THREE EXPERIMENTS OF LEARNING BY EXAMPLES

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Abstract

The paper proposes three experiments of examples based on learning. The students concerned are students attending in the bachelor of technology courses in the electrical engineering domain including the computer science domain. The teachers-researchers from France, Romania and Poland have been collaborating for many years mainly in Erasmus background. The first experiment is concerned with a method called the DARE method by the authors. The method builds a connection in real time with maths and applied sciences by the use of a computer algebraic system during a three hours session of intensive practical work. The second case focuses on the virtual prototyping learning. The method spread in 3 months for students in an Erasmus placement. The last example discusses the reverse learning technique. These approach turned out to be necessary because of the short working time that is a one week international challenge.

The DARE method : the method has been built by teachers/researchers in an Institute of technology involved in a way to motivate their students. The use of computers in the maths course motivates students to practice maths in connection with other scientific domains such as the electrical engineering domain.

The virtual prototyping method :

The domain of investigation is the virtual prototyping. The virtual product development replaces traditional material object tests with digitized form product by building product digital model. The virtual prototype technology carries out any product optimization. Virtual prototype technology is a kind of engineering method which can shorten new product development cycles by replacing a physical prototype by a virtual digital model. The subject detailed here deals with a virtual prototyping using Delphi programming environment. The example based teaching method is thus applied. There are several potential advantages of example based learning programs, including the ability for people to learn from their home and study without the assistance of an instructor. As the use of computers in life is increasing, all teaching methods and strategies should be renewed to match with the advancement of technology. It means that videos, texts, lessons, homeworks in electronics format should be easily downloaded by any new learner.

Flipped classroom for an international challenge :

The last experiment deals with a recent collaboration with a Polish University concerning French students in part time course and full course Polish students. The educational system in France offers to students to become workers while taking lessons at university. They are called apprentices. Roughly speaking they share their time one month at the university and one month inside their company. At the university, the students must participate to a one week international seminar as mentioned in their syllabus. For a couple of years, this week has been spent at the Warsaw University of Technology. Conversely, the Polish students and their teachers have been invited to participate one week to an educational challenge with students from the Valenciennes Institute of Technology. Due to the restricted time devoted learning and to the negative and positive comments on the feedback, an intensive working week has been built for 2 years in both countries. Base on the internet connection, the teaching and practicing week can be considered as a kind of a flipped classroom. The paper describes the French system for apprentices and two examples of the international challenge.

Keywords: learning by examples, international week, virtual prototyping, DARE method for maths

1 INTRODUCTION

The paper proposes three experiments of an example based learning method. The students concerned are full time students or part time students in the bachelor of technology courses in electrical engineering domain including computer science domain. The teachers-researchers from France, Romania and Poland have been collaborating for many years mainly in Erasmus background. The first experiment is concerned with a method called the DARE method by the authors. The method builds a connection in real time with maths and applied sciences by the use of a computer algebraic system during 3 hours session of intensive practical work [1,2,3]. It has been used mainly at the Valenciennes Institute of Technology (www.univ-valenciennes.fr). The second case focuses on the virtual prototyping learning applied many years at the Transylvania University of Brasov (www.unitbv.ro). The method spreads last three months for students in an Erasmus placement. The last experiment discusses with the reverse learning technic. These techniques turned out to be necessary because of the short working time. In one week the Valenciennes Institute of Technology apprentices and full courses students from the University of Warsawa (www.pw.edu.pl) participate to an international challenge both in France and in Poland.

The DARE method has been built by teachers researchers at the Valenciennes Institute of Technology involved in a way to motivate their students. The use of computers in the maths course motivates students to practice maths in connection with other scientific domains as the electrical engineering domain. The term DARE is acronym for Discovering, Applying, REsolving. They represent the three steps working with a computer algebraic software. First the students discover the general subject written in the proper terms for the software, then they apply the syntax for maths questions and finally, they model a situation, propose some solution elements and try them on the software. This last part is focusing on the way for students to write down they own ideas and solve within the software.

