TEACHING SOFTWARE PROJECT MANAGEMENT:
THE INDEPENDENT APPROACH

Costin-Anton Boiangiu [1*]
Adrian Firculescu [2]
Ion Bucur [3]

ABSTRACT

The process of learning has continuously evolved throughout time. Several didactic approaches have been designed to meet certain academic needs. In light of today's technological advancements, new educational topics have emerged, some which do not explicitly fit other already defined didactic methods. This paper aims to propose a specifically designed learning approach for teaching Software Project Management in a university-based environment by adapting parts of other general learning techniques into a new and better defined teaching approach for a computer software education field.

KEYWORDS: *software project management, educational models, teaching strategies, collaborative learning, cooperative learning, competition-based learning, mixed collaborative-competition learning, independent learning, anarchy learning.*

INTRODUCTION

Among the different oriented approaches, the following can be distinguished as efficient learning processes: collaborative, competitive, anarchic, independent and mixed.

One of the most frequently used forms of education offered by many academic institutions is independent study, a form of learning that has been applied to a number of different methods and levels of teaching, which aimed to offer students more freedom in pursuing some part of their learning through personal research, a form of student autonomy [1]. Through a low level of collaboration, students improve skills of researching and identifying relevant information, in addition to acquiring knowledge.

Independent study is basically any type of educational activity that a student is capable to carry out with little or no help, advice or guidance. Thus, independent study is considered to be a pure form of self-directed learning (SDL) [2], where individuals may have the possibility of engaging in topics and activities of personal choosing.

Although team-work might be involved, an individual learning plan occurs by establishing the role of each member. The purpose of this paper is to present the particularities of the independent approach through following the students' behavior while developing a "Multiple Choice Testing Application". In spite of assigning the task to a

[1*] corresponding author, Professor PhD Eng., "Politehnica" University of Bucharest, 060042 Bucharest, Romania, costin.boiangiu@cs.pub.ro
[2] Eng., "Politehnica" University of Bucharest, 060042 Bucharest, Romania, adrian.firculescu@cti.pub.ro
[3] Associate Professor PhD Eng., "Politehnica" University of Bucharest, 060042 Bucharest, Romania, ion.bucur@cs.pub.ro

team, the communication between the members of that team had to be kept to a minimum level.

The outcome consisting of the students' progress, the overall quality of the products developed and the final grades are indicators for the efficiency of the independent approach.

PREVIOUS WORK

Despite the fact that various studies had been conducted on the different oriented learning approaches applied within groups, most of them tend to favor cooperative learning [3-7], while several others focused on the fact that students tend to struggle with independent learning if they have not been previously acquainted with this study approach [8-9].

Among academics, the exact definition of independent learning is not properly determined, although the concept has been around for some time [10]. The problem lies with the fact that there has not been a consensus for an accurate description because the term itself 'independent learning' has been used synonymous to other similar learning approach like 'autonomous learning, independent study, self-directed learning, student initiated learning, project orientation, discovery and inquiry, teaching for thinking, learning to learn, self-instruction or lifelong learning [11].

While independent study offers a student the chance to adapt the learning process to a self-paced rhythm, applying those self-taught concepts in a small group scenario would depend on the level of peer interaction with fellow workmates based on the characteristics of students, groups and tasks [12]. Mood, emotions, sentiments or other emotional intelligence that members bring to a group could have an important effect on the overall chance of success [13].

PROPOSED APPROACH

The Independent approach aims to put forward a new way of teaching Software Project Management. The method aims for a different manner of training students how to develop computer software and how to work and interact in a small group. Students have the opportunity to interact with different types of hierarchies: didactical hierarchy – communicating with the professor and teaching assistants – or team hierarchy – interacting with other team members in other to fulfil their tasks. Each project can have multiple components which can be independently evaluated.

During the Software Project Management course held at the University POLITEHNICA of Bucharest, several projects were proposed in order to illustrate the independent approach. The students were allowed to develop their own ideas or choose from the following ideas: "Mortar Mayhem", "Fastest and Brightest", "Battleship", "E-commerce Lite", "SimTraf", "Stonemason", "TTSched", "Image Analyzer", "Circuit Designer" or "Multiple Choice Testing Application". The independent approach started as a competition among the students, based on their CVs and the Software Design Document associated with projects. This step represents the first time students get to compete based on their own skills and capabilities for a spot to work on the project they want. They have

the option of applying to multiple projects, therefore they can be easily redistributed in case a project already has a considerable number of students accepted.

