RECENT ADVANCES in EDUCATION and MODERN EDUCATIONAL TECHNOLOGIES

Proceedings of the 2013 International Conference on Education and Modern Educational Technologies (EMET 2013)

Venice, Italy
September 28-30, 2013
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Keynote Lecture 1

Ant Decision Systems for Combinatorial Optimization with Binary Constraints

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Abstract: In this paper is considered a problem (P) which consists in minimizing an objective function $f$ while satisfying a set of binary constraints. Function $f$ consists in minimizing the number of constraints violations. Problem (P) is NP-hard and has many applications in various fields (e.g., graph coloring, frequency assignment, satellite range scheduling). On the contrary to exact methods, metaheuristics are appropriate algorithms to tackle medium and large sized instances of (P). A specific type of ant metaheuristics is designed to tackle (P), where in contrast with state-of-the-art ant algorithms, an ant is a decision helper and not a constructive procedure.

Brief Biography of the Speaker: Swiss citizen, Nicolas Zufferey is Professor of Operations Management at the University of Geneva. He holds a PhD in Operations Research from EPFL. His research and publications relate to the heuristics, operations research, optimization, logistics management and quantitative management methods.

The full paper of this lecture can be found on page 260 of the Proceedings of the 2013 International Conference on Applied Mathematics and Computational Methods, as well as in the CD-ROM proceedings.
Keynote Lecture 2

A New Framework for the Robust Design of Analog Blocks Using Conic Uncertainty Budgeting

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Abstract: In nanoscale technologies process variability makes it extremely difficult to predict the behavior of manufactured integrated circuits (IC). The problem is especially exacerbated in analog IC where long design cycles, multiple manufacturing iterations, and low performance yields causes only few design to have the volume required to be economically viable. This paper presents a new framework that accounts for process variability by mapping the analog design problem into a robust optimization problem using a conic uncertainty model that dynamically adjust the level of conservativeness of the solutions through the introduction of the notion of budget of uncertainty. Given a yield requirement, the framework implements uncertainty budgeting by linking the yield with the size of the uncertainty set associated to the process variations depending on the design point of interest. Dynamically adjusting the size of the uncertainty set the framework is able to find a larger number of feasible solutions compared to other robust optimization frameworks based on the well known ellipsoidal uncertainty (EU) model. To validate the framework, we applied it to the design of a 90nm CMOS differential pair amplifier and compared the results with those obtained using the EU approach. Experimental results indicate that the proposed Conic Uncertainty with Dynamic Budgeting (CUDB) approach attain up to 18% more designs meeting target yield.

Brief Biography of the Speaker: Claudio Talarico is Associate Professor of Electrical and Computer Engineering at Gonzaga University. He holds a PhD degree in electrical engineering from University of Hawaii where he conducted research in the area of Embedded System-on-Chip. Before joining Gonzaga University, he worked at Eastern Washington University, University of Arizona, University of Hawaii, and in industry where he held both engineering and management positions in the area of VLSI integrated circuits. The companies he worked for include Infineon Technologies, in Sophia Antipolis, France, IKOS Systems in Cupertino, CA and Marconi Communications, in Genova, Italy.

The full paper of this lecture can be found on page 49 of the Proceedings of the 2013 International Conference on Electronics, Signal Processing and Communication Systems, as well as in the CD-ROM proceedings.
Keynote Lecture 3

On Mutual Relations Between Bioinspired Algorithms, Deterministic Chaos and Complexity

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Abstract: This lecture is focused on mutual intersection of three interesting fields of research i.e. bioinspired algorithms, deterministic chaos and complexity, introducing a novel approach joining bioinspired dynamics, complex networks and CML systems exhibiting chaotic behavior. The first part will discuss a novel method on how dynamics of bioinspired algorithms can be visualized in the form of complex networks. An analogy between individuals in the populations in an arbitrary bioinspired algorithm and the vertices in a complex network will be discussed as well as the relationship between the communications of individuals in a population and the edges in a complex network. The second part will discuss the possibility of how to visualize the dynamics of a complex network by means of coupled map lattices and to control by means of chaos control techniques. The last part will discuss some possibilities on CML systems control, especially by means of bioinspired algorithms. The spirit of this keynote speech is to create a closed loop in the following schematic: bioinspired dynamics --> complex network --> CML system --> control CML --> control bioinspired dynamics. Real-time simulations as well as animations and pictures demonstrating the presented ideas will be presented through this lecture.