The virtual prototyping method is devoted to the use of the oriented object programming to investigate virtual prototyping [4,5]. The virtual product development replaces traditional material object test by digitized form product by building product's digital model. The virtual prototype technology carries out any product optimization. Virtual prototype technology is a kind of engineering method which can shorten new product development cycles by replacing cost physical prototype with virtual digital model. The subject detailed here deals with a virtual prototyping using Delphi programming environment. The example based teaching method is thus applied. As the use of computers in life is increasing, all teaching methods and strategies should be renewed to match with the advancement of technology.

The final part deals with a flipped classroom for an international challenge. It details a new collaboration with a Polish university concerning French students in part time course and full course Polish students. The educational system in France offers to students to become workers while taking lessons at university. They are called apprentices [6]. An official organism is managing all apprentices in any domain and course for the Nord Pas de Calais region (http://www.formasup.fr/region/nord-pas-de-calais). Roughly speaking students share their time one month at the university and one month inside their company. At the university, the students must participate to a one week international seminar as written in their syllabus. For a couple of years, this week is spent at the Warsaw University of Technology. Conversely, the Polish students and their teachers are invited to participate one week to an educational challenge with students from the Valenciennes Institute of Technology. Due to the restricted time devoted learning and to the negative and positive comments on the feedback, an intensive working week has been built for 2 years in both countries. Based on the web connection, the teaching and practicing week can be considered as a kind of a flipped classroom. The paper describes the French system for apprentices and two examples of the international challenge.

Some conclusions are drawn to end the paper.

2 THE DARE METHOD

The first example is based on a way to make the connection between maths and technology. The method has been built by teachers-researchers in maths, automation, electronics and computer science in an Institute of Technology involved in a way to motivate their students. A couple of years ago those teachers have thought hard on their teaching experience. A particular attention has been put on a special

vocabulary used by both domains. Students concerned by those two domains are second year students in electrical engineering technical course. More recently the method has been chosen for experimentation in a higher school of engineering in the first year course in mechanics and in hydraulics. All practical mathematics are based on real technological situations in that context.

2.1 Linking maths and technology

This section shows how maths referring to a technical subject can be attractive in a computer algebra system background. To experiment, explain, modify, check, model, and write down all events are some required elements to build a scientific work. The first paragraph is devoted to some computer algebra systems while the second describes the method in use.

2.2 On computer algebra systems

A computer algebra system-CAS in short- is a software program for easy manipulations of formal mathematical expressions. The wide distribution of Mathematica and Maple contributed to make these software as popular as possible. Other CAS in open source as Mathcad, Matlab, Maxima, Mupad, Python, Scilab are also used by the community. Some of them are devoted to numerical calculation. Shrinking the time for numerical or calculation is the main reason for their development. In addition, a profuse literature is growing in a large scale of scientific domains. All the authors mainly deal with a problem from its mathematical formulation to its computer aided solution and the tools required in that context are detailed page after page. This technique applied for many years to students in practical mathematical works was not quite satisfying for many reasons. Students need at the beginning some main functions on the given subject, they spend too much time learning the tools rather than investigate other directions, they have no reflex to use the software 's help. As a result, the authors have focused on a method which is as efficient as possible, as it motivates students to applied maths to the technology and saves time while learning the software and doing a scientific work. The major part of the efficiency is due to the choice of only one technological application for the three hours work.

2.3 Using a computer algebra systems

The framework is now related to a given technological problem, e.g. a water tank model and its formulation accordingly to the mathematical model established before. An instruction guide including questions is given to the students at the beginning of a three-hours course. Groups of two students work on a computer equipped with the Maple software and have to read, explain to each other and fill in a log book. The LabRoom contains twelve students. The road-map inside the instruction guide splits into three roughly equivalent periods denoted as Discovering the tools, Applying the tools and REsolving a problem. That forms the DARE method.