As opposed to a traditional approach, where students have to complete a unique general assignment, this approach offers a diverse number of project topics, each with several individual components that require specific skills to develop. This also means that not all project will be equally balanced in terms of difficulty. Some students might find their project to be more demanding especially if the project they're working on was not their first choice.

In the first weeks of the semester, each project was assigned to a small team of students according to the aforementioned selection process, based on the CVs that were handed in. In the early stages the responsibilities were not definite, but every member had to self-determine an individual role within the team before carrying on with the completion of the project. It is of utmost importance for the group to be hierarchized according to a project management schema. The main roles in a team are:

1. Project Manager (PM) – this role implies high responsibility, both in team monitoring and visible progress. A good PM must possess excellent soft skills, ensure that deadlines are met, take decisions in favor of the whole team and motivate the subordinates when necessary. A good PM also communicates with the project sponsor (in this case either the professor or one of the teaching assistants) and briefs the sponsor on the progress and the direction in which the project is heading.

2. Team Leader – covered by two members:

    a. Lead Developer
    b. Lead QA

   It is highly important for a team leader to be sufficiently skilled to guide the other members of the subsequent team. Furthermore, technical knowledge and experience are compulsory in case any issue that requires rapid solving arises. The team leaders maintain a continuous communication between them and the PM in order to maximize the success of the project.

3. Developer – responsible with implementing the project according to the requirements. The members occupying this position are coordinated by the Lead Developer, who is expected to find a solution to any raised predicament.

4. QA Engineer – responsible with testing the project after the development engineers finished implementing it. The testers have to maintain a strong relationship with the developers in case any incident occurs. Besides verifying the functionalities, they also have to periodically report to the lead QA.

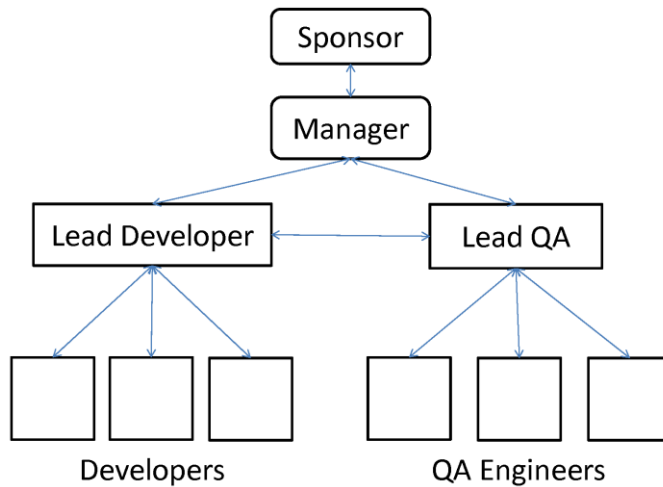The structure presented above can be visualized in fig. 1.

Figure 1. Simple internal group structure used by most teams

It is very important to receive continuous feedback from the sponsor to make sure the project develops according to their needs. Particularly, in a faculty project, the client will be the teacher. If the teacher is pleased with the results obtained up to that point, the development of the project should be carried on in the same manner. Otherwise, the team members should reconsider the initial plan, consult the teaching assistant and find a solution.

Any project may be divided into four phases:

1. Initial phase – marked by the beginning of the project, the assessment of related work and the role assignment among the team members;

2. Planning phase – resource plan, budget, activity plan, milestone definition;

3. Execution phase – the actual product is being developed and tested. There is also a quality check, taking into account possible risks and bug fixing;

4. Closing phase – delivering the product to the client and receiving feedback according to the quality of the functionalities provided.

It comes out as no surprise that the independent approach does not necessarily imply competition or collaboration between the teams. It is easier to find a suitable application for the students as each team implements its own choice, although there is a chance that the difficulty of the main idea will vary among students. Because of that, it is harder to evaluate the overall activity and set the milestones according to everyone's demands. Moreover, team competition arises in order to "present" and "sell" their own application in an original manner. The tasks assignation is done according to the best specifications offer and the best match with the team member skills.

Further an example shall be presented to better understand how the independent approach works. This paper focuses on the development of "Multiple Choice Testing Application".

The project requirements may be structured according to the following schema:

- Document Purpose

- Document Content

- Brief Description of the software product

- Solution Description:

    o Solution Architecture

        ▪ Architectural Patterns

        ▪ Architectural Diagram

    o Development tools and technologies

- The experience of the team in the field of the product:

    o Technical knowledge of the team-members (using the levels: Advanced, Medium, Beginner)

    o Team experience

- Resources:

    o Establishing the role within the team (ex: Developer, Project Manager etc.)

    o Establishing the distribution of the team regarding the roles (how many participants have the same role?)

    o Establishing the effort of each role in a week (x hours/week)

- Delivery Calendar Presentation (when will intermediate stages of the project be shown to the client?)