Brief Biography of the Speaker: Ivan Zelinka is currently working at the Technical University of Ostrava (VSB-TU), Faculty of Electrical Engineering and Computer Science. He graduated consequently at Technical University in Brno (1995 - MSc.), UTB in Zlin (2001 - Ph.D.) and again at Technical University in Brno (2004 - assoc. prof.) and VSB-TU (2010 - professor). Before academic career he was an employed like TELECOM technician, computer specialist (HW+SW) and Commercial Bank (computer and LAN supervisor).
During his career at UTB he proposed and opened 7 different lectures. He also has been invited for lectures at 7 universities in different EU countries plus role of the keynote speaker at the Global Conference on Power, Control and Optimization in Bali, Indonesia (2009), Interdisciplinary Symposium on Complex Systems (2011), Halkidiki, Greece and IWCFTA 2012, Dalian China. He is and was responsible supervisor of 3 grant of fundamental research of Czech grant agency GAČR, co-supervisor of grant FRVŠ - Laboratory of parallel computing. He was also working on numerous grants and two EU project like member of team (FP5 - RESTORM) and supervisor (FP7 - PROMOEVO) of the Czech team.
Currently he is professor at the Department of Computer Science and in total he has been supervisor of more than 30 MSc. and 20 Bc. diploma thesis. Ivan Zelinka is also supervisor of doctoral students including students from the abroad. He was awarded by Siemens Award for
The Role of Presence, Flow and Education Components in the Continuing Intention to e-Learn

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Abstract—This paper investigates learners’ experiences in virtual education environments and the impact on their continued intention to e-learn. We study how presence and flow affect behavioral intention to continue e-learning, and analyze the role of TAM perceptions on core components of the virtual education environment. We develop an integrated conceptual model, and we test it by means of a questionnaire-based survey and registered data collected from a broad sample of learners within a virtual education environment. The results strongly support the conceptual model, suggesting that the virtual education environment’s components (categorized by professor attitude and perceived didactic resource quality) play a key role in prompting learners’ perceptions, attitudes and behavioral intentions.

Keywords—e-learning; professor attitude; didactic resources; presence; flow; TAM

I. INTRODUCTION

Digital didactic resources and teaching processes have been identified as central components of e-learning programs. Yet scholars and education institutions alike still have much to study about the connections between these two important components of online programs and the e-learners’ tendency to continue using virtual education environments.

To analyze continuing intention to e-learn, TAM [1] [2] is a valid theoretical framework. However, the TAM constructs of perceived ease of use and perceived usefulness do not fully capture the range of psychological phenomena elicited by e-learning. On the basis of literature in consumer behavior, reference [3] suggests that users of virtual environments interpret incoming information from affective and cognitive mechanisms. While affective processing facilitates perceptions related to utilitarian facets of the virtual environment, like TAM perceptions, cognitive processing intervenes in the emergence of senses of presence and flow states, which occur when users entirely immerse themselves in the virtual environment [3].

We further understand presence and flow as related, yet distinct facets of individual’s cognitive immersion [4] in a virtual education environment. While presence will cover the spatial aspects when feeling placed in the virtual education environment, flow will refer to the state occurring when being focused on the learning activity developed in this alternative realm.

II. CONCEPTUAL MODEL AND HYPOTHESES

Our integrated model of the continuing intention to e-learn includes four types of causal pathways: pathways that stem from presence research (H1-H4), pathways from Flow Theory (H5-H8), extended TAM pathways rooted in e-learning literature (H9-H13), and original TAM paths (H14-H17) – see Table I.

TABLE I.

