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Abstract

ProMES[1] fills the gap of educational software in training on basic tools of project management. It offers aid to trainees in project management positions or courses to understand how CPM, PERT and RACI are used and enhances conditions for the acquisition of the required knowledge based on pedagogical approaches.

Keywords: Project Management, Educational Software, CPM, PERT, RACI

Introduction

Project management is regarded lately as a very important scientific area in nearly all organizations that base their profitability in implementing projects, as well as public and not for profit organizations which implement projects to serve their goals. It is regarded now as a separate cognitive field of application concerning principles of management and operations research in various sectors of application such as manufacturing, operations, government and others [28]. *Project Management is the application of knowledge, skills tools and techniques to project activities to meet project requirements* [20]. The knowledge areas that reside in it can be summarised in integration management, scope management, time management, cost

[1] ProMES software is freely provided for academic purposes and can be downloaded from: http://simor.mech.ntua.gr/Kirytopoulos/promes.asp

management, quality management, human resource management, communications management, risk management and procurement management [20]. Thus, someone wishing to effectively perform project management should have knowledge regarding the processes involved in all these knowledge areas, as well as knowledge of the tools that support these processes.

The interest for project management continuously increases and this has led to the growth of an education and training industry around it. At the same time professional associations all over the world are introducing new project management standards and business certifications in order to cover the increasing demand for knowledge and knowledge validation. Such standards or competence baselines have been developed by the Project Management Institute [20] the International Project Management Association [5], the Australian Institute of Project Management [1, 27], UK Government [19], Greek Government [10] and other organizations. All these standards, competence baselines and certifications contribute substantially in the field of education and training in project management [13].

The paradox in this very active market of project management education is that, even if there are many software tools for supporting the use of specific project management tools, few educational software packages exist and most of them are limited to multiple choice questions generators. On the other hand, educational software tools have been widely used in other fields such as operations research [21, 22, 23, 24] and the gap in the discipline of project management comes in the forefront. Aim of this paper is to address this gap by proposing a software tool that may support learning of specific tools used in time management and human resource management. Project time management includes *the processes required to accomplish timely completion of the project* [20] and basic tools that are often used in this area are the Critical Path Method –CPM [4], the Program Evaluation and Review Technique – PERT [14], the Critical Chain Method [7], Monte Carlo Analysis and the

Gantt diagrams [25]. On the other hand project human resource management *includes the processes that organize, manage and lead the project team* [20]. Commonly used tools are the organization charts along with RACI method of responsibility assignment. Of all these tools, the proposed Project Management Educational Software (ProMES[2]) includes CPM, PERT and RACI. The selection of the tools to be included in this first version of the software was based on the popularity of each tool in the real market.

The goal of ProMES is on one hand to help university students or trainees in project management positions to understand how CPM, PERT and RACI are used and on the other hand to enhance conditions for the acquisition of the required knowledge based on pedagogical approaches. The use of ProMES will enhance the typical training approach as educational software can be used independently from other methods of teaching at the trainee's convenient time. Moreover, ProMES lets the trainee define progress pace, instantly directs on how to solve the problems posed and how to correct errors and finally allows the trainee to repeat the training as many time as appropriate for in depth learning.

The rest of this paper is organized as follows: Section 2 presents a literature review of the limited existing educational software programs used in project management. Section 3 offers ProMES general description. Section 4 focuses on the educational characteristics of ProMES and Section 5 deals with student feedback and suggestions as occurred from the testing of the software. Finally, concluding remarks are exposed in Section 6.

[2] PROMES is freely available for academic purposes by kkir@central.ntua.gr

Educational Software for Project Management

The importance of using software packages for educational purposes in project management is well argued in Ku et al. (2008). Ku et al. (2008) used different software packages to solve the critical path network problems at the University of Southern Queensland (USQ) course in Australia. The main comparison was done between MS Project 2007, a typical business software and POM-QM for windows, which is partly educational software as it is accompanying the relevant OR book. According to authors, when used in education, the comparison between the two is in favor of POM-QM thus indicating that even the best in class business software cannot always serve equally as education packages.

This increasing need for education in project management has led to the creation of relevant educational software which in turn makes more effective the learning process. However, there are still few software programmes that can be used for educational purposes in project management. This section presents those available. The presentation of bibliographic research findings follows a chronological order so as to show the evolution that has taken place.

