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Ali O. Mahdi
Department of Information Technology, Faculty of Engineering & Information Technology Al-Azhar University, Gaza, Palestine

Mohammed I. Alhabbash
Department of Information Technology, Faculty of Engineering & Information Technology Al-Azhar University, Gaza, Palestine

Samy S. Abu Naser
Department of Information Technology, Faculty of Engineering & Information Technology Al-Azhar University, Gaza, Palestine

Correspondence:
Samy S. Abu Naser
Department of Information Technology, Faculty of Engineering & Information Technology Al-Azhar University, Gaza, Palestine

An intelligent tutoring system for teaching advanced topics in information security

Ali O. Mahdi, Mohammed I. Alhabbash, Samy S. Abu Naser

Abstract
Recently there is an increasing technological development in intelligent tutoring systems. This field has become interesting to many researchers. In this paper, we present an intelligent tutoring system for teaching information security. This intelligent tutoring systems target the students enrolled in Advanced Topics in Information Security in the faculty of Engineering and Information Technology at Al-Azhar University in Gaza. Through which the student will be able to study the course and solve related problems. An evaluation of the intelligent tutoring systems was carried out and the results were promising.

Keywords: Tutoring System, Teaching, Information Security, Expert System, and E-learning

Introduction

Computers have been used in education for more than forty years. The computer-based training and computer-aided instruction consider as first systems that were using a computer in teaching [8,9,10]. These systems were not specified for individual learner needs but it was for decisions that are concerning movements of students inside the scientific material, which was governed, in pre-planned form. Therefore, the capabilities of the learner have not been taken into account. Despite the efficiency of Computer-Based Training (CBT) and Computer Aided Instruction (CAI) systems in helping learners, it did not provide individual attention to students as a natural teacher (human) does. Therefore, for computer-based education system could provide this attention, the system had to think in both the field and the learner itself also, this had encouraged research in the field of building intelligent tutoring systems. These systems provide flexibility in the presentation of scientific material and a greater capacity to respond to student needs. These systems are gaining intelligence property through their ability to offer educational decisions about how the learning process is going, as well as to acquire personality information of the learner. This allows a great degree of diversity by changing the system interactions with the student.

The field studies have shown that the intelligent tutoring systems are highly effective [9, 10]. The difference between traditional learning systems (CAI) and Intelligent Tutoring Systems (ITS) in two main assumptions:

1. Individualized Education (directed to one person) by a competent teacher is much better than education through semester pattern because all of the content and methods of education can be adapted continuously to satisfy the needs of the situation (the educational status of the individual).
2. Students learn better in environments that are close to the ones where they use their knowledge, the sense of "learning by doing" .They learn from their mistakes and learn from forming and formulation knowledge in very distinctive way individually. These assumptions define the reason behind the construction of intelligent tutoring systems.

In addition, artificial intelligence break into the area of computer-based learning systems to automate the educational process for sensible improvement and development which can be measured in the educational process through the provision of artificial intelligence techniques and the integration of multimedia, such as text, audio, image and video.

Intelligent tutoring systems can be defined as computer-based learning systems that have independent databases or knowledge bases of educational content (define what is being taught), in addition to education strategies (which define how teaching). In addition, it tries

to use the conclusions about the ability of the learner to understand the issues and to identify weaknesses and strength points so that it can adapt the learning process dynamically.

Literature Review

There are several systems designed and developed for the purpose of education. These systems help students to learn quickly and increase their self-confidence. Some of these systems dedicated to teaching computer science such as [1, 2, 3, 6], Arabic and English language such as [4, 7] and Mathematics such as [5]. S. Abu-Naser et al. [1] they created and designed an ITS called JO-Tutor for helping Computer Science students to learn Java Programming language. Carter et al. [6] they developed an ITS for helping Computer Science students to learn debugging skills and use case-based reasoning. S. Abu-Naser. [2] He developed an ITS which called CPP-Tutor for helping Computer Science students to learn C++ Programming Language. C.J.Butz et al. [3] they created and developed an ITS which called Bits for helping Computer Science students to teach C++ Programming Language. Mona H. Mahmoud et al. [4] they developed ITS called AG_TUTOR for helping Arabic language students to teach grammar of the Arabic language. Maria Virvou et al. [7] they developed an ITS for helping English Language students to teach the Passive Voice of English Language and given exercises to students. Sara Hennessy et al. [5] they developed an ITS for helping students who are 8-to12-year-olds to learn Primary Mathematics. A comparative study between Animated Intelligent Tutoring Systems (AITS) and Video-based Intelligent Tutoring Systems (VITS) [25], An agent based ITS for Parameter Passing In Java Programming[26], Java Expression Evaluation [28], Linear Programming[27,32], effectiveness of e-learning[29], computer aided instruction[30], effectiveness of the CPP-Tutor[31], teaching AI searching algorithms[33], teaching database to sophomore students in Gaza[34], and Predicting learners performance using NT and ITS [35].