Hypothesized paths of the model and contexts of prior testing

<table>
<thead>
<tr>
<th>Hypothesized pathways</th>
<th>Contexts of prior testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1 (+) PA→P</td>
<td>E-learning satisfaction [8]</td>
</tr>
<tr>
<td>H2 (+) PDRQ→P</td>
<td>No prior testing</td>
</tr>
<tr>
<td>H3 (+) P→F</td>
<td>E-learning attitude [9]</td>
</tr>
<tr>
<td>H4 (+) P→CINT</td>
<td>E-learning adoption [10]</td>
</tr>
<tr>
<td>H5 (+) PDRQ→F</td>
<td>E-learning adoption [11]</td>
</tr>
<tr>
<td>H6 (+) PEOU→F</td>
<td>Continuing intention to e-learn [12]</td>
</tr>
<tr>
<td>H7 (+) F→AP</td>
<td>Self-reported performance [7]</td>
</tr>
<tr>
<td>H8 (+) F→AU</td>
<td>Continuing intention to e-learn [13] [14]</td>
</tr>
<tr>
<td>H9 (+) PA→PDRQ</td>
<td>Perceived quality of e-learning [15]</td>
</tr>
<tr>
<td>H10 (+) PA→PEOU</td>
<td>No prior testing</td>
</tr>
<tr>
<td>H11 (+) PA→PU</td>
<td>E-learning adoption [11] [16]</td>
</tr>
<tr>
<td>H12 (+) PDRQ→PEOU</td>
<td>E-learning adoption [11] [16] [17]</td>
</tr>
<tr>
<td>H13 (+) PDRQ→PU</td>
<td>E-learning adoption [11] [16] [17]</td>
</tr>
<tr>
<td>H14 (+) PEOU→PU</td>
<td>Continuing intention to e-learn [13] [18] [19]</td>
</tr>
<tr>
<td>H15 (+) PEOU→AU</td>
<td>Continuing intention to e-learn [13]</td>
</tr>
<tr>
<td>H16 (+) PU→AU</td>
<td>Continuing intention to e-learn [13] [18]</td>
</tr>
<tr>
<td>H17 (+) AU→CINT</td>
<td>Continuing intention to e-learn [13] [18]</td>
</tr>
</tbody>
</table>
III. METHOD

A. Data collection

The data employed was obtained from the Universitat Oberta de Catalunya (Open University of Catalonia) in Barcelona, Spain. Data collection was carried out through a web-based survey (conducted in Spring term 2010), and registrar’s office data of students’ course grades (also for the Spring term 2010).

The sample frame consisted of current undergraduate and graduate students of online programs, who had already taken and passed a term at the University. A total of 2,530 usable questionnaires were obtained.

B. Measurement

Measurement items for the constructs in the survey were selected from prior research [1] [15] [19] [20] [14] [21] [2]. Items were adapted to the concrete virtual education environment of the University, and made available in the two languages used by e-learners (Spanish and Catalan). All items were answered on a 7-point Likert-type scale, anchored between ‘strongly disagree’ and ‘strongly agree’.

AP was captured by adding the final marks achieved in all courses taken by the e-learner in the term of reference. Course grades ranged from zero (unsatisfactory) to five (excellent work).

IV. RESULTS

Tests of the model were carried out through structural equation modeling. Model estimation was done with the maximum likelihood approach.

A. Measurement model

To assess internal reliability, the Cronbach’s α and item-to-total correlation were computed for each construct. All values improved the minimum required bounds. To analyze the convergent validity, it was checked first that all factor loadings (associated to each construct) were above the value of 0.60; second that the composite reliability values were greater than 0.70; and third that the variance extracted was lower than the composite reliability values. With respect the discriminant validity of each construct, it was obtained the required condition that the average of the variance extracted was greater than the maximum shared variance and the average shared variance.

B. Structural model

The absolute fit measures of the model (goodness of fit index, standardized root mean square residual, root mean square error) satisfied the required standard conditions. The incremental fit measures (the adjusted goodness of fit index, Tucker-Lewis index and the comparative fit index) were greater than the required lower bounds. All parsimonious fit measures (parsimonious goodness of fit index, parsimonious normed fit index, and parsimonious comparative fit index) were closer to 1. These results showed a good fit of the model.

Since all path weights were positive and significantly different from zero at 99%, all the hypothesized pathways were supported.

V. CONCLUDING DISCUSSION

Our investigation fills a gap in the literature in e-learning, by connecting two critical components of online education programs (PDRQ, PA) with e-learners’ behavioral intentions. Our research suggests that these two education components are relevant antecedents of P, PEOU and PU; and that PDRQ triggers F. Furthermore, it notes that PDRQ and PA indirectly elicit CINT. Another interesting result is that PA influences PEOU and, indirectly, F. These findings further shows the crucial role played by professors (along with didactic resources) in continuing intention to e-learn.

References


Dynamics of Mechatronics Engineering in Pakistan

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Abstract — Mechatronics, being a new engineering discipline in Pakistan, has to face many risks for its successful establishment and growth. Every discipline owes its evolution and progress to the stakeholders, government, universities and experts. This paper discusses the general view of Mechatronics engineering education in Pakistan, the evolution of Mechatronics engineering in Pakistan and the status of Mechatronics in the industries of Pakistan. The paper presents a survey based approach and the use of Cronbach Alpha for assessing reliability of the data.