Early as in 1984, Spicer (1984) described the experiment of a management instructor who was teaching a *software engineering project management* course at a software education school. The innovation in this experiment was that the instructor applied an approach named "spiral". The objective of this approach was to obtain, a much higher level of students' acceptance for the new teaching method that used a specific software tool, than the traditional methods. In order to achieve the goal, the instructor taught the course twice, first by using a traditional method and next using a more innovative approach, based on software, so as to provide a balance between the science of management and the practice of management.

A few years later, EduSET was provided by Livson (1988). EduSET is an educational *software engineering tool*. It was developed in order to *simulate the real working environment and allow students to act in the* areas of development, software quality assurance, configuration and project management [3]. This is probably the first educational software that although not dedicated to project management it includes a module about it. EduSET enables software engineering course instructors to define a class project with participants in different roles and supports experiments with real life circumstances.

Pfahl et al. (2001) presented the design of a simulation model and training scenarios offered by existing Computer Based Training (CBT) and the concepts of CBT module for students' education in software project management, as well. CBT, in university education, according to the researchers, *provided to computer science and software engineering students not only technology-related skills but in addiction a basic understanding of typical phenomena occurring in industrial (and academic) software projects. The simulation component of the CBT module is implemented using the system dynamics simulation modeling method* [6]. This educational software assists students in understanding the basic project management concepts and improves their knowledge of the complex decision-making situation in software project management. Finally Pfahl et al. suggested that *these are often characterized by trade-off effects between conflicting goals, which implement a specified functionality such as to control or shorten project duration (time to market), to control or decrease project cost and to control or improve the quality of the delivered end product (for specified product functionality).*

Vanhoucke et al. (2005) created the Project Scheduling Game which is a simulation game that illustrates the complexity of scheduling a real-life project. Aim of this educational software was to focus on the time/cost relationship in each activity of the project. The basic tool that is used in Project Scheduling Game is the CPM.

Specifically, the Project Scheduling Game creates scenarios. For instance, one of them deals with a project which aims in maximizing the capacity of a water purifying procedure. The goal for the trainee is to allocate resources to a particular activity, when the manager decides about the duration and the corresponding cost of each network activity. Taking into account the project deadline, potential project managers (trainees) try to minimize the total project cost.

The most recently developed educational software tool relevant to project management is RESCON (RESource CONstrained). It was proposed by Deblaere et al. (2008) and deals mainly with project scheduling and project management concepts such as careful planning, scheduling and management of the project. Specifically, RESCON entails heuristic scheduling procedures, visualization of networks, project schedules, resource profiles, activity slacks and project duration distributions. It combines the *state-of-the-art scheduling algorithms with an elaborate schedule visualization component* that results *in a valuable tool for illustrating advanced project management concepts in classroom setting* [8].

Taking into account that only few educational software packages exist it is supported here that the introduction of ProMES arrives to fill a gap and enhance the training in project management.

ProMES description

Concept

The goal of Project Management Educational Software (ProMES) is the development of an educational software for project management that will mainly embed basic educational characteristics such as pedagogical approach, easiness of use and trainee help, as well as existence of levels for trainees of different levels/expertise.

The educational software includes the basic functions which concern, the selection of one of the three techniques/methods (CPM, PERT, RACI) that are supported by the educational software, the selection of the scenario by the trainee (out of twelve available for each technique/method), checking of the solution given by the trainee and indication of the mistakes made. This procedure of solving the scenario, checking and indicating the mistakes keeps recurring until the scenario is solved correctly by the trainee (ref. to flowchart in **Figure 2**). Other basic functions offered by the system is help given to the trainee about what to do and statistics showing the percentage of completion and time spent for the solution of the scenarios.

The pedagogical approach of the educational software puts the trainee in the center of every process/activity. The most basic attribute of the system is the interaction between the trainee and the system. Indeed, it's clear that with the help offered to the trainee about the way the educational software works and the indication of the mistakes to the trainee by the system, an interactive relationship is created. The system helps the trainee solve the scenarios, so that the trainee learns to use the tools correctly. Moreover, the system, gives the capability to the trainee to proceed in the pace he wishes by saving and loading at the stage where he/she wishes to stop.

Finally, the system offers a choice of the level of experience of the trainee. For now, the trainee can select between Trainee or Professional level of experience. The difference is the help offered to the trainee who selects the Trainee level while the Professional level doesn't offers any help. Also, the Trainee level starts with a demonstration to the trainee about how to select and solve the scenarios. An illustrative view of the interface settlement of ProMES is offered in **Figure 1**. As one can see the screen is divided in two parts. The upper part contains basic menus, command buttons, statistics and the description of the problem/ scenario, while the lower part consists the working space where the trainee solves the problem posed.