Security-Tutor

In this paper, we used ITSB authoring tool [11]. This tool designed and developed by Samy S. Abu Naser [11]. He used Delphi Embarcadero XE8, 2015; this tool supported two languages: English and Arabic and has two systems in one application. The first system is teacher system where it allows the teachers to add course materials, questions and answers. The second system is the student system where it allows the student to study course materials and answer exercises.

System Architecture

This tool contains four modules: domain model, teaching model, student model and user interfaces. The first model arranges and organizes the material in chapters or lessons. The second model works as control engine. The third model provides the system with all required information so it can adapt itself to the student. The last model has two sections - one for the student and the other for the teacher as shown in Fig 1.

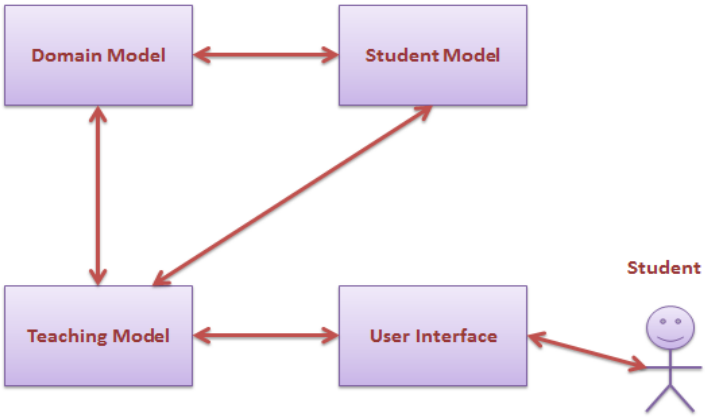

Fig 1: Overall System Architecture.

Domain Model

This model deals with the chapters in the course of Advanced Topics in Information Security. This model works on arrangement of the chapters. There are two fundamental components in it. The first one, Domain Organization Model, deals with the organization and arrangement of the Chapter and its topics. Where chapters organized as follows: Chapter 1, Chapter 2, Chapter 3 and Chapter 4. The second components, repository, deals with the materials being taught itself.

The material of the Advanced Information Security course consists of the followings [13-24]:

Chapter one includes

Key Security Concepts, Levels of Impact, Computer Security Challenges, Assets of a Computer System, Vulnerabilities & Threats & Attacks, Countermeasures, Threat Consequences & the Types of Threat Actions That Cause Each Consequence-Based on RFC 4949, Computer & Network Assets, Examples of Threats, Passive & Active Attacks, Security Requirements, Fundamental Security Design Principles, Attack Surfaces, Attack Surface Categories, Computer Security Strategy & Security implementation.

Chapter two includes

Cryptographic Tools, Symmetric Encryption, Attacking Symmetric Encryption, Data Encryption Standard DES, Triple DES, Advanced Encryption Standard AES, Practical Security Issues, Block & Stream Ciphers, Message Authentication.

Hash Function Requirements, Security of Hash Functions, Public-Key Encryption Structure, Requirements for Public-Key Cryptosystems, Asymmetric Encryption Algorithms,

Digital Signatures, Digital Envelopes, Random Numbers, Random Number Requirements, Random versus Pseudorandom, Practical Application: Encryption of Stored Data, Hash Functions, Hash Function Requirements, Security of Hash Functions, Hash Algorithms, MD5, MD4, Secure Hash Algorithm (SHA), SHA-1, SHA-512, SHA-3, Attacks on Hash Functions.

Chapter three includes

Message Authentication, User Authentication, Authentication Process, Problems in Authentication, Risk Assessment for User Authentication, Assurance Level, Potential Impact, Password Authentication, Password Vulnerabilities, Threats to the UNIX password, UNIX Implementation, Password Cracking, Password File Access Control, Password Selection Strategies, Memory Cards, Smart Tokens, Electronic Identity Cards (eID), Password Authenticated Connection Establishment (PACE), Biometric Authentication, Remote User Authentication, Authentication Security Issues.

Chapter four includes

Access Control, Access Control Principles, Access Control Policies, basic elements of access control, Subjects, Objects, Access Rights, Discretionary Access Control (DAC), Protection Domains, UNIX File Access Control, Mandatory Access Control (MAC), Compartments and Sensitivity Levels, Classification & Clearance, Dominance Relation, Role-Based Access Control, Task Based Access Control, Passive, Active Access Control, Attribute Based Access Control, Identity Management. Credential Management, Access Management.

Student Model

A new student account must be created to have a profile where it allows the student to study course materials and answer exercises. The profile has information about the student such as session date, student name, student number, current score, overall score, level difficulty, and problem number during the each session. The current score represents student score for each level. The overall score represents student score for all level.

Teaching Module

Teaching module works as a coordinator that controls the functionality of the whole system. Through this model, a student can answer questions on the first level and if he/she gets 70% mark or more, he/she can move to the second level. But if he/she fail to get the marks, he/she repeats to the examination at the same level.