The use of computers in the maths course motivates students to practice maths in connection with other scientific domains as the electrical engineering domain. The students concerned are on a French bachelor of technology course for the second or third year. The first period, called Discovering the tools drives students from a computer algebraic system to maths. It represents 25% of the whole time and of the final assessment too. In order to practice the software, students have to type all helpful functions, observing their effects, modifying parameters if any. During the time they write down the mathematical form of statements and everything that happens including errors, questions to the teacher and their own remarks. At the same time, the teacher discusses on the subject, puts comments in real time on their work, explains instructions if necessary and answers any questions. As all students succeed in this elementary but not simplistic work, this part represents the starting point of the positive attitude and motivation. Based on Pareto's law known as the 80-20 rule it also represents the most useful information to tackle future problems proposed in the last part.

The second period called Applying the tools -25% of the whole time and of the final mark- guides students from maths to CAS. They will both apply the software in well mathematical formulated problems and improve their software knowledge of the given subject. The second period offers as well the opportunity to explore new parameters in built-in functions and to write down everything that occurs.

The last period called Resolving a problem - 50% of the whole time and of the final mark- puts an end to all previous works and should prove the needs of using CAS for any technical problem. In that part, a
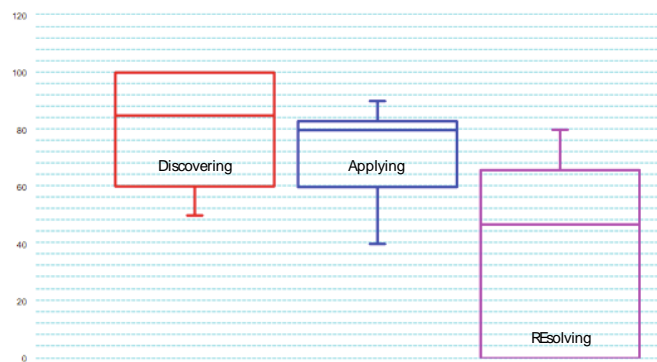
problem coming from a real technical situation has to be dealt with. Except for given numerical data, the problem is formulated in current language terms. It means that students should go further, adapt to the problem and thus prove their scientific skills. A final report including all events ends the course and contributes to the student assessment.

The students are also being asked during the labwork to participate in a questionnaire

2.4 The questionnaire and some comments

DARE Actions	Description
Discovering	Typing without errors Changing parameters Writing down notes Copy/Paste help examples Giving explanation on the First help item
Applying	Adapting the maths syntax to the software syntax Select the right information from help Writing down notes Asking questions
Resolving the problem	Modelling the problem Defining significant parameters Setting and Solving equations Teacher 's favorite

Table 1 : Questionnaire on the DARE method effects

Figure 1 : Representation of the students evaluation for each item of the DARE Method

The questionnaire in Tab.1 is given to students and filled up by the teacher while moving on groups. The starting marks are smileys that represent one of the following states as satisfying, to be improved or needs efforts. It has been proposed to 8 groups of 12 students each. In figure 1, a box plot representation for any item is proposed in Fig.1. The results confirm the teachers intuition coming from previous experiments. As the time is flowing during the labworks, each part discovering, applying and resolving is getting more and more difficult for students. This method has been applied since ten years. Now it appears the weak points