Please insert here < **Figure 1** The ProMES concept>

ProMES can be regarded as an information system for project management education. A system can be broadly defined as an integrated set of elements that accomplish a defined objective [29]. An *information system* is a system that collects and stores data. It consists of the input, the processing and the output. The specifications of the input, the processing and the output concerning ProMES are the following (refer to **Figure 2**):

Intro Input: As a first input to the system the trainee enters his profile (name, affiliation, role) and then selects the level of experience (Trainee, Professional).

Main Input: In the main input of the system the trainee selects the type of problem (CPM, PERT, RACI), selects one out of twelve gradually increasing in difficulty scenarios and solves the problem (draws the diagram and completes the data missing).

Processing: In the processing stage the various data entered in the system are processed in order to give the result. Specifically when the trainee asks the system to check the solution/data entered, the system processes the data and indicates any mistakes or omissions. The trainee corrects the initial solution and resubmits the revised one. The process keeps recurring until the trainee comes up with the right solution.

Output: After the processing stage, the system shows on the screen the percentage of completion of the specific scenario and the time spent (it will be 100% only for rightly solved scenarios). It also shows the statistics of the

whole percentage of solved scenarios and the time spent (sum of every solved scenario in percentage).

An illustrative view of the system's work flow is shown in **Figure 2**. When the system checks and indicates the mistakes or omissions of the user, feedback is given to the main input so that the user can revaluate the mistakes made and enter the correct data or draw the right diagram.

Please insert here < **Figure 2** The System's Architecture>

The following paragraphs present the three modules included in ProMES and offer snapshots of the solution stages.

CPM Module

The CPM is an algorithm based on operations research, with the purpose of scheduling the activities of a project. It is one of the most important tools for effective project scheduling [15]. It was developed in 1950 in a consortium between the DuPont and Remington firms, for the project management of facilities maintenance [18]. Today, CPM is used widely with all kinds of projects, including construction, software development, research projects and others. By using the CPM tool we can save time and money through better planning [18]. The approach which is used more often today is the "Activity on Node", where activities are depicted as nodes and precedence relationships are depicted as connection arrows [17].

In CPM the basic objectives are to develop the network and define the critical path. The network is formed by depicting the successive activities linked with connection arrows and the critical path is identified after the "calculation of the network" by identifying activities with no total slack. The total slack of an activity is the time

between its earliest and latest start time and its physical meaning is the time that an activity can be delayed past its earliest start without delaying the delivery of the project.

Within ProMES, after the selection of CPM problems module the trainee may activate "Mr. Help" so that the demonstration of the CPM module begins. The demonstration guides the trainee, by showing an example on how to solve a typical CPM scenario. After the demonstration has finished, the trainee selects the first scenario and begins to solve it, by drawing the CPM diagram according to the scenario. In the middle of the screen the trainee can see his statistics concerning time and percentage of completion of the current scenario (refer to **Figure 3**). The scenario is presented at trainee's will either in text (word description of the problem) or table form (table containing only necessary information for solving the problem, such as activities, predecessors, duration, etc).

The trainee connects the activity boxes by clicking on the colored area of the circle of each activity (refer to **Figure 3**). Then the trainee fills in all the activity boxes according to the scenario. Finally by selecting the button "Check" the system checks the CPM diagram as well as the input data. If any mistake occurs in the input data or any wrong connection in the diagram, the system displays a message advising the trainee to try again. The message displayed by the system concerns the specific mistake which is referred in the message so that the trainee knows what to correct.

Please insert here < **Figure 3** CPM module – Solving the scenario>

Now let's assume that the trainee puts an extra activity box which is not needed and then presses the "Check" button as shown in **Figure 4**.

Please insert here < **Figure 4** CPM module – Wrong Diagram>

The system displays an error message as shown in **Figure 5**. A similar error message appears if the trainee fills an activity box (for instance activity's A duration) with the wrong input data.

Please insert here < **Figure 5** CPM module – Error Message>

When the trainee deletes the extra activity and re-checks the diagram, the system displays a success message.

PERT Module

PERT is a technique for analyzing the activities needed for the completion of a project and based on the time needed for the completion of each activity it gives a stochastic distribution that describes the time needed for the completion of the whole project [20]. This technique was first used by Booz Allen Hamilton and was originally developed with the purpose of simplifying the scheduling and planning of big and complex projects [2].

The procedure in ProMES concerning the PERT module is the same as CPM module except that instead of Activity's Duration, Activity's Expected Time is used.