- Team Motivation

The project was designed as an E-Learning module which would be integrated in an existent platform as a method of evaluation. The application comprises firstly of a teacher interface which includes adding or updating a test and checking the students' details; secondly, it consists of a student interface which allows one to register and take a test. The logic of the application provides features like randomly generated tests based on a list of questions and grade computing.

Initially, the team is established and the members' attributions are determined according to each one's experience and knowledge base. Moreover, the technologies, programming languages and algorithms used in the application development are set. In the planning phase, the requirements are summarized by the technical writer in the Software Design Document. In addition, the budget and the resource plan are taken into consideration by the Project Manager. The execution part is the most time consuming phase of all. The developers are able to work independently on the modules of the application, as they are clearly delimited. At the end of the development stage, the QA engineers test the features

and the bug fixing stage may follow. Each of the testers develops their own test cases and checks the functionalities independently. Although the independent approach encourages little communication between the team members, developers should certainly receive feedback from the testers, thus ensuring the correctness of the application. When the application passes all the test cases, it is considered successful and sent to the client in the closing phase.

Having a wide range of subjects to choose from and working individually, the students have completed their assignment by bringing their personal contribution from an original point of view based on their personal experience, too. The satisfaction of the students is noticeable with the aid of the final results.

Although the communication within the team should be minimal, it would be helpful to exchange opinions, points of view and approaches to improve the project. Regardless of the benefits of this approach, it lacks the incentive produced by sheer competition. However, the students are motivated in this case by obtaining the best final results.

Another example suited for this type of approach is the "Image Analyzer". This is an application that allows image uploading, exporting, visualizing and permits user process definition. Its main purpose is to integrate several image pre-processing techniques including black-and-white binarization, image segmentation and clustering into a complete configurable image analyzing software that can generate output images along with additional metadata files. Below there is an example that shows how image analyzing works. In this given sample, clusters are formed at an approximate five-pixel distance, with each cluster framed within a black-colored rectangle and each member pixel colored with a random-generated cluster-specific color.

Die Bundesregierung sagt voraus, daß es 1998 ein Wirtschaftswachstum von bis zu drei Prozent und am Jahresende weniger Arbeitslose geben wird. So steht es im Jahreswirtschaftsbericht, den das Kabinett am Mittwoch verabschiedete. Die Opposition sprach von „Schönfärberei", Gewerkschaften vom „Prinzip Hoffnung".

Figure 2. Example of an Image Analyzer application result

"Mortar Mayhem" is a multiplayer strategy game, which simulates trajectory-type artillery conflicts. All players are opponents, with each player aiming to eliminate all the other adversaries throughout several rounds. Each player has available several artillery-like weapons that can be deployed as an offensive attack at any other opponent, with the possibility of launching under a specific angle, shooting power and several other battle options. Based on individual performance, players are awarded points and game-credit at the end of each round. With the earned credit a player can buy more advanced weapons, upgrade the existing ones or buy better protecting armor. The winner of a round is determined on the last-one-standing principle. After a user-defined number of rounds a final player ranking is compiled based on the points won thus far.

"Battleship" is a multiplayer strategy 3D game, where each player has available a number of ships to combat the other adversaries. The winner is determined on the last-one-standing rule. The game is played on a user-defined size grid where each player has available a specific number of combat ships. Based on the defined size, the board is divided into a number of square, with different type of ships occupying a specific number of squares on the grid. The ships cannot overlap each other. Each player takes turns in launching attacks with each available battleship. If the targeted square is occupied by a player ship, the ship is considered partly damaged. A ships is destroyed when all of its occupied squares have been hit. At the beginning of the game players can customize a set of variables and arrange their available battleships on the individual grid. The game ends when a player has destroyed all the opponent's combat ships.