of the method. In fact, the two first steps are turning students more passive. They typewrite the texts from the Computer algebraic system to maths and conversely. The last part should give them more active. But when any difficulty is getting up, they are leaving down the work. But recently, some students took the initiative of explaining and discussing to their friends during the classroom. They take the pen, go to the board, write down ideas, useful formulas and start explanations either to their friend and to the teacher who is giving the least help as possible but giving the time to students to teach. This sharing knowledge part will be more precised after new experiments. The three steps method detailed here takes 3 steps for 3 intensive working hours. The method described in the next section takes also three steps where main items are closed to the former method. It mainly concerns a three months student placement.
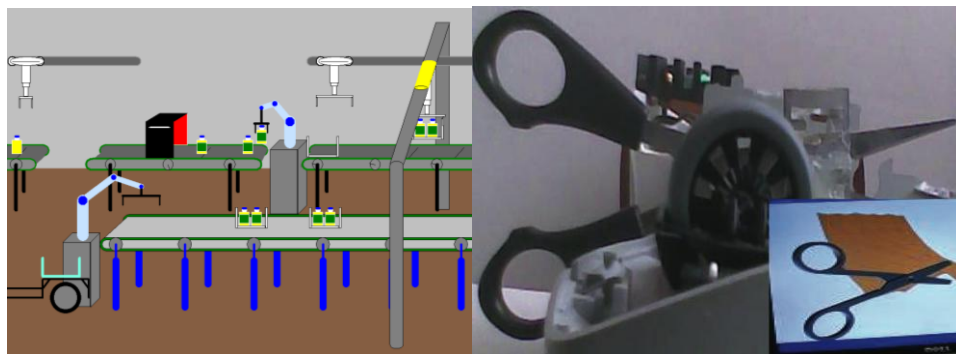
3. THE VIRTUAL PROTOTYPING METHOD

3.1 Overview

The impact of computers on our lives encourages the development of new software. The software applications development can be used to help students/designers to develop and implement the virtual prototypes in engineering. The virtual prototyping method –VPT in short- can help students/graduates develop knowledge and skills to pursue such as software applications developer job or software applications engineer job. The virtual product development replaces traditional material object test with digitized form product by building product's digital model. The VPT is a kind of engineering method which can shorten new product development cycles by replacing cost physical prototype with virtual digital model [7,8,9].

Typical product development cycles can be expensive procedures, particularly when physical prototypes are required. When a physical model is involved, the product must be designed, built and tested. Physical prototypes must be built and re-built after every unsuccessful test, making them a less than optimal choice for a company that values efficiency. With virtual prototyping, the development of a product moves directly from design to testing and analysis, and then finally to build. The VPT allows for the digital exploration the carries out any product optimization and complete behavioral simulation before it is in reality built, decreasing the number of rebuilds necessary and minimizing material waste. A virtual prototype allows product design teams to view moving parts within a system, ensure that elements operate together impeccably, and validate real world performance; all before manufacturing always takes place. A product's design defects or assembly problems are discovered before it physically exists, and the laborious cycle of build-test-fix-rebuild becomes considerably shorter.

The VPT can be used not only to observe and examine products before fabrication, but also to test products and parts before physical product build, to test systems and infrastructure strategy before implementation. The VPT brings virtual prototypes to a whole new level by permitting the designer to experience an entire manufacturing process, complete with interactive features and real time tracking of the components' movements. In this virtual environment, engineers observe a product's build process before the build still takes place, allowing a company to preview and update complex manufacturing processes the same way they would a new product. The VPT cut down the costs of virtual prototype. Therefore, it allows a product to move to market more quickly and efficiently.

Figure 2: *Left , a virtual prototype of the experimental manufacturing robotic line ; Right,a physical device and its virtual prototype.*

In the virtual environment, in order to view the projected images, the 3-D scene projections are created using specialized software. These are known for their advanced visualization solutions for 3-D applications designed to display virtual prototypes. In the case of 3-D virtual objects such as a manufacturing robotic line, designers can observe around the 3-D objects exactly as they would in the real world (Fig.2 left). The designer can essentially experience a 3-D environment while interact with the virtual world accordingly. Product or infrastructure testing and analysis become far more effective when the viewer can interact with the 3-D world in real time; such is the case of haptic interfaces, another viable example of the VPT. Haptic technology allows the collaborative work between virtual world and physical world (Fig.2 right).