The difference with the PERT module is the ability given to answer questions about the probability of a project completion within a certain time 'Δ'. ProMES offers a screen where the trainee can answer such questions (refer to **Figure 6**).

The trainee begins by entering the values based on the scenario to the expression $\frac{b_i-a_i}{6}$ (where a_i and b_i are the optimistic and pessimistic durations of the activity, respectively) and by pressing the button "Calculate σ" (where σ the standard deviation) the system calculates the result. Next, the trainee selects the button "Calculate σ_E" (where σ_E the standard deviation of the whole project duration, as defined by the central limit theorem) and enters the values found by using the expression $\frac{b_i-a_i}{6}$. By clicking on "Result σ_E" the system checks the answer and shows either a message to continue if the result is correct either a message of failure if the result is wrong. Then the trainee follows guided steps in order to find the corresponding duration of 'Δ' to the typical normal curve N(0,1) so that the typical normal distribution tables of u (or z) can be used. ProMES uses tables that give the probability that a value x will reside in –u<x<u. If the final result is correct then the system displays a message to continue.

Finally, after all the calculations have finished, the trainee gives the answers in the two last boxes answering the first question, for example, "Which is the probability the project can finish in 17 days?" and the second "Which is the probability the project to exceed the deadline of 14 days?" as shown in **Figure 6**. If the answers are correct then the trainee can continue to the next scenario.

Please insert here <**Figure 6** PERT module – Solving the Scenario>

RACI Module

RACI is a simple tool that can be used for the specification of roles and responsibilities that each member of the project management team should perform. RACI is an abbreviation for [26]:

R- Responsible. One and only one “R” should exist in every activity.

A- to whom “R” is Accountable – must sign, approve the project.

C- Consultant – who should be asked for consultancy.

I-Informed – must be informed for the results.

In the RACI module of ProMES the trainee completes (with drag ’n’ drop) the colored boxes with the correct R, A, C, I boxes in the right of the screen as shown in **Figure 7**. Then the trainee selects the button “Check”.

Please insert here < **Figure 7** RACI module – Solving the Scenario>

In **Figure 8**, there are three problems because of the double R combination in line 1, the R-A, A-R combination in lines 3-4 and because there is no R in line 2. The system warns by displaying the appropriate messages as shown in **Figure 9**.

Please insert here < **Figure 8** RACI module – Wrong Combinations>

Please insert here < **Figure 9** RACI module – Error Messages in RACI module>

Finally when the trainee corrects the errors as shown in **Figure**, a success message is displayed on the screen and the trainee may proceed to the next scenario.

Please insert here < **Figure 10** RACI module – Correct RACI>

Educational Characteristics

The educational characteristics of ProMES, concerning CPM, PERT and RACI tools, make it an effective tool in the training process.

First of all, ProMES offers to the trainee feedback through the interaction between the trainee and the system. When the trainee begins to solve a scenario, the system checks and displays in message style all the mistakes. The trainee can revise his thoughts and try another solution. This procedure continues until no mistakes can be identified by the system. So, the trainee learns how to use the tools through feedback and interaction with the system.

Another very important educational aspect of ProMES is the help offered to the amateur trainees. When the trainee enters the tool interface, a demonstration of how the tool works is first displayed. The trainee is not helpless but on the contrary he/she is being helped continually by the system. In this way the trainee feels like a personal teacher guides him/her continuously.

Finally, the trainee can use the educational software on his/her own pace. This is possible with the save/load option given by the system where the trainee can stop at any time saving the work done and continue some other time.

Student Feedback

ProMES educational software has been developed at the Financial and Management Engineering Department of the University of the Aegean and specifically through a master thesis developed in the area of the master course *Project and Risk Management*. Part of the course that is attained yearly by 15-20 students includes quantitative techniques in project management with special focus on CPM and PERT among other techniques. ProMES tool has been presented to students of the master course (academic year 2008-2009) who found it very interesting and helpful. The students found the tool user friendly both for its graphical interface and the help function. None of them had problems in data entry or results' reading. The special feature of the tool that was indicating the problems of each solution instead of revealing it, thus giving to the student the opportunity to try again for finding the right answer, was highly appreciated. Moreover, students found interesting the idea of gradually increasing difficulty of the scenarios.

On the other hand, students, indicated that ProMES should be expanded to cover more project management tools that are included in the course syllabus, such as Gantt charts and Monte Carlo Simulation.