User Interfaces

This tool has one interface; it supports two classes of users, teachers, and students. When the teacher's log in the system, the teacher can add lessons, exercises, answers, initial information about the student, configure and adjust the color, font name, and size of all buttons, menus, combo boxes etc. Thus, this interface provides the system with the required robustness and flexibility. A screenshot of the teacher's interface is shown in Fig 2, Fig 3, Fig 4, Fig 5 and Fig 6.

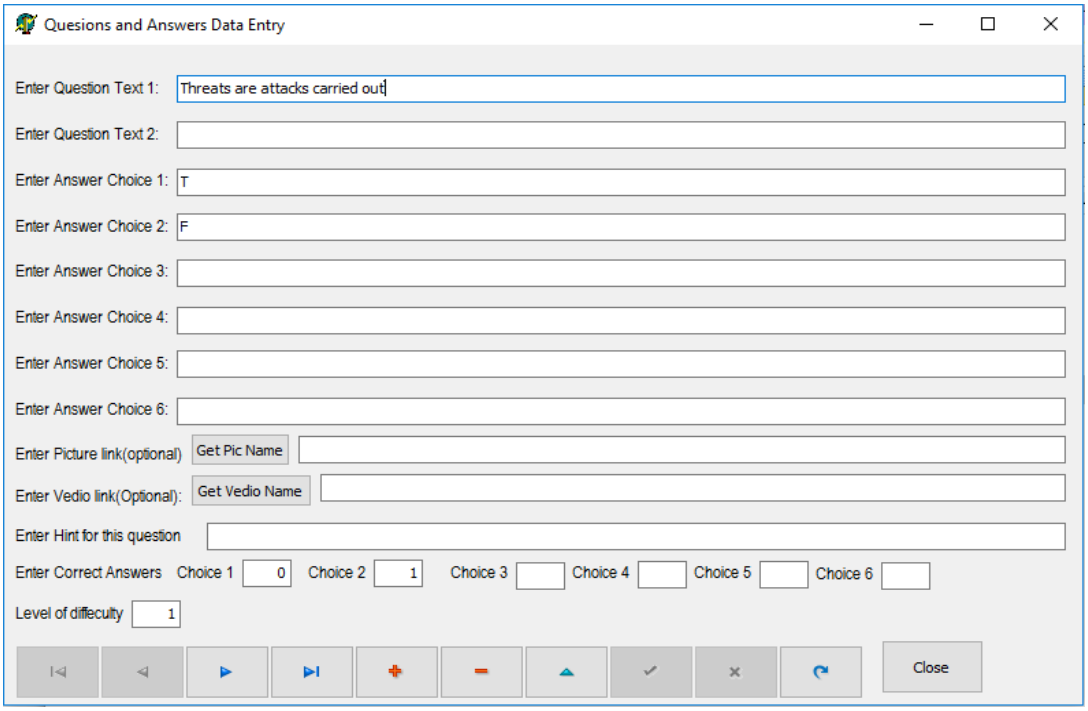

Fig 2: Form for adding questions and answers

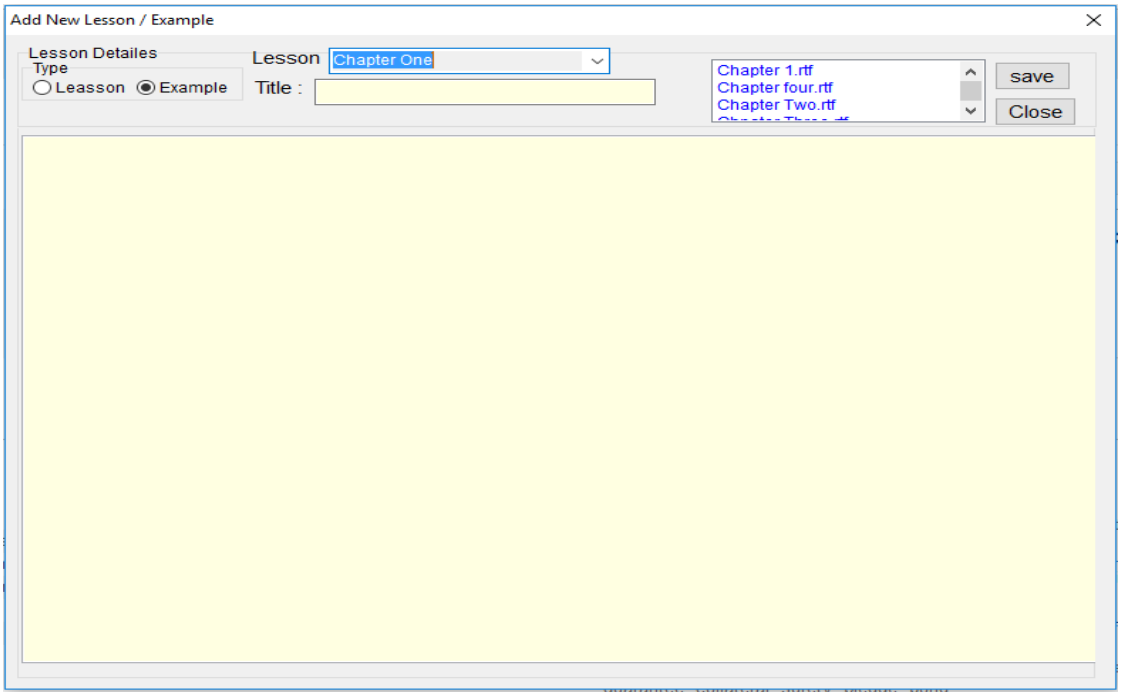

Fig. 3: Form for adding Lessons and Examples

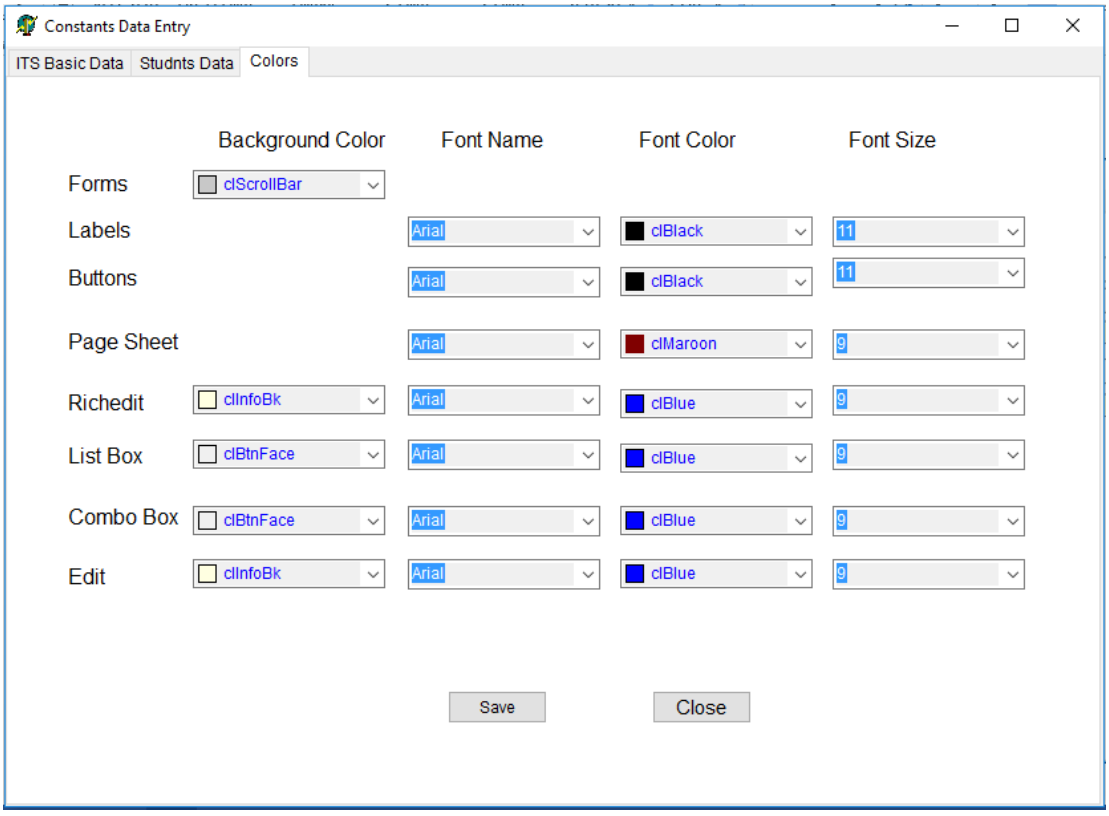

Fig. 4: Form for adjusting Fonts of all screens of the system

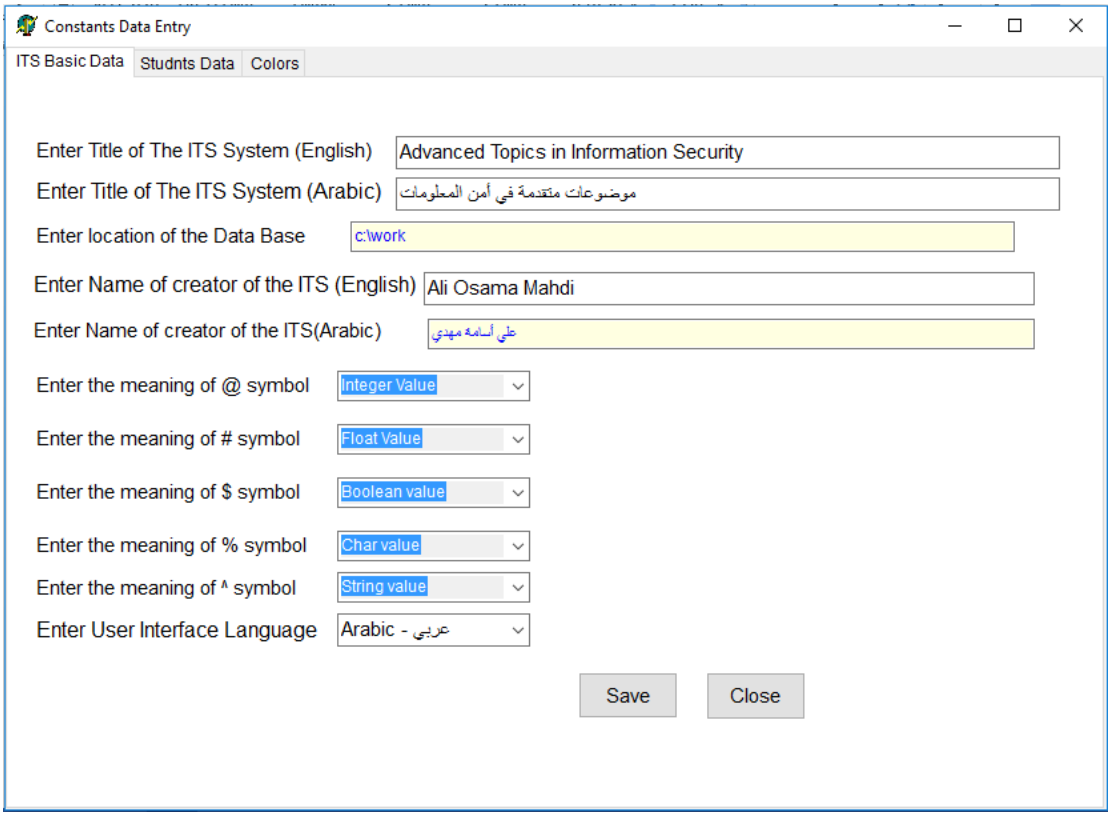

Fig. 5: Form for adding constants of the system

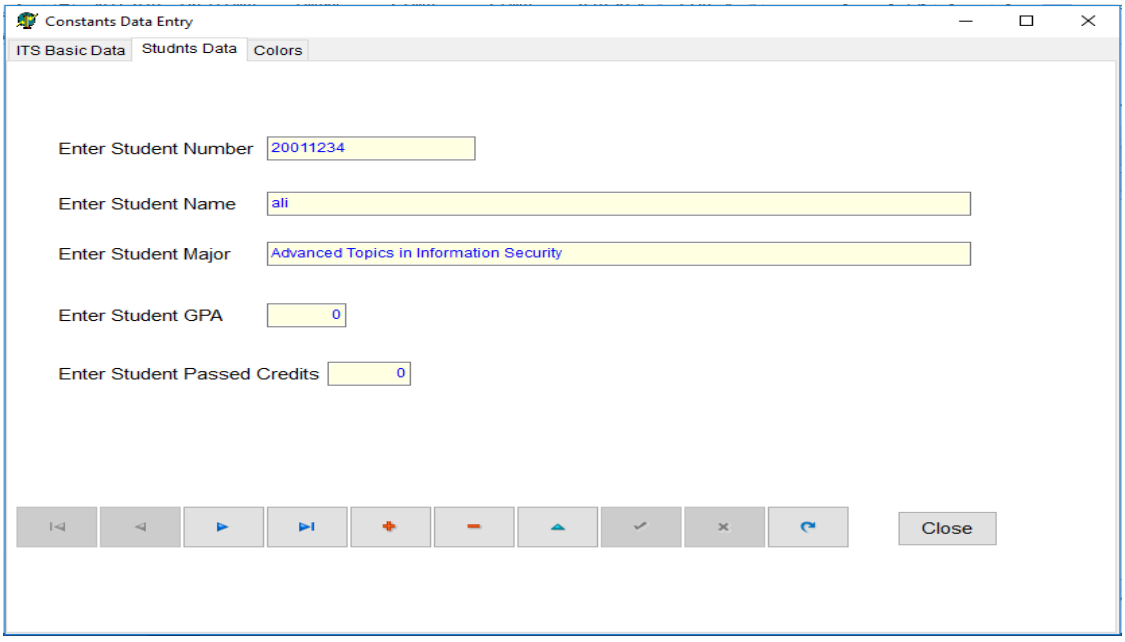

Fig. 6: Form for adding initial students' information

When the student log into the system, he/she will be able to see the lessons, examples and questions.

The lessons will appear in the rectangle with the name “lessons area” and the example for each lesson will appear in the rectangle with the name “example area”. When the student clicks on Exercises button then new problem button will be able to see Questions. Thus, be able to answer these questions. To ensure they are correct answer must click on check button. When the student wants to see his/her performance must click on a state. See Fig 7, Fig 8, Fig 9 and Fig 10.