The VPT in all forms allow a company to cut down on costs, minimize rebuilds, and move products to market more efficiently. Because of the recent innovations made to virtual technologies, virtual prototypes are more affordable and versatile for any company that desires now has the opportunity to greatly improve their product development cycles through the use of the VPT. Small and medium-sized businesses – futures employers for Erasmus students - can now afford to make the move from physical prototyping to virtual prototyping, a luxury that was previously only afforded to larger corporations.

The next part is focusing on the applied method to teachings.

3.2　　The proposed method

The method described has been applied for many years with two types of students. These are local students or Erasmus students. The first are local students coming from the Transylvania University of Brasov in Romania. They chose the master of technology course in the robotics domain or in the building engineering domain. The final part of their course is concerned with a project in the virtual programming environment. The second kind are Erasmus students coming mainly from the University of Valenciennes in France. To end their bachelor of technology course, the French students in electrical engineering domain follow a 3 months placement at the Romanian university. They are supervised by the teachers mentioned in the paper head. The method also called the DARe method is used to design virtual prototypes based on examples. The word DARe represents the acronym of Discovering, Applying, Realizing. The 3 steps method is described below.

The first step called Discovering offers the connected student to download as many examples as he wants. Any example is given in an executable format only. During one week, the student launches the example, takes notes and comments on the scenario and writes down new ideas on a working platform. Hundreds examples are coming from previous works done by local or foreign students. The general framework matches the robotics or civil engineering domain. During this week devoted to trials, the supervisors are asked to detail the objectives or the specifications of a given application. They focused on the starting motivation and the results. In some cases, the virtual prototype application is coming from local companies and patents can be defined of the realized product. This first step is feeding the imagination of the students to define their own product.

The second step takes one week too and is called Applying. It means that the student gets from the supervisors the source code of the few examples he ran. He is checking the different parts of the source code and their effects when running. The supervisor is proposing to change one elementary part of the source code and its application on the product. At that moment, the student is discovering and applying by his own the new programming language for the virtual prototyping. The supervisor comments the results. This second step is defining the student project he will build himself. At that moment the student is sure to end the product during the placement.

The last step represents the most important work either for quantity and quality and is called Realizing. That part starts 2 weeks after the beginning of the placement.

Programming, compiling and running the code, writing comments in a logged book, proposing new ideas, preparing the final report are the main tasks carried out by the student till the placement's end. Once the product achieved, all program source codes are printed out. The running virtual prototype application is installed on a compact disk for archives at the university library and further use.

The programming language is now explained in depth by the supervisor. All menus are detailed. Special lessons are given to the students to improve the fresh knowledge they catch by their own. The oriented object programming delivers its secret to the students helped by teachers, relayed by the notes written in

the logged book. These comments are setting the structure of the final report. During the Erasmus placement and thanks to the net, all student work are also checked by their home university. At the home university, from the starting week to the last week, a more administrative supervisor is also checking the improvements of students abroad. Each student sends him the details of the working week. One reason is to link all persons involved in the project. The second is a more academic reason. That is, in Erasmus background placement, the home and host universities must prove at any time to the European Community the use of all funds for teaching and continuing collaborative exchanges. Back to the student project, the choice by his own of the product to realize determines and keeps going the motivation. The following section focuses on this point.

3.3 From an idea to its achievement

3.3.1 The flicker

This is where the initial flicker for a project comes from passions, or a colleague's passion. The students have the total freedom to choose their project about her original idea. A project's initial flicker may take many forms: it could be a question or it could be a product that you'd like students to do. Teachers are the designers of learning who created the conditions for the students to conduct their own enquiries, and advisers to whom learners can come as they create their product. For both students and teachers, this is work that matters.