Index Terms— Mechatronics, Evolution, Career, Mechatronics Industry Survey, Cronbach Alpha.

I. INTRODUCTION
A. History – Mechatronics

The word 'engineering' originated when man started inventing devices like wheel and pulley, using his skills. The word engineer originated from the word 'engine', which comes from the Latin word ingenium. Ingenium means "innate quality specifically of mental power". So the word engineer evolved as a person who makes effective and practical inventions. Today the definition of an engineer is a person who has got scientific and technical knowledge and is making use of this knowledge to design, analyze and build functional works. Engineering is a wide discipline with many sub-disciplines dedicated to various fields of study with respect to specific technologies. The history of engineering can be roughly divided into three overlapping revolutionary phases. These are:

1) Pre-Scientific Age

Before the revolution of science, an engineer was defined as "a constructor of military engines" [1]. Initially, engineering was categorized as: Civil Engineering and Military Engineering. Military Engineering was related to construction of walls to strengthen an army, city, nation etc against attack and involved the manufacturing of military engines. Civil Engineering was related to non-military construction, like construction of bridges and houses. These meanings of engineering are no longer in use now because engineering has expanded to involve variety of disciplines.

2) Industrial Age

After scientific revolution, modern engineering’s first phase emerged. This phase evolved when machines started to replace men in production sector. The traditional artists got converted into professionals. The French led civil engineering by emphasizing on mathematics and worked for the development of engineering education in universities. The British initiated mechanical engineering and autonomous professional societies [2]. With the passage of time, practical thought process transformed into scientific realization in addition to the power of understanding, as engineers worked for the development of mathematical analysis and controlled experiments. Technical training got shifted from learning a trade to university education. Information got spread more rapidly in organized meetings and journal publications as professional societies evolved. After the advent of electricity and mass production, the industrial revolution got driven by many branches of engineering. Chemical and electrical engineering emerged and worked together with chemistry and physics and played essential roles in the evolution of chemical, electrical, and telecommunication industries [3]. Marine engineers tamed the great danger of ocean exploration. Aeronautical engineers transformed the dream of flight into a travel freedom with ease [4]. Control engineers catalyzed the pace of automation. Industrial engineers worked for designing and managing mass production and distribution systems. University engineering curricula got well established and graduate schools emerged. Workshops transformed into the laboratories, industrial research started and individual inventions were organized into systematic innovations.

3) Information Revolution

After the expansion of graduate education, the evolution of engineering research started. Engineering got catalyzed by evolution of new technologies. Microelectronics, telecommunications and computer engineering joined force to initiate the information revolution. For the development of these new technologies, engineers reshaped themselves by reforming educational programs and expanding research. In depth, engineering research gave rise to new technologies and gave power to the systematic knowledge, the engineering sciences and systems theories in information, computer, control, and communications. The coordination and merger of traditional
disciplines in the development of new technology became the trend of the future.

In the end of last century the field of engineering was gradually divided into the following categories:

- Civil Engineering
- Aerospace Engineering
- Electrical Engineering
- Chemical Engineering
- Mechanical Engineering
- Computer and Software Engineering etc.

Since, the human race has been swiftly progressing and developing in terms of technology, new fields of engineering have been developed. Although all these fields may be defined in different manners, still there is generally a great overlap. These fields are:

- Molecular Engineering
- Nanotechnology
- MEMS
- Biomedical Engineering
- Bio-Molecular Engineering
- Optical Engineering
- Structural Engineering
- Vehicle Engineering
- Mechatronics etc.

The merger of maximum number of engineering fields occurs in mechatronics. A mechatronics engineer is a person who integrates a number of technologies to produce a working system. The traditional disciplines have gone so far from each other that they can no longer work together. Mechatronics engineering is based on elements of mechanical engineering, electrical and electronic engineering and computer science, but is a distinct discipline in its own right.

II. EVOLUTION OF MECHATRONICS

Mechatronics evolved due to cross breeding and merger of various technologies and disciplines, not only merger, it has novelty in it. Basically mechatronics is an industrial driven program because the term mechatronics was first coined by Tetsura Mori of Yaskawa Electric Corp back in 1969. Because of needs of the society and the products that were needed by society, Mechatronics evolved. A pure mechanical, electronic or computer engineer was unable to deal with the problem of design of a product which was mechatronics in nature, electrical or electronics driven and computer controlled.