Conclusions

ProMES has been designed in order to offer aid in project management training. Initially only three of the methods/techniques/tools of project management processes have been incorporated in the tool. According to Phahl et al. (2001), the trainees *should analyze their errors, so as to gain sufficient knowledge of the problem*. Thus, educational software should have the capability of indicating in real time the wrong answers, as well as to offer guidance to the right solution of the problem and not function just as a black box that only provides the right answer. After the trial of system as well as its evaluation from trainees, it is concluded that, ProMES satisfies

it's main objective which is the education of the trainee to the CPM, PERT, and RACI in project management.

There are three important characteristics that make ProMES promising in relation to other existing educational software. First, the educational procedure which follows a pedagogical approach that offers trainees a more efficient learning environment. This is mainly achieved through the continuous interaction between the trainee and the software. Second, the easiness of use and trainee help that guides amateur trainees to learn the process for solving such problems and provides instantly through messages guidance to the right direction for solving the problem. The system does not give the solution of the scenarios to the trainee, but helps the trainee to learn the appropriate usage of each tool and thus leads him/her to a right solution. This is also promoting the critical thinking of the trainee. Third the existence of levels for trainees of different expertise and the measurement of their efficiency through indexes (ratio of problems' solved and time spent). Last but not least, the software gives the capability to trainees for advancing on their own pace as they can save the scenarios and continue whenever convenient.

As far as further research is concerned, a structured experimental evaluation of the software remains to be done in order that the increase of efficiency of training can be measured. Apart from the experimental evaluation, ProMES will be enriched in the future with more content (new scenarios) as well as extended context (inclusion of other methods and tools such as Monte Carlo Simulation, Resource Levelling etc). Other improvements that the designers are working on include creation of graphics so that the trainees' interest is stimulated, as well as sound inclusion in the various operations of the software.

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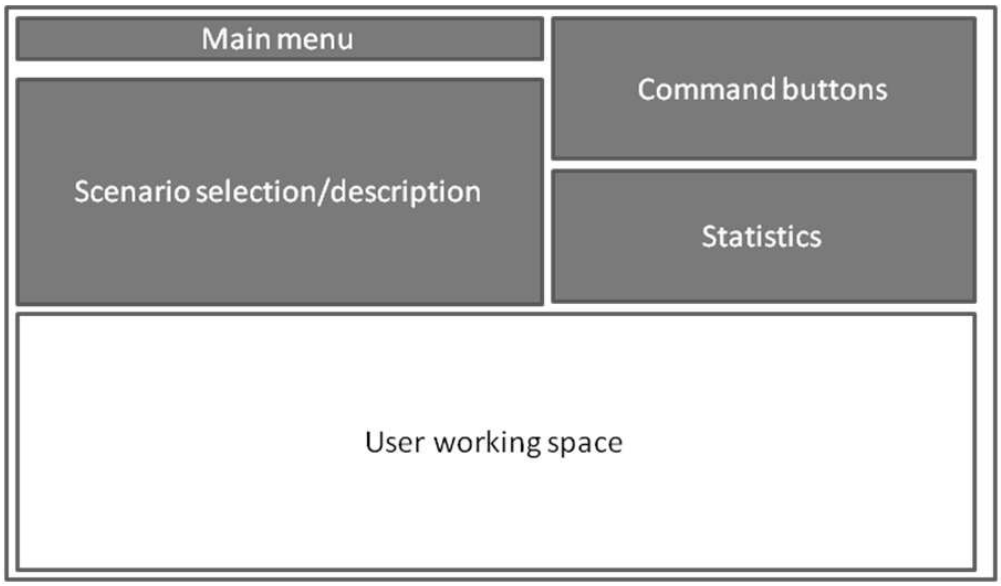

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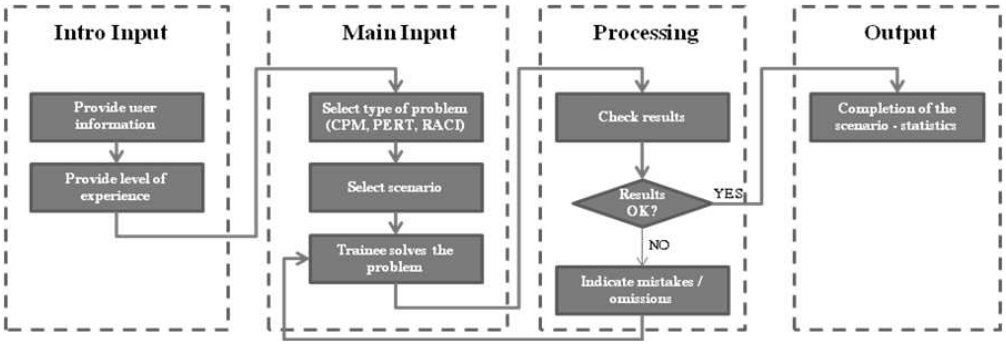