The "Circuit designer" allows the drawing of an electrical schema using a symbol library. This is similar to programs like "Proteus", "Multisim" or "Spice". The goal of this project is to implement a circuit drawing application with vector graphics capabilities in order to achieve great graphical quality of the schemas and circuit logic. The application will have a graphical user interface (GUI) that would allow diagram drawing using a library of electronic symbols similar in functionality with other computer software like "Microsoft Visio" or "Smart Draw". In terms of the GUI drawing canvas, the application would allow several operating procedures: put element, move element, connect wire, move wire, make connection, delete object and select element from library. The application would allow several exporting formats, particularly PDF, JPEG and a vector drawing format chosen by the students.
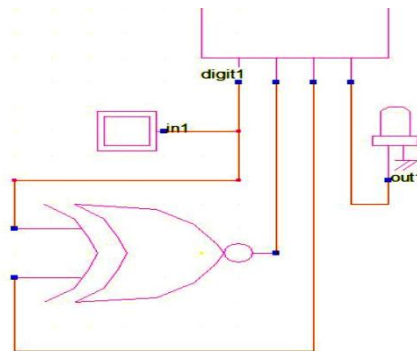

Figure 3. Example of a "Circuit Designer" outcome

"E-Commerce Lite" is a product-oriented data storage platform that can be interfaced using an access application program interface (API). Several higher-level applications are developed on top of the given API: a GUI application for adding, editing and administrating the current inventory, a custom product attribute module and a front-end inventory presentation application in the form of an online store. The system would support a hardware-limited number of simultaneous connections. The platform would consist of several separate modules: a storage module acting as a back-end database of the current inventory, an API module for accessing the storage module, a client module for managing all the user accounts, an inventory administration module for adding, editing or deleting entries in the product database, a data import module for block importing

database entries given in a comma separated values (CSV) format, a custom attribute module which allows users to add customized attributes to the existing list and a front-end inventory presentation application used to visualize the available products.
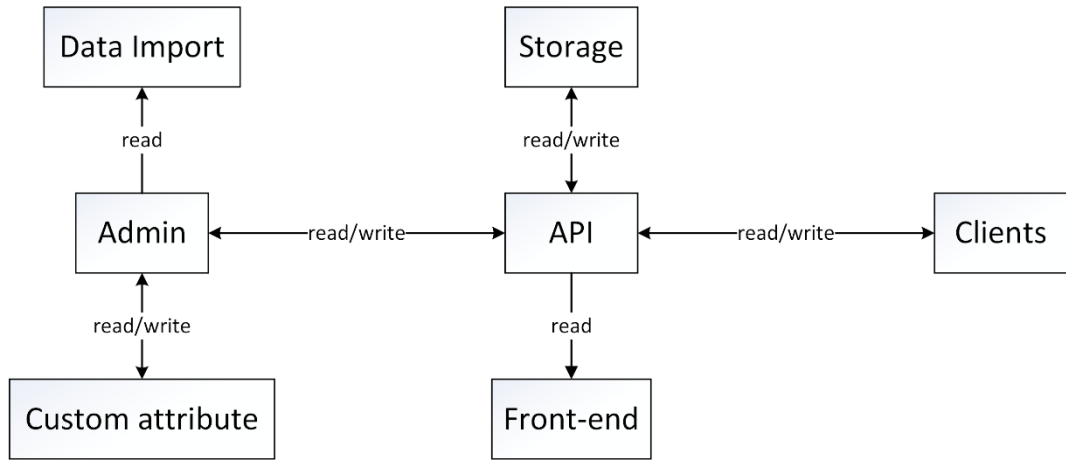

Figure 4. "E-Commerce Lite" module integration scheme

"Fastest and brightest" is a multiplayer game contest which involves agility and intelligence in solving lexical challenges. The game has four different variations, each having two or more game levels designed based on the difficulty of each stage.

The first variation implies find a set of words within a matrix of letters. Each word may occur in either top-bottom, bottom-up, left-right, right-left or in diagonal form. The player who is the first to correctly find all the given words wins. For this variations, a more difficult level would imply a larger input matrix and a fixed time limit.

The second variation has eliminate the set of given words from the input and lets the player look for any lexically correct word from a given language within a time limit. The player who finds the most words that are linguistically correct wins. A more complex level would imply a larger input matrix along with a score penalization if the player fails to find a correct word within the given time.

The third variation follow a similar strategy to the first one, but instead of a list of words, there is only one dynamically given word. The player who is the first to identify the word in the matrix is awarded a number of. If the generated word is not in the matrix there is no score earning. A more difficult level would implement a score penalization for the other players whenever there is one player that finds the generated word. If no player is able to find the given word, all players are penalized.

The forth variation challenges the player to form lexically correct words using letters which are arranged on the face of a clock. For the first level it does not matter the order in which the letters are picked provided that a single letter is not used more than twice. For higher levels there are only nine letters scattered around the clock with one letter in center. Every word generated must include the letter in the center.

