High level intelligence through horizontal and vertical networking of tutoring applications

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ABSTRACT

The research on Intelligent Tutoring Systems (ITS) has shown that the top-down approach used by traditional ITSs has not been able to satisfy all the student, teacher, curriculum and institutional needs and requirements [2]. To this end, Intelligent Tutoring Tools (ITTs) were developed [1]. The ITTs have rather narrow focus even if they encompass all the typical elements of an ITS. This paper describes how the integration of ITTs can lead to higher-level intelligent applications that provide all the benefits of traditional ITSs, circumvent the problems of traditional ITSs, and provide additional benefits arising from the modular structure and reusable coding.

INTRODUCTION

In old times, tutors were chosen to be the personal guardians, and their responsibility was to superintend the conduct and the expenditure of the students. They had no more tools to teach students than face-to-face teaching during those times. Nowadays the situation has greatly changed and a tutor has many choices regarding tutoring tools, especially in computer-aided tutoring areas.

The intelligent tutoring systems (ITSs) were developed as computer-based training systems which emerged from the combination of Computer-Aided Instruction (CAI) and Artificial Intelligence (AI) technology, and they incorporate techniques for communicating or transferring knowledge and skills to students [4]. These ITSs provided many benefits for education through adapting the curriculum to each student and allowing self-directed learning [5]. However the disadvantages of ITSs limit their development. For this reason, many researchers tried to find out an approach where the limitation can be improved or removed. The Intelligent Tutoring Tool (ITT) is just one of the approaches designed to reduce the limitation.

An individual and adaptive intelligent tutoring system has been developed to satisfy the goals of the intelligent tutoring systems. Distinguishing it from the conventional Intelligent Tutoring System (ITS), Intelligent Tutoring Tool (ITT) is introduced to the new individual and adaptive intelligent tutoring system.

However, to solve a more difficult and complicated problem, such a basic intelligent tutoring tool is not enough. A more powerful tutoring tool – a high level intelligent tutoring application is required to be constructed. This paper tries to describe the construction of an adaptive high-level intelligence through horizontal and vertical networking of tutoring application.

THE EVOLUTION OF INTELLIGENT TUTORING TOOLS

Traditional Intelligent Tutoring System (ITS)

Traditional intelligent tutoring system (ITS) designers have attempted to provide tutoring facilities that try to satisfy all of the student, teacher, curriculum and institutional needs and requirements [2]. However this has to be approved an immense task and to be hard to carry out. Since achieving this level of complexity by designing ITS top-down is almost an impossible task, it would be useful to view the highly complex system as being made up of smaller entities that are networked. When this smaller entity has a degree of intelligence, it is an intelligent system of a lower order. An individual and adaptive intelligent tutoring system has been developed to satisfy the goals of the intelligent tutoring systems. Distinguishing it from the conventional Intelligent Tutoring System (ITS), Intelligent Tutoring Tool (ITT) is introduced to the new individual developed and adaptive intelligent tutoring system.

An Individual Intelligent Tutoring Tool (ITT)

While a traditional Intelligent Tutoring System (ITS) attempts to be fairly comprehensive and covers enormous chunks of a discipline's subject matter, a basic ITT has a narrow focus. It focuses on a single topic or a very small cluster of related topics. [3].

The ITTs were first introduced in Byzantium project, a consortium of six universities obtained substantial funding from the UK'S teaching and Learning Technology Programme in order to develop tutoring software for introductory accounting. The prototype was developed in order to demonstrate utility of applied artificial intelligence to student learning. Unlike traditional intelligent tutoring systems that attempt to outperform a human tutor and claim improved learning, the Byzantium project produces intelligent tutoring tools (ITTs) that extend a lecturer's scope. It supervises the development of operational skills, and assigns them to a computer tutor. This can be recognized that computers are only one of the educational technologies applied in a learning environment. This recognition may cause a shift away from comprehensive ITSs to ITTs that can be mixed and matched with other educational technologies and human teachers in various configurations in order to

create a computer integrated learning environment (CILE) to suit classroom-based, open and distance learning strategies [2].

