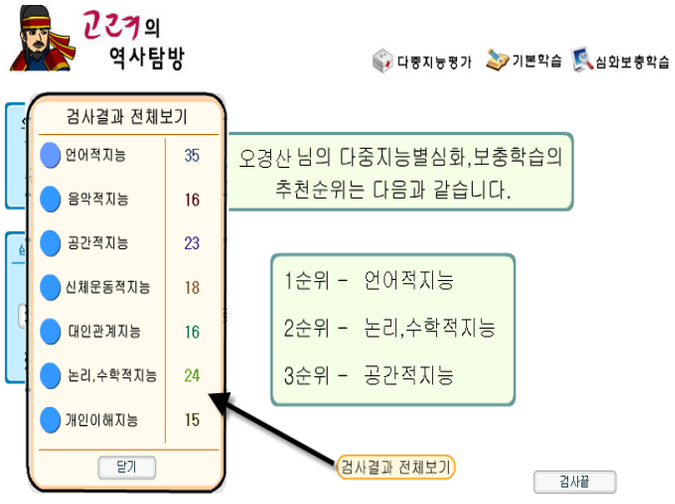

Figure 4. Result of Multiple Intelligence Evaluation

3.5 Provide learning with proper intelligence

When the main menu located above it selected, the screen for learning more, which is the learning associated with each multiple intelligence, appears in the same way as in Figure 5. By basing on the multiple intelligence evaluation results displayed on the left side of the screen to select the appropriate intelligence, outstanding multiple areas needed for the learner are displayed in order of 1st, 2nd, and 3rd ranking. The learner can look at the recommended ranking and select the appropriate outstanding intelligence; then, move on to the selected learning. When the 'view all inspection results' is selected, the score for the multiple intelligence evaluation is shown for each of the seven intelligences.

Figure 5. Menu Screen for adaptive learning

In the selected learning screen, the outstanding intelligence domain of 1st to 3rd ranking, as shown in the multiple intelligence evaluation results, is selected and selected learning takes place. If, for instance, linguistic intelligence comes out in the ranking of outstanding intelligence, linguistic intelligence is selected for the learner in order that the instruction be expressed through speech and writing during the learning. A learner who selects spatial intelligence applies mind mapping to the instruction. In addition, learners who select logical-mathematical intelligence utilize numbers effectively or conduct learning that applies inferring abilities and logical thinking skills. Because of the characteristics of the adaptive learning system, in order to conduct self-directed learning, selected learning for each intelligence is guided so that the learner can select and conduct more self-directed instruction. Our system provides content for each learner that considers his or her outstanding intelligence. We will describe three adaptive learning instructions in the next section: for linguistic intelligence, logical-mathematical intelligence, and for spatial intelligence.

3.6 Learning through Linguistic Intelligence

When linguistic intelligence is selected, learning that applies the learners' linguistic abilities are conducted. Linguistic intelligence refers to the ability to effectively implement language that can be expressed through speech or writing.

This is the kind of instruction that is based on linguistic intelligence and shows an appreciation of the people who brightened the history of Korea. The learning method is implemented by selecting ‘one’, and involves writing in text on a ‘paper’ figure that is like a letter format. It is a text insertion format, so text revision is possible. In addition, since the scroll bar automatically goes down in the case of longer writing, learners can write longer texts. After writing the text, the learner can print the text that he or she has written. The learning screen of for the linguistic intelligence domain is shown in Figure 6.

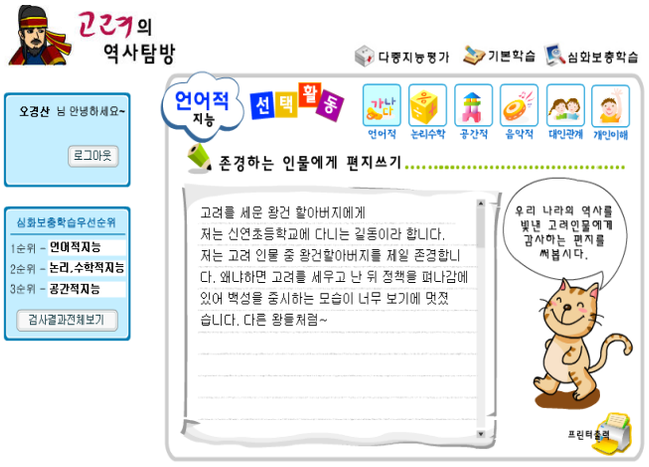

Figure 6. Learning for Linguistic Intelligence

3.7 Learning through Logical-Mathematical Intelligence

When logical-mathematical intelligence is selected, instruction that applies to a logical and mathematical ability is implemented. Logical-mathematical intelligence effectively uses numbers and has inferring abilities and logical thinking skills. In this domain, events are distinguished and collocated in order of time period and suit the chronology. This is the kind of instruction that is based on logical-mathematical intelligence. This learning method follows the line with the written year and event, and takes the given figure and related event title listed in a circle located in the bottom and drags it to the chronology line with a mouse. Answers can be checked after dragging is complete. The instruction for the logical-mathematical intelligence is shown of Figure 7.