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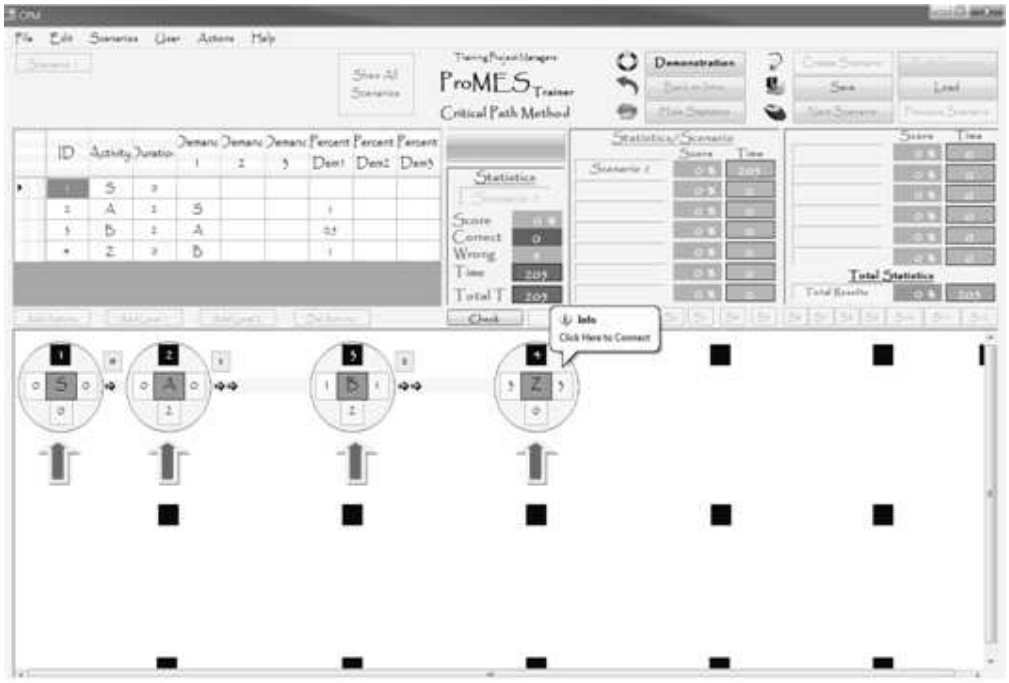

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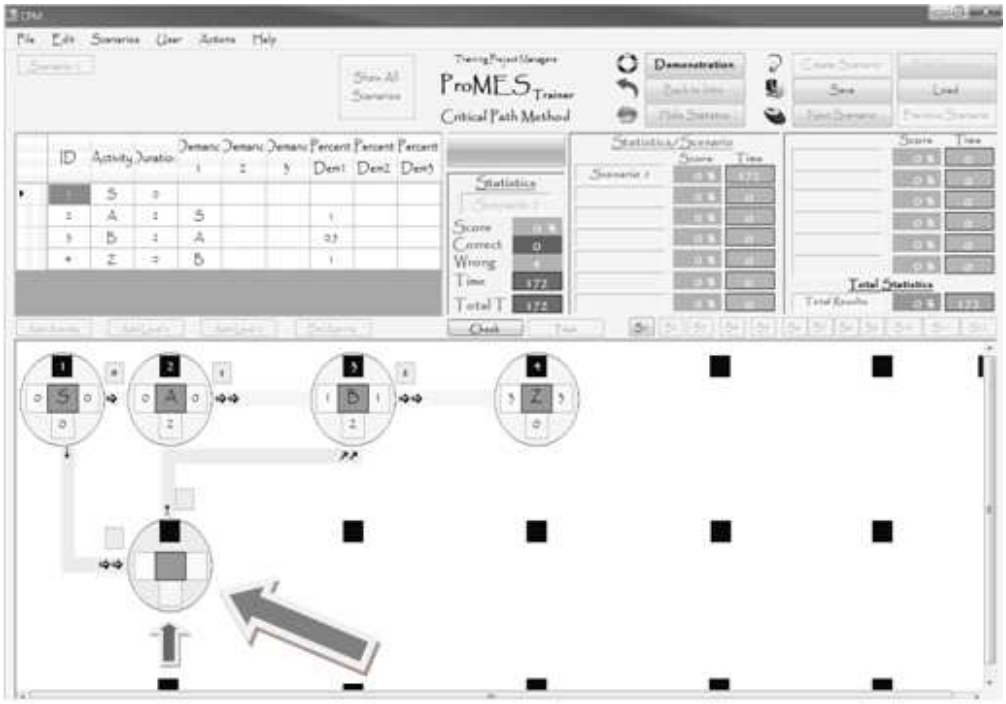