High Level Intelligence Tutoring Application (ITA) through ITTs

While an individual ITT focuses on a single topic or a very small cluster of related topics, combining various ITTs into an ITT Networks can enlarge the scope of an individual ITT. An ITT may thus be regarded as a building block of a larger and more comprehensive tutoring system. It may also be mixed and matched with other technologies (e.g. video or audio) as well as human teachers, in various configurations of Computer Integrated Learning Environments (CILE) to suit classroom based, open and distance learning [3]. The higher level intelligence through the integration of horizontal and vertical networking of tutoring applications, short in Intelligent Tutoring Applications (ITAs), are based on this theory and integrate ITTs in two directions: vertical and horizontal.

MAIN FEATURES IN THE ADAPTIVE HIGHER LEVEL ITAS

Vertical integration (Ranking)

The vertical integration allows holding and comparing results of different instances of an ITT, e.g. comparing five different investment proposals in a Capital Investment Appraisal domain.

Horizontal integration (Linking)

Horizontal integration allows use of multiple ITTs to solve a given problem, e.g. Marginal Costing ITT providing contribution figures for maximizing profit in a Linear Programming ITT. The sequential relationship of different domains is not necessary in this integration. The relationship between different ITTs can be parallel or even independent.

Modular structure

The modular structures are created in the ITAs. The database is at the core of the network of ITAs. All the adaptive higher level ITAs or low-level ITTs and the console that administrates the database are connected to the database can be used standalone, independently of each other. Figure 1 shows the relationship between ITTs, ITAs, a database which stores all the information of different level intelligent tutoring systems and a console which controls and maintains the database. The person who may be a lecturer or a tutor or anyone who has authority to access to the database can administrate and maintain the database.

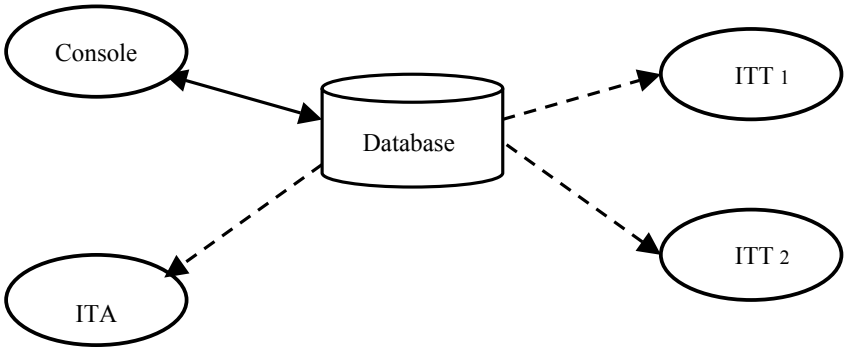

Figure 1. The relationship between ITA, ITTs, Console and Database

Centred database structure

The database as shown in figure 1 is in the centre of the whole system. All the information those including the labels on the buttons, names of variables, the calculative relationship between the variables or operators between variables, learning and testing information, and users' information etc. for ITTs and ITAs are stored in the database. This benefit makes an ITA can asks for the information from a basic ITT directly rather than to contact to a basic ITT.

Reusable coding

A new ITA can be created only by adding new information into the database, while using existing code for interface and other components of the ITA. Because the adaptation in ITAs are used either at the interface level (the labels on the buttons, names of variables, the calculative relationship between the variables or operators between variables, learning and testing information, and users' information etc. are stored in the database) or at the logical level (adaptive presentation and adaptive navigation).

Independency and reliability

Though an ITA is based on the basic ITTs through the information stored in the database, each ITA is independent or isolated from the ITTs. When an ITA asks for the information that is provided by the basic ITTs and stored in the database, the ITA can interact with the database directly. The independency makes the development and maintenance of the ITAs and ITTs easier and more straightforward. Any problems or mistakes within an ITA or an ITT do not affect while network. It provides a high reliability for the whole network of the system.

Security management (the function of console)

A console is developed to maintain and administrate the centre database. Only the people who have the authority to access the database (may be a lecturer or a database administrator) can modify it. Otherwise nobody has chance to try to change any information in the database. It presents a high security management for the whole high level intelligent tutoring system.