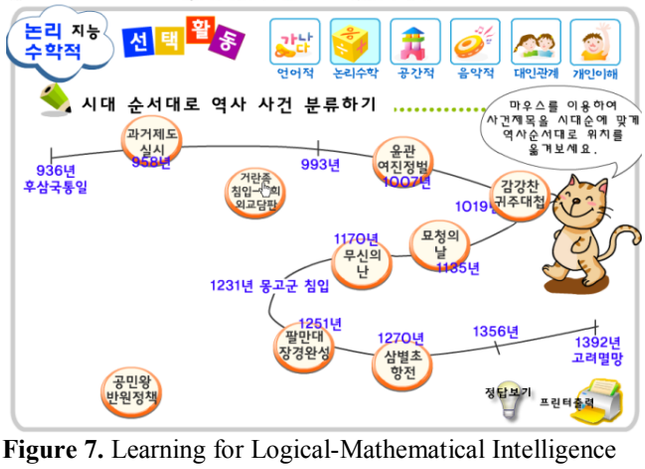

Figure 7. Learning for Logical-Mathematical Intelligence

3.8 Learning through Spatial Intelligence

When spatial intelligence is selected, instruction that applies spatial abilities is conducted. Spatial abilities are the abilities that can accurately perceive the spatial world, and uses the ability to change forms through these perceptions.
In this domain, mind mapping takes place with general knowledge of Korean history and is a form of instruction that conducts learning based on spatial intelligence. For the learning method, prior knowledge learned about Korea history in the basic instruction is used to create a mind map about Korea history.
First, circles and the branches are transferred to appropriate locations, and titles for the major branches (historical events and figures, lifestyle, cultural asset, etc.) are inserted.
After recording the major branches, sub branches are created and titles are inserted in the circles. After generating the mind map, learners can print out what they have created. The learning screen for spatial intelligence is shown as Figure 8.

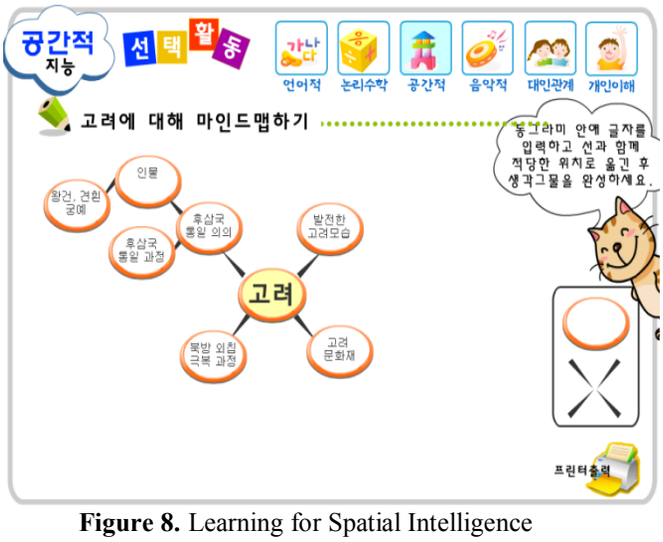

Figure 8. Learning for Spatial Intelligence

4 Conclusions

This study deals with the development of a system that can find the most effective method with which to provide instruction according to learners' preferences and individual 'intelligences'. We presented an adaptive learning system that applied Gardner's Multiple Intelligences to social studies instruction for elementary school students. Our work shows how the learner performed individual learning that considered his or her preferences and shows how Gardner's Multiple Intelligences can be incorporated into an adaptive learning system.
This system has distinguishing features that support efficiency. The expected effects in the application of this system are as follows:
First, this study was implemented in a way such that the learners' interests and individual differences were considered, and that the outstanding intelligence relevant to multiple intelligence evaluation results was recommended. It allowed the learners to find suitable instruction according to Gardner's Multiple Intelligences and using instruction based on logical-mathematical intelligence, interpersonal intelligence, spatial intelligence, bodily-kinesthetic intelligence, or musical intelligence.
Second, the system allows the learner to evaluate his or her own intelligence using the multiple intelligence evaluation tool and displays which intelligence shows outstanding aspects by suggesting the three most outstanding intelligences in form of a recommendation form instead of displaying the results through numerical figures. This is done so that the learner can, him or herself, select the learning style when he/she is conducting the instruction.
Third, the use of Multiple Intelligence is not restricted to Social Studies. Instead, this tool can be applied to subjects such as Korean language, Science, and English.
In the future, we need to study with more dynamic linking methods in order to support changes in learning styles which occur while the learners are studying. Furthermore, we need to develop more mathematical diagnostic algorithms that evaluate a learner's learning style. We need to provide various learning styles to achieve effective learning that considers learning objectives and subject domains. We also need to develop adaptive learning systems that will support not only learning styles but also motivation or other aspects of educational methodology. Finally, we need to integrate ontology and adaptive learning to

support adaption and instruction content representation.

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