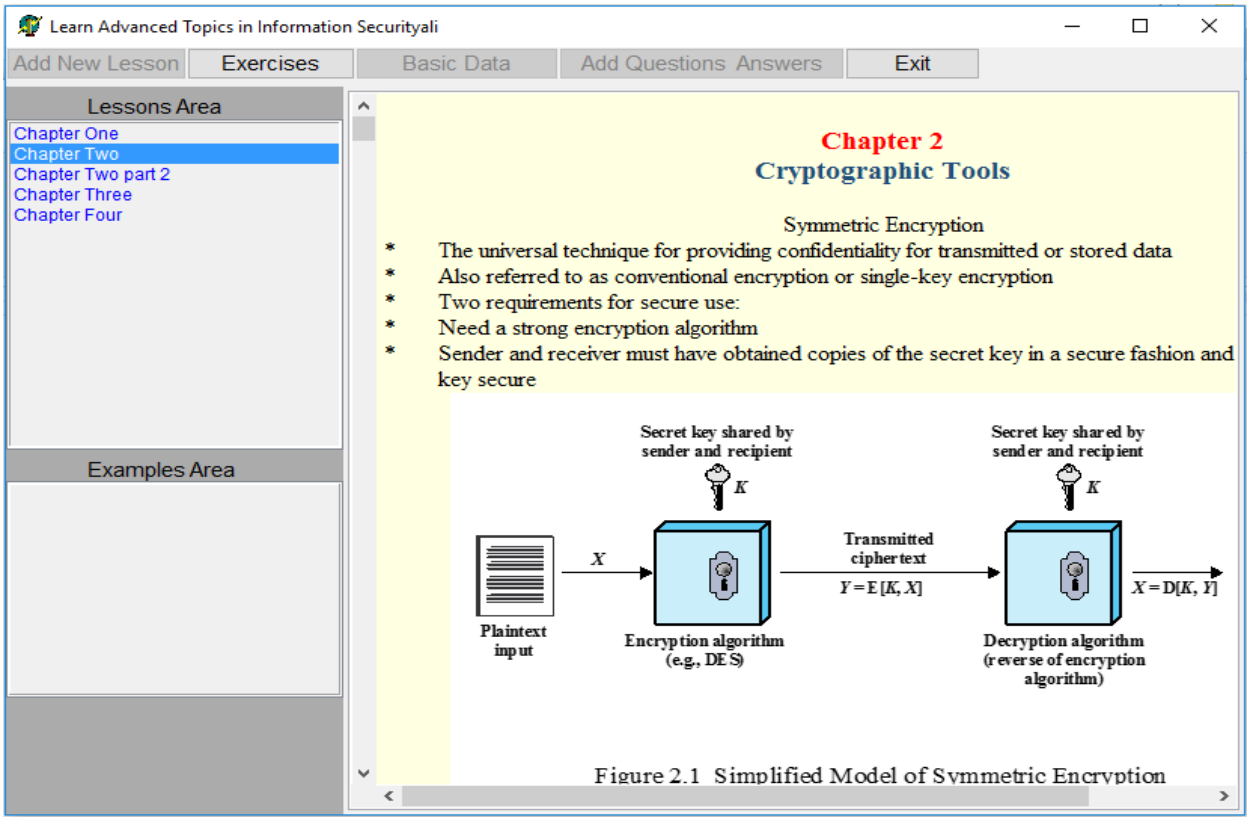

Fig. 7: Student lessons and examples form

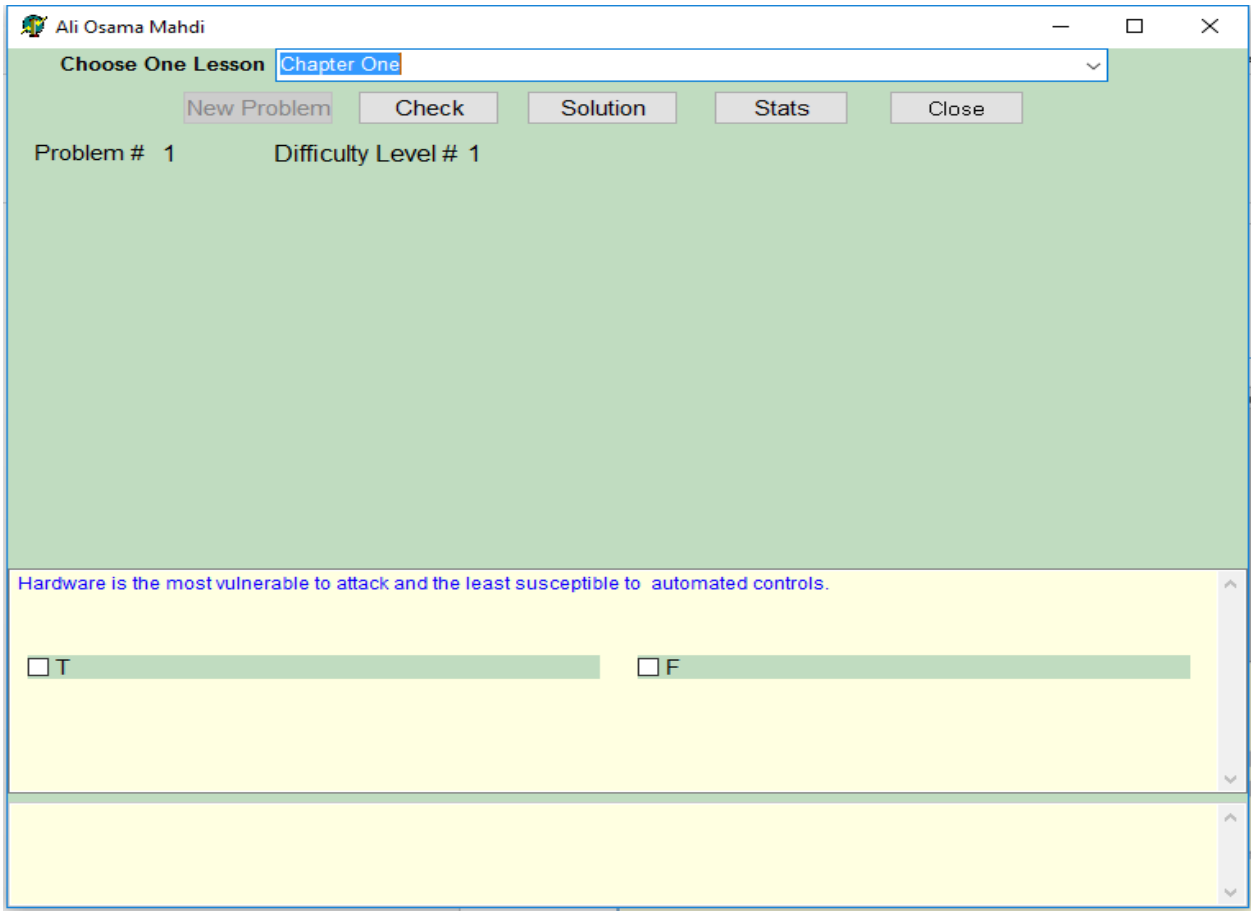

Fig 8: Student Exercises form.