IMPLEMENTATION OF ITAS

The implementation of higher level intelligence of tutoring application is done by integrating two separate parts: vertical integration (ranking) and horizontal integration (linking). Vertical integration part integrates an ITT several times (as ranking) whereas the horizontal integration part integrates different ITTs (as linking) (figure 2).

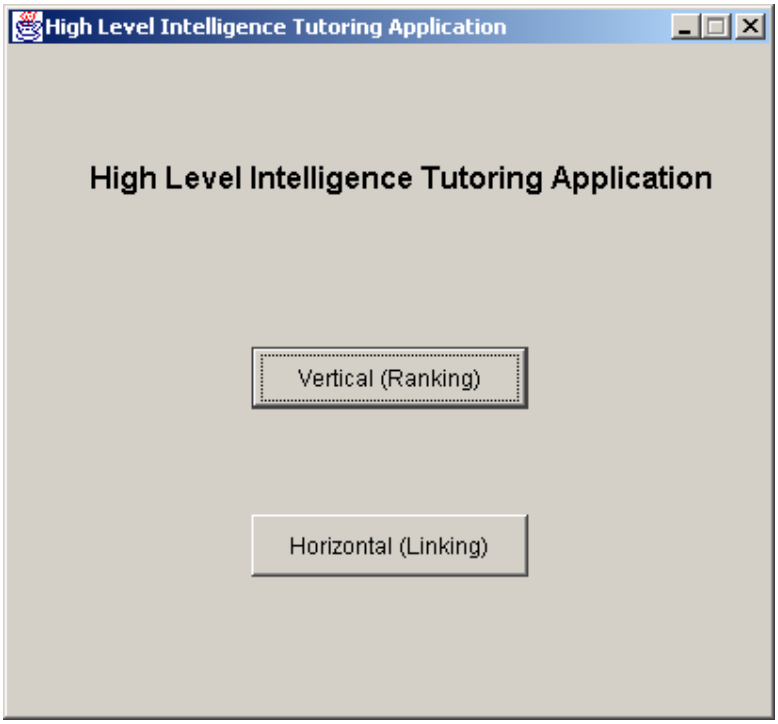

Figure 2. Initial ITA interface

VERTICAL INTEGRATION

When vertical (ranking) is selected, an interface containing names of all existing ITTs is displayed. User can then select one ITT to create its different instances for ranking

purposes. For example, if the Marginal Costing ITT is selected, an interface similar to figure 3 appears.

User is then required to select a variable on which the ranking process will be based. As soon as the user selects the variable, the system provides space for inputting the values of the variable that would calculate the selected variable. After the values are entered and the "Calculate" button is pressed, the ranking results interface pops up as shown in figure 4 and the ranking results will be displayed on the interface.

The project name, variable value, and the project rank order are displayed in this form. "More Project" button then allows ranking as many projects as required. By repeating the same process, all the values of different projects can be obtained and all the ranking numbers are displayed on the interface as shown in figure 5.