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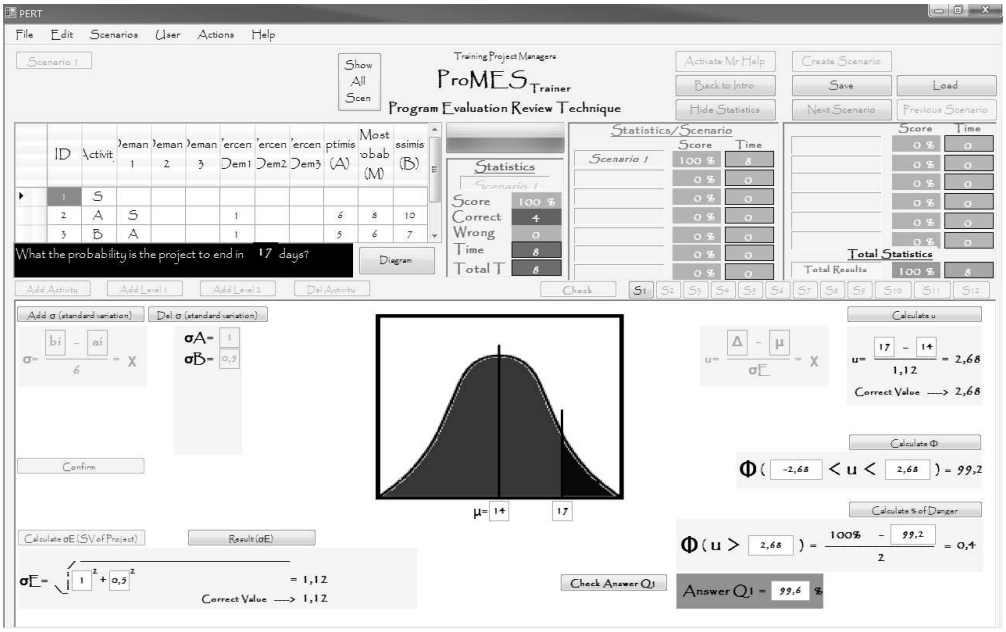

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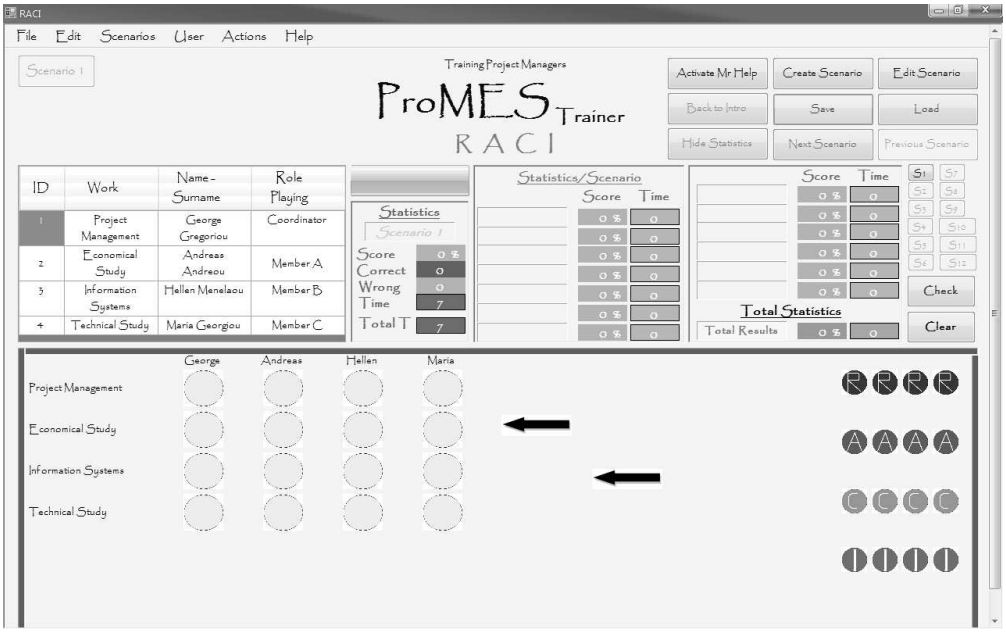