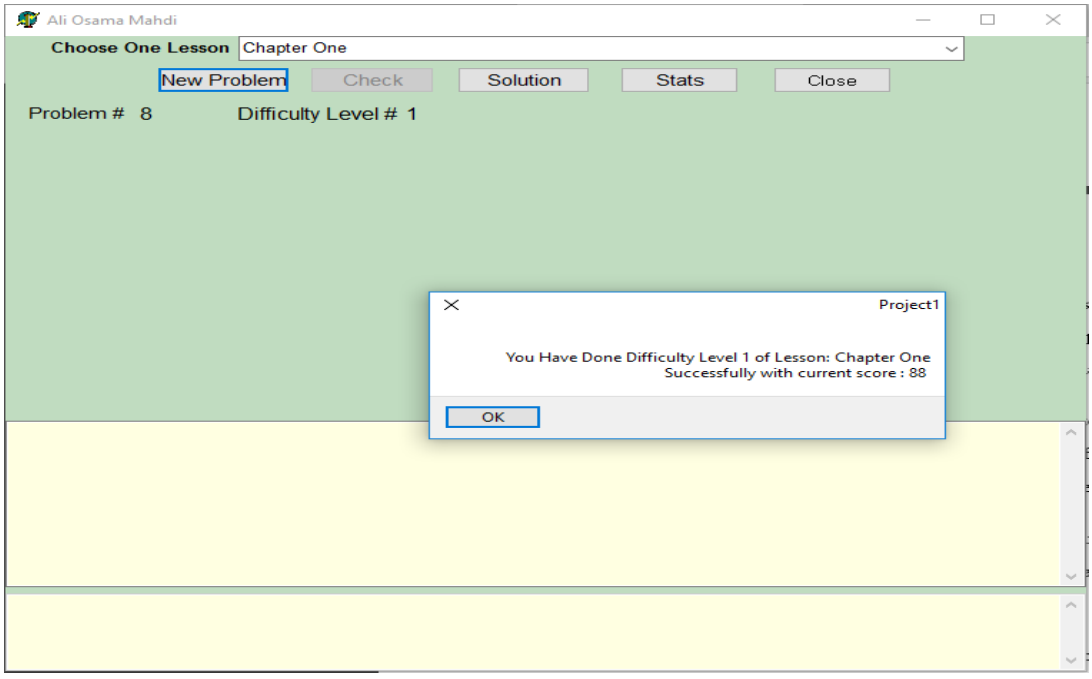

Fig 10: message to tell student successfully in this level

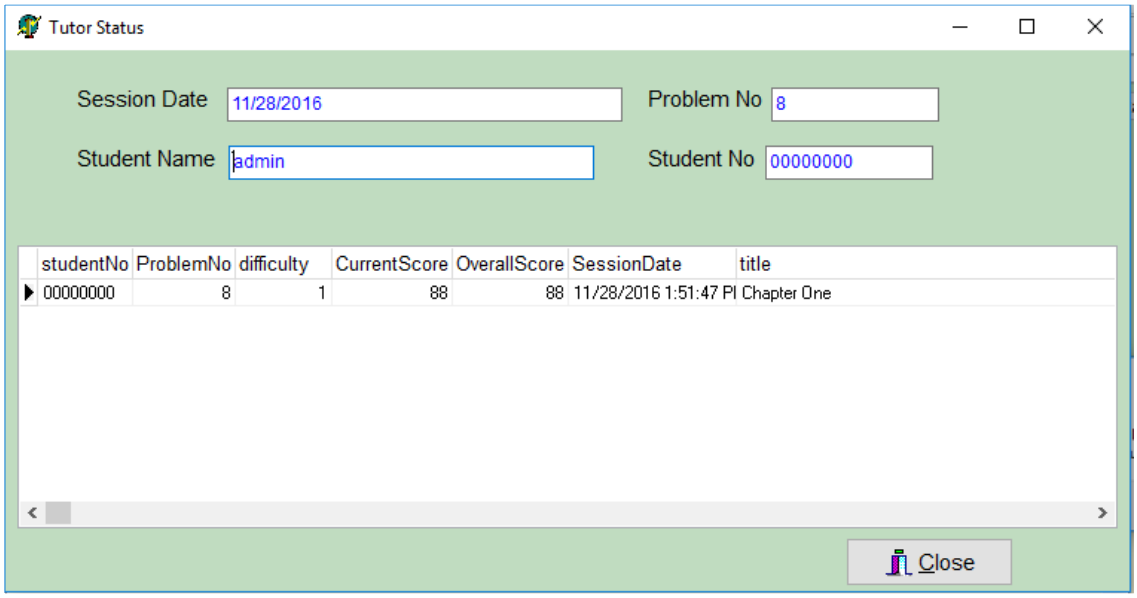

Fig. 11: Student statistics form.

Evaluation

We have evaluated the Intelligent Tutoring System for teaching Advanced Topics in Information Security by presenting the system to a group of teachers who specialize in teaching Information Security and a group of students in Al-Azhar University taken the course. We asked both groups to evaluate the ITS system. Then we asked them to fill questionnaire about the ITS system. The questionnaire consisted of questions concerning benefit of ITS, comprehensiveness of the material, quality of ITS design and quality of the material. The result of the evaluation by teachers and students were superb.