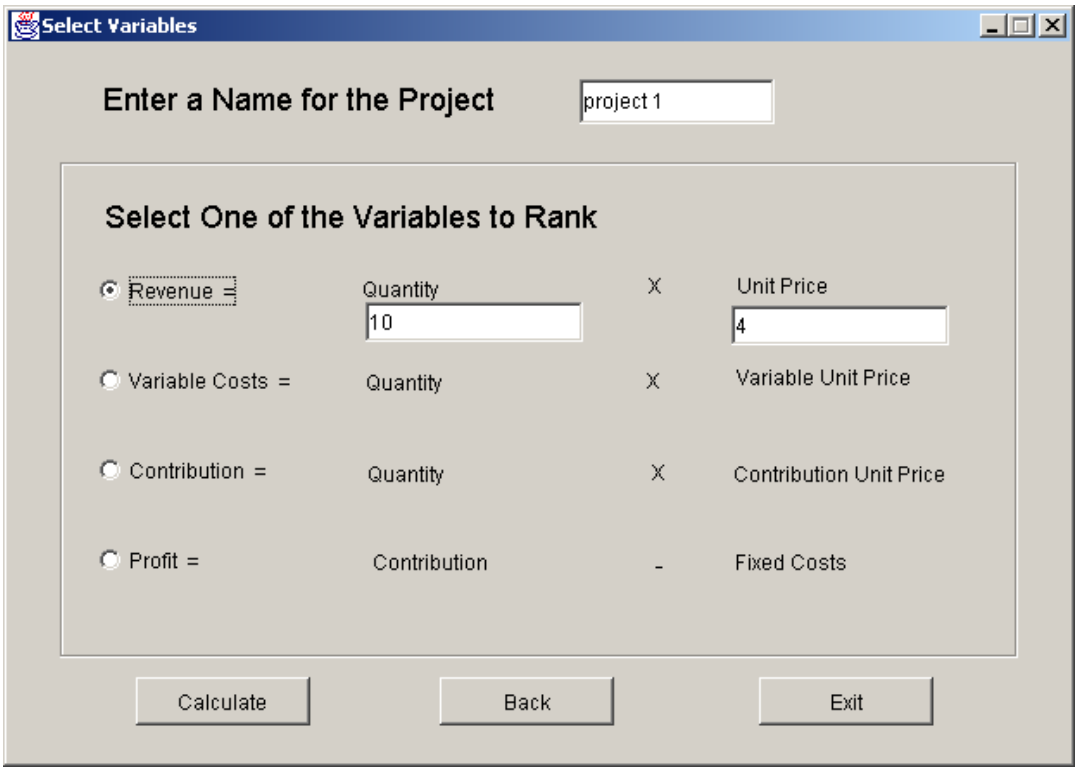

Figure 3. Marginal Costing ITT interface for vertical ranking

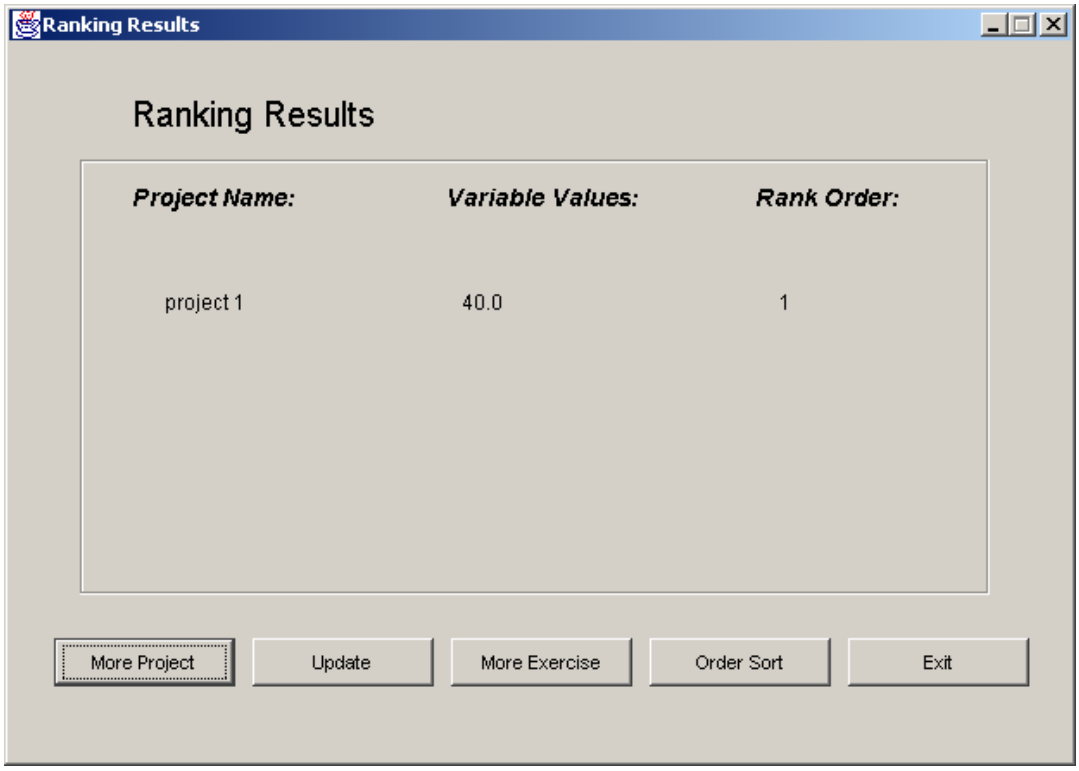

Figure 4. Ranking results

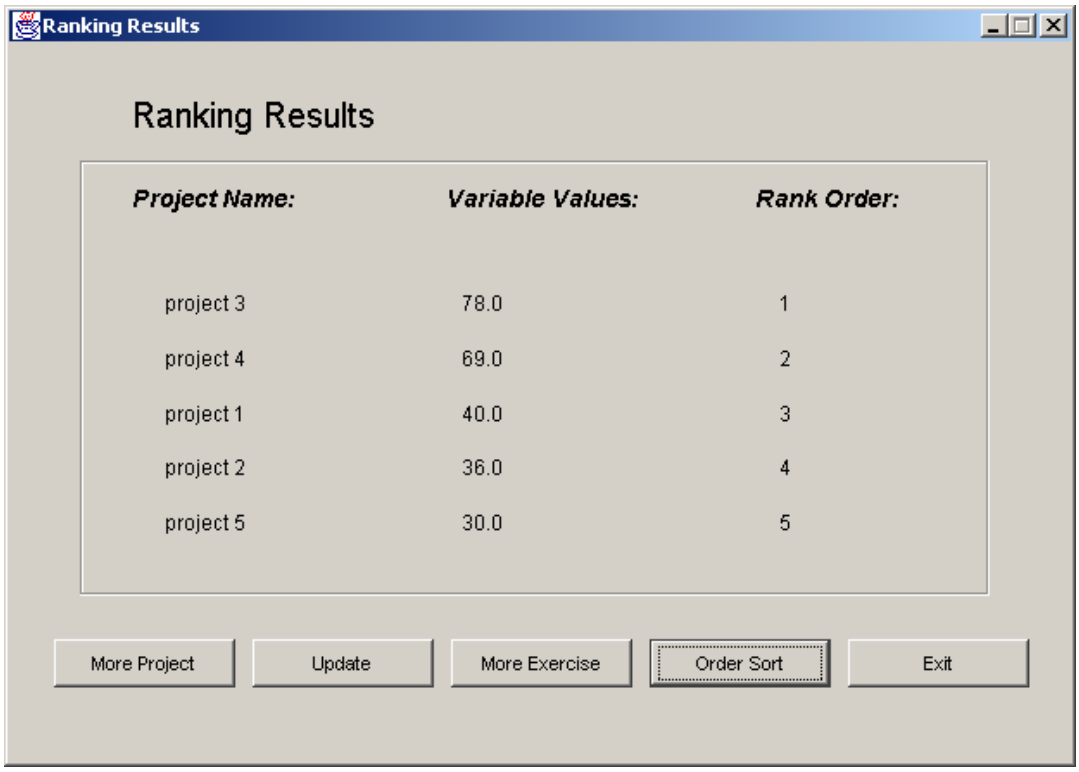

Figure 5. Ranking results of multiple projects

The rank order could be sorted when the "Order Sort" button is pressed. If there is any need to correct any data, the "Update" enables the user to modify the input. More exercises of vertical (ranking) can be accessed by pressing the "More Exercise" button.

HORIZONTAL INTEGRATION

The horizontal (linking) interface allows the use of multiple ITTs to solve a particular complex problem. The interface of horizontal (linking) integration is shown in figure 6. The problems that need to be solved by linking different ITTs are displayed as the questions in this interface and they are stored in the database. The interface allows the calculation of certain variables by accessing low-level ITTs. Of course, a value could be input directly if it is already known.

In that interface, the final answer of horizontal (linking) could be obtained by entering the values into the field boxes directly and pressing the "Get Anser" button, or by selecting a proper value that needs to be obtained from an individual ITT and then pressing the "Get Answer" button.