3.3.2 An essential question

The best project always contains an essential question that both inspires and requires student to conduct serious researches. It's never too early for students to mind an essential question. However, this essential question would probably change once the project 's design is settled. Three criteria for a compelling essential question follow : it should be a question that students ask in the 'real world', It should be a question that has no easy answer for virtual world and It should be a question that ignites students' imaginations. Finding a question that fits these three criteria is not easy: it takes time, trial and error, and lots of discussion with colleagues. Some of the best essential questions are those that students come up with themselves. By discussing the issue and doing some initial research, groups (or individual students) can come up with a question that will guide each of their enquiries; for example, 'Is manufacturing as efficient as it could be expressed in virtual world ?

3.3.3 Personalize the project

Each student has a model project to show the study before it begins, so the student knows what expectations are. Successful projects are designed so that students make decisions for themselves throughout the proces; each student chooses what to focus on.

3.3.4   Patent or Motivating student to innovation

The most popular way to encourage innovation is to offer students recognition for innovative ideas by allocating time for innovative work and by satisfying with opportunities for career progression. Recording the number of patents is one of the popular measures of innovation [4]. During the stage the students are preparing to work in the innovative companies which are known for encouraging innovation by freeing up its staff to spend one day a week developing their own innovative projects.

The didactic project model presented in the text shows a sequence of the evolution of the diary activity that implies the evolution of the intelligent parts, allowing step-by-step visualization.

The virtual prototypes models appear as an important tool for the intelligent structures or parts surveillance and for supporting decisions based on the visual analyses of alternative solutions. In that case, many alternative modeled solutions worked out the optimal solution.

4.   A FLIPPED CLASSROOM FOR AN INTERNATIONAL CHALLENGE

The last example deals with a new collaboration with a Polish University concerning French students in part time course and full course Polish students. The educational system in France offers to students to become workers taking lessons at university. They are called apprentices. Roughly speaking they share

their time one month at the university and one month inside their company. At the university, the students must participate to a one week international seminar as written in their syllabus. For a couple of years, this week has been spent at the Warsaw University of Technology. Conversely, the Polish students and their teachers are invited to participate one week to an educational challenge with students from the Valenciennes Institute of Technology. Due to the restricted time devoted to learn and to the negative and positive comments on the feedback, an intensive working week has been built for 2 years in both countries. Based on the web connection, the teaching and practicing week can be considered as a kind of a flipped classroom. The following describes the French system for apprentices, 2 examples of the international challenge and their contents and some feedback on the organization in order to improve the future collaboration.

In France, companies have to pay taxes to the government. Among these, a special tax called apprenticing tax represents a ratio of the all taxes collected. This tax is used to finance learning organisms devoted to teach to apprentices and connected to companies. The French Institutes of Technology are one of them. Their missions consist in proposing professional courses for full time or part time students in connection with local companies. Mainly, part time courses alternate within one month. That choice is a good compromise for universities and companies. There are 3 types of persons involved in the process : the student, the company's supervisor and the teachers. All are linked with contracts.

According to the salary grid of apprentices, the company gives wages to the student. The employer provides to the student a training program corresponding to the chosen profession and a guide aimed at supervising the work. The supervisor skills match the student's domain. The supervisor also helps and checks the student's work.

The apprentice signs up to agreeing to the company's rules, doing the planned tasks, attending all theorical lectures and taking the examination inside the organism devoted to teach. The center must define the teaching objectives, carry out the teaching, tell the supervisors. a contract where he for two years practicing. The company receives advantages while welcoming apprentices as no adding apprentices to the workforce, no contribution and a tax credit. All jobs in any domain are covered by the apprentices system from workers to engineers. The famous cook Paul Bocuse started as an apprentice. Here the paper deals with the bachelor of technology in electrical engineering domain. Written in their syllabus, an international week should be organized to make apprentices sensitive to the international background as mainly their host company are working worldwide sending engineers or technicians for international missions.

An international week in Poland. For instance, the French apprentices receive elementary information on robotics and image recognition. They discovered team working, explanations in fluent English language, sharing knowledge. A report including program sources and a final presentation end the intensive week work. The main difficulty was to be as efficient as possible in a really short time and intensive working sessions.