C	I	R	E	S	N	I	H	C	O	M	S
F	C	A	S	T	A	N	M	S	D	O	M
B	R	M	P	E	Q	L	T	P	V	L	E
Q	P	W	N	J	U	N	C	C	A	I	S
S	M	S	F	A	A	G	I	I	B	D	T
P	O	L	P	R	U	N	W	S	E	E	E
N	S	R	T	F	A	G	P	K	I	P	A
U	U	A	A	P	B	S	O	Z	U	V	C
L	R	D	Z	P	M	N	I	R	T	S	A
A	O	D	A	M	I	K	F	N	U	C	N
U	C	R	E	R	F	H	T	B	G	N	B
R	S	M	T	C	B	Z	C	D	P	R	M

ALUN	CIRES	MESTEACAN	SMOCHIN
ARTAR	FAG	MOLID	STEJAR
BRAD	FRASIN	NUC	TEI
CAIS	GORUN	PLOP	ULM
CASTAN	GUTUI	PRUN	VISIN
CEDRU	LAUR	SALCIE	
CHIPAROS	MAR	SCORUS	

Figure 5. Fastest and Brightest

"SimTraf" is an urban traffic simulator, which provides the ability to configure various specific features such as traffic congestions, traffic lights duration or the speed limit. The simulation will be visualized on a 2D map consisting of alleys, streets, roads and boulevards bounded by non-drivable areas such as pedestrian areas, flats or buildings. The maps can be predefined or dynamically generated. The road intersections can either be a three-way intersection or a four-way intersection, all controlled with traffic lights. Each road has two traffic lanes per direction of travel. There are only two specific points on the map where simulated cars are generated after a period of time. Throughout the simulation the user can visualize statistics regarding the average speed, the current traffic load or number of cars on the roads. The user cannot control or modify the simulation while it is running. Each statistic is recorded into report that is generated when the simulated has ended.

"Stonemason" is a 3D Breakout-style game. Breakout was an arcade game published by Atari in 1976. The purpose of the game is to destroy several layers of bricks situated in the top third of the screen using a ball that travels around the screen and bounces off the side margins of the screen. The ball must not hit the bottom of the screen and to prevent that the player can turn a paddle to make the ball bounce back upwards. When the ball hits a brick, it destroys it and bounces back downwards. Since its launch there have been numerous block-breaking games inspired by Breakout. Stonemason follows a similar strategy as the original Breakout, but aims to adjust the mechanisms and the game style to a 3D environment. The gaming grid will become a cube, the paddle will move along the lower part of the cube and the wall to-be-destroyed situated in the top third of the cube will be made out of 3D bricks.

"Time Table Scheduler" is an application developed for the automatic management of academic schedules in a university environment. Planning class, laboratory and course time slots present a set of constraints regarding availability of lecture halls, number of enrolled students or necessary laboratory equipment. The structure of the application is based on the Constraint Satisfaction Problem model. The goal of the project is to determine a solution to this particular model by taking into account all the input constraints and generating candidate schedules where time between classes and lectures is minimum and it better complies with high priority constraints.

After the projects are completed the teams will compete in a final-product-selling contest. This is the second time competition is involved in the independent approach. This stage was developed so the students participating will be faced with a real-life scenario: selling the product they worked on. A highly complex and successful project can be poorly received if the team lacks any sales expertise just like a mediocre project can exceed expectations if the team has a superior marketing strategy.

CONCLUSIONS

In conclusion, the independent approach is beneficial not only for achieving a high quality final project, but also to offer a satisfying process in which individuals can perform at their best. Using this approach, even the laziest students get involved.

The purpose of any project is to achieve a final functional product. The time and effort put in by students in order to complete the project was provided with an engaging environment to work in especially because it was a self-selected project, not an imposed one. The students were not displeased by the unbalanced contribution of each team member to the project, as their combined work led to the final result. The teaching strategy was developed so that each student would work both individually as well as in a team, making the individual's evaluation have an impact on one's final score, regardless of the team's achievement.

Research is needed to clarify which mechanisms operate on the group as a whole and which are tied to specific experiences in group interaction. If, for example, increased student morale plays a major role in increasing achievement, then individuals may benefit from the group experience regardless of their own rate of participation.

In conclusion, the independent approach presents both advantages and disadvantages. It works perfectly with projects that are divided into independent modules, whereas it is not suitable for projects that require integration between subsequent modules. Moreover, each individual should have enough experience to work independently, otherwise additional time is implied for research and studying.

FUTURE WORK

Considering the small number of scientific papers on the independent learning process, this topic leaves plenty of room for further research and conduction of case studies. More details about alternate educational approaches in teaching Software Project Management can be found in [13-14].

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