Once the user presses the "Get Value" button, an interface lists all existing ITTs for the user to select the one which should calculate that value. For example, if an ITT (calculating area) is selected then the calculation interface of "Area" ITT is shown as in figure 7.

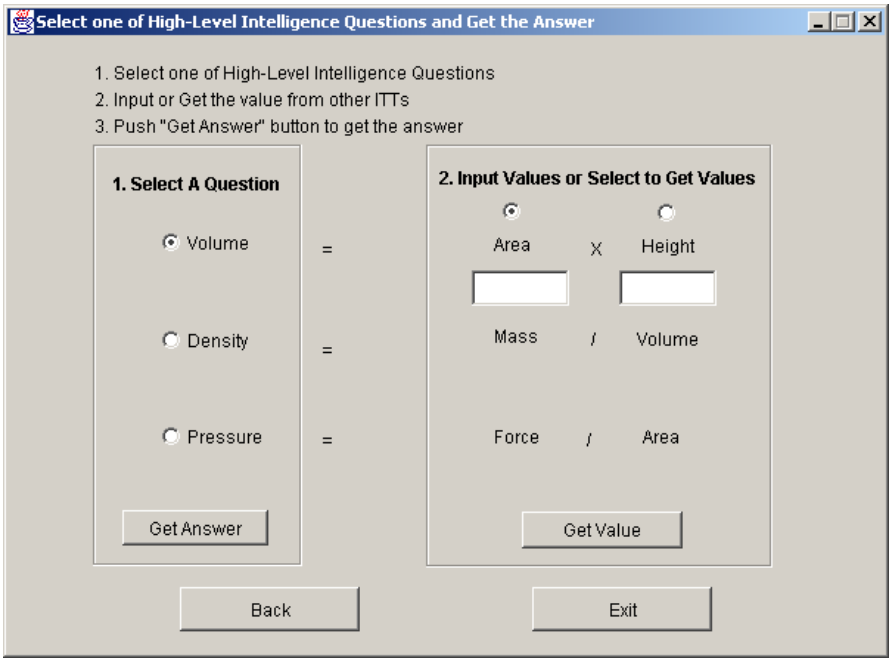

Figure 6. Horizontal (linking) integration

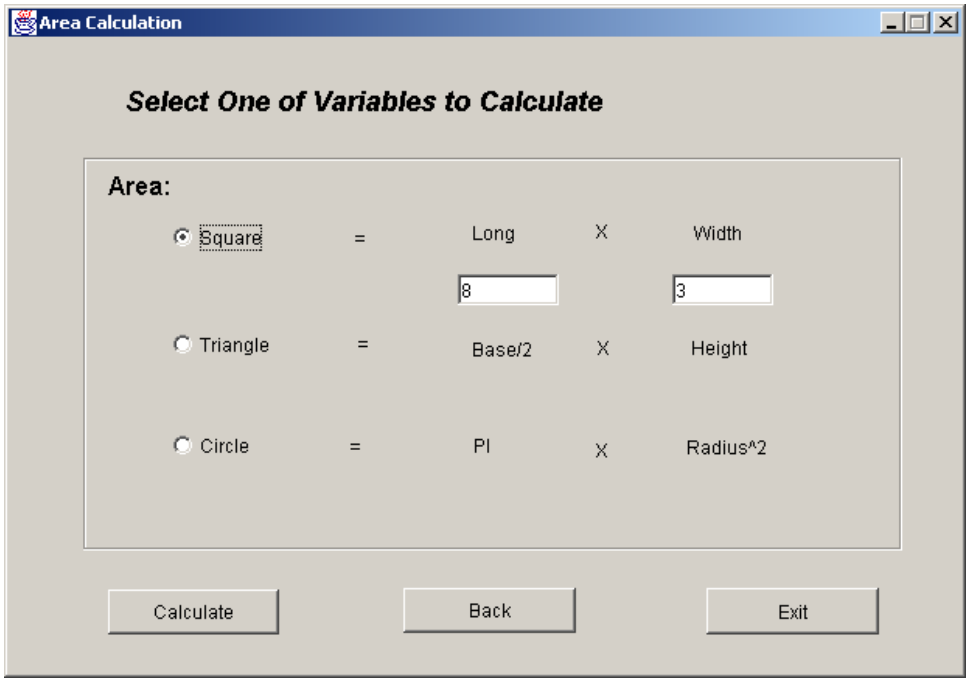

Figure 7. The Area ITT

The area could be calculated through different formulae such as square, triangle, circle, and so on. The calculated value is then transferred into the interface of original horizontal (linking) integration. The final answer is then displayed as soon as the user presses "Get Answer" button (figure 8).