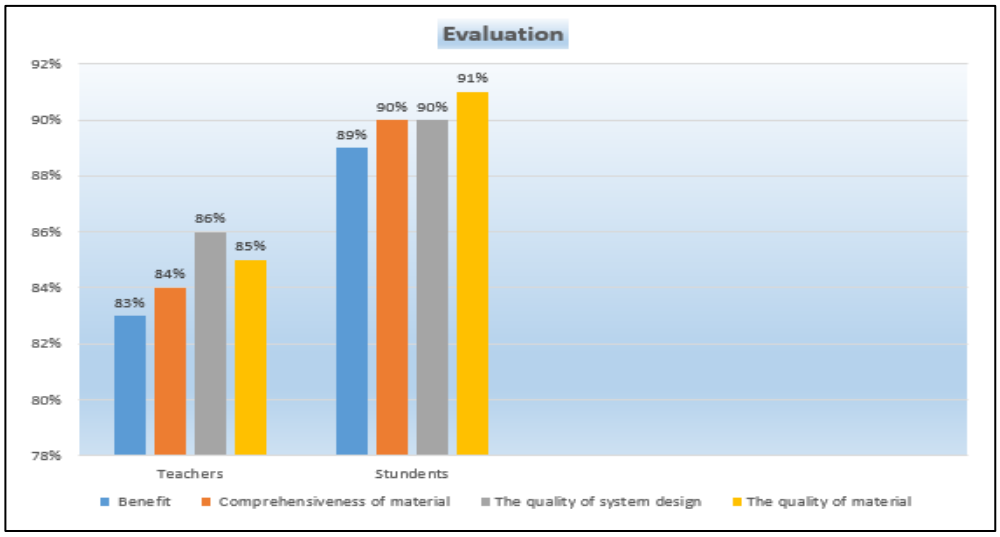

Fig. 11: shows the evaluation of ITS.

Conclusion

In this paper, we have designed an Intelligent Tutoring System for teaching Advanced Topics in Information Security by using ITSB authoring tool. The system was designed to facilitate the study of teaching Advanced Topics in Information Security to students and overcome the difficulties they face with ease and smoothness. System architecture and requirements of each part in the system have been explained. We conducted an evaluation of the ITS system by teachers and students and the results were more than very good.

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