This has been done for 2 years. The first year was an experiment for anybody involved in the project. Administrators, teachers and students launched the project and a feedback has been drawn at the end of the session to get improvements for the forthcoming years. The week was organized as follows.

The group of 14 students is divided in two, one for the robotics domain (Fig.3. left) and the second for image recognition domain.

Day 0 : welcoming at the airport by hosts, travels, accommodation and rest.

Day 1 (8 hours work) : for both group, the students launches previous examples identify helped by the supervisor the different parts acting in a given system. A problem to solve is thus given to the group. The group has to be structured to be as efficient as possible. Thus a manager, a report writer, a speaker and technicians are defined.

Day 2 : (8 hours) A succession of trials , experiments and videos, feedback comments, improvements has been done all day long.

Day 3 et 4 the groups alternate.

Day 5 (morning) a report, a presentation and videos are presented to the jury of experts in order to validate the work and classify the domain skills of each group. A questionnaire given to the students and their teachers push out the problems. Difficulties to understand technical and common English language, Too much new knowledge in too few hours are the main negative aspects. Conversely, the students are now sensitive to the importance of English language. Even if they know the team working inside their companies, they discover, organize and practice themselves this team working.

Day 6 : Travelling back

The next year working class was planned long before. The sending and the receiving university obtained the technical reports and presentations. Some videos on the running software are also sent to both institutions. As the students are a little bit afraid of the amount of work to do, the flip classroom offers the required knowledge to students and turns them more confident on the work to carry out.

An international week in France. A couple of months later, a group of Polish students is selected to participate in France at a robotics competition for the first year. The second year another group programmed automatic systems. In both cases, the week schedule looks like the following.

Day 0 : the travelling day: welcoming at the airport by hosts, transportation to residence and rest.

Day 1 : (8 hours) Presentation of the week with French students, defining the groups and the tasks. Five groups are built. They are each composed of 3 French students plus 3 Polish students one Finish or one Irish student. For the first year a Legomindstorm systems has been considered. For the second year two automatics systems were held on. The Lego project consists in moving a rover inside a maze. A lift mock up and the electrical engineering building mock up (Fig.3. Right) were considered. In both cases, some tasks are designed from elementary to more sophisticated. A task once completed is checked by the supervisors that are the teachers involved in the projects.

Day 2,3,4 : (8 hours/d) Intensive work on project and tasks validation

Day 5 (in the morning): final report and presentation including videos in front of the jury of experts. Rewards given to the students for participation.

Day 6 : Travelling back

Now, all further activities have been planned months before. The teachings success is mainly due to the reverse teaching in an international challenge. The main documentations, reports, presentation and programs are given to the student through a data base as Moodle for example. Such a success has been possible thanks to administration, colleagues, academic staff and students.

Figure 3: Left, a rover in Lego bricks moving in a maze ; Right, a building mock up equipped of sensors to be programmed

5 CONCLUSION

The paper presents three experiments learning by examples teaching. The first is based on method that links maths to technology. This method used for a decade has shown its weakness. By the way, the last step of the method is requiring more initiative rather the two previous steps. As the difficulty is growing up,

the motivation is getting down. But, a recent behavior of some students opens the door to improve the method. These students take the initiative to explain to their friends asking questions. The teacher should make huge efforts to be quiet and not to reveal the solution. The second experiment is concerned with the virtual prototyping method. The virtual prototype is a modern concept that saves times and money for the design of a new product. The method implies the use of the oriented object programming. This language is applied by French students in Erasmus placement in Romania. The last experiment deals with a cooperation with the Warsaw University of Technology in Poland. One week is devoted for students in a teaching challenge by the way a robotic competition. To be as efficient as possible the flip classroom is preparing the French apprentices and the Polish students to the new knowledge.

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