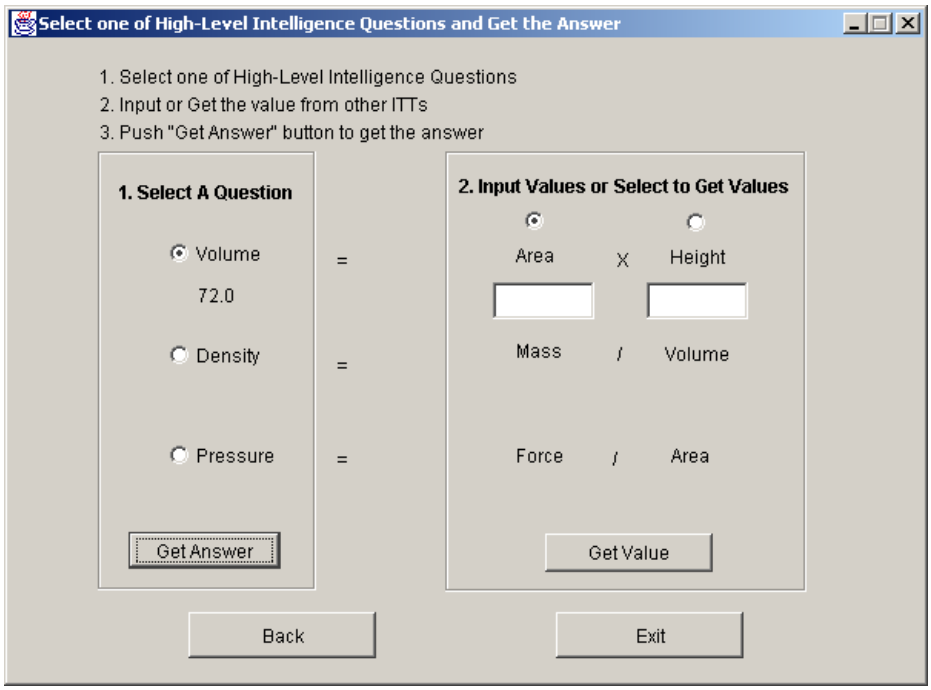

Figure 8. Final answer in horizontal integration

FUTURE WORKS

The eventual target of high level intelligent tutoring system is to help students to take tutorials to solve real world problems. This tutoring system could be extended to the actual high-level intelligent application for a real world problem by the same methodology. Qualitative, probabilistic and noisy data that represent behavioural and environmental factors such as psychological affection, risks and political factors will be added.

CONCLUSION

The above contributions of this research project basically carry out the objectives of this research project. The divide and conquer strategy is applied by the construction of higher-level intelligent tutoring application. A complex intelligent tutoring system can be broken down into small pieces that focus on single topics. The complex intelligent tutoring system can be assembled through the integration of vertical and horizontal directions. The modular structure, centred database structure, reusable components and adaptive functions are also employed in the higher-level intelligent tutoring application. A new higher-level intelligent tutoring application is easily created because of the above structures. The higher-level intelligent tutoring application can be used at a fairly basic level of learning process nowadays.

Although the prototype displays the potential of the approach, it is still at a distance from real world problem solving. It is hoped that the methodology of the adaptive modular structure of the higher-level intelligent tutoring application through networking can provide an approach to break down the complexity of problems, and solve more difficult problems than traditional ITSs. A real world problem-solving program is planned in the near future using the same methodology. The program may combine the existing adaptive high level ITAs with behavioral and environmental factors such as psychological affect, risks and probability factors.

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