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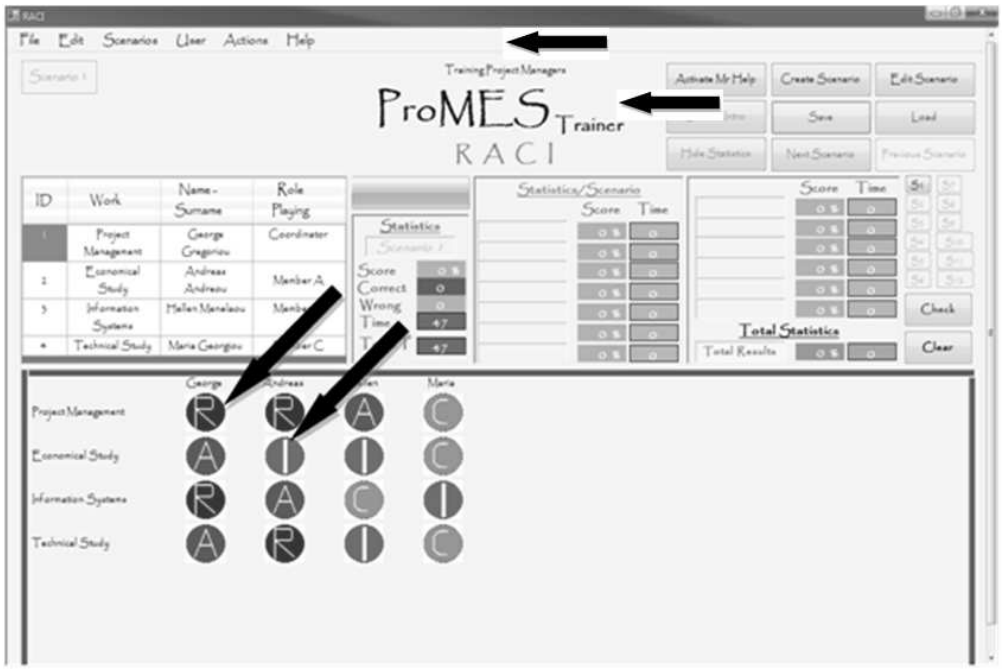

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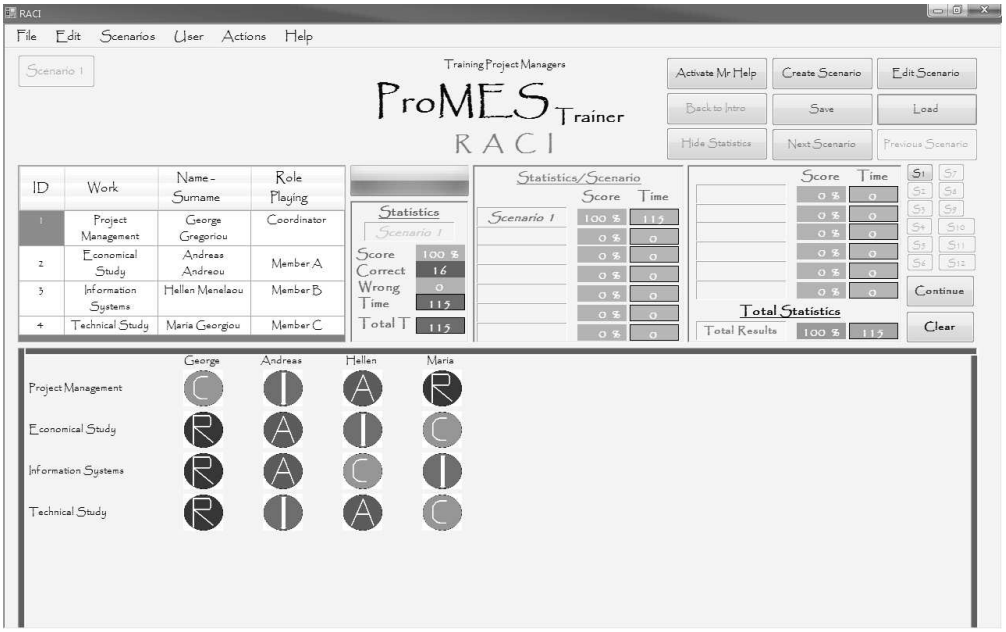
273x35mm (96 x 96 DPI)



338x211mm (96 x 96 DPI)