Some ‘traditional’ engineers still argue on the fact that a mechatronics engineer does not have his own identity that makes him distinct. But in reality our own research reveals and predicts that almost all the technical knowledge and approximately all working roles in engineering have to be learned and all the technical skills have to be developed in one after completion of an engineering qualification degree at university. Mechatronics engineers start with many different but extremely useful foundation backgrounds and have been well received and welcomed in almost every industry across the world. In fact, it is important to remember that the most mechatronics engineering courses evolved because of the industry pressure for producing more adaptable and multi-disciplinary engineers [5].

III. MECHATRONICS IN PAKISTAN

A totally new and nascent field of engineering for Pakistan, the “Mechatronics” was pioneered in Pakistan by the NUST College of E&ME in 1998 [6]. At that time, the society was totally unaware of mechatronics and no one knew about this field. People only had a general idea that it was a blend of Mechanical and Electronics. In 2002, UET Lahore, getting lead from NUST, started its Undergraduate program and later on in 2003 Air University came forward and became the third institute to start an undergraduate Mechatronics Engineering Program in Pakistan. But today some more Universities in Pakistan including UET Taxila (Chakwal Campus), Wah Engineering College and UET Peshawar are offering BE Mechatronics programs. Universities offering mechatronics engineering in Pakistan are listed in Table I.

<table>
<thead>
<tr>
<th>Program Name and the year of first intake of students</th>
<th>Institution Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.E. Mechatronics (From Intake of Batch 1998)</td>
<td>College of Electrical and Mechanical Engineering, NUST, Rawalpindi</td>
</tr>
<tr>
<td>B.Sc. Mechatronics &amp; Control Engineering (from intake of Batch 2001)</td>
<td>University of Engineering and Technology, Lahore (Main Campus)</td>
</tr>
<tr>
<td>Bachelor of Mechatronics Engineering (From Intake of Batch Fall-2003)</td>
<td>Air University, Islamabad</td>
</tr>
<tr>
<td>B.Sc. Mechatronics &amp; Control Engineering (From Intake of Batch 2004)</td>
<td>University of Engineering and Technology, Lahore (Faisalabad Campus)</td>
</tr>
<tr>
<td>B.Sc. Mechatronics Engineering (From Intake of Batch 2005)</td>
<td>Wah Engineering College, Wah Cantt (affiliated with University of Engineering and Technology, Taxila).</td>
</tr>
<tr>
<td>B.Sc. Mechatronics Engineering (From Intake of Batch Fall-2005)</td>
<td>University of Engineering and Technology, Taxila (Chakwal Campus)</td>
</tr>
<tr>
<td>B.Sc. Mechatronics Engineering (Intake Batch 2007)</td>
<td>NWFP University of Engineering &amp; Technology, Peshawar (Main Campus)</td>
</tr>
</tbody>
</table>

A brief history of Mechatronics in above mentioned engineering institutions is as follows:
A. History of Mechatronics in Universities of Pakistan

In today’s world, almost all production processes and production lines working in the industry are electromechanical in nature. It is unavoidable for the people working on those process and production lines to have all the knowledge of all the concerned systems. Currently, the employees get training while doing on the job training but it is not so helpful for them because they lack the required theoretical knowledge. The College after realizing this difference between national industrial requirements being aware of world’s need and the contents of curriculum gave rise to Mechatronics Engineering from January 1999 at the undergraduate level. MS leading to PhD program in Mechatronics engineering started in the College in 2005. The Masters’ program is focused towards intelligent Autonomous Systems and Robotics & Manufacturing. In UET, Lahore, the Department of Mechatronics & Control Engineering (MCE), was established in December 2005. In main campus, the postgraduate and undergraduate programs were established in 1999 and 2001 respectively and are being run successfully. Of course with strong reasons, strangely, UET Lahore started postgraduate program prior to BE.

In Faisalabad campus, department of mechatronics was established in 2004. The Bachelors Programme in Mechatronics is specifically designed to cater the needs of technology-based-industries. The objective of the programme is to enable the student to work effectively [7, 8]. In Air University, Islamabad, the Mechatronics Engineering Department, was established in 2003. Three batches with Bachelor’s degrees have been graduated from the university [9]. Wah Engineering College, a constituent college of the University of Wah, was established in 2004 and has started department of mechatronics in 2005. The department of mechatronics is affiliated with UET, Taxila.

In UET, Taxila (Chakwal campus), the department of mechatronics was established in 2005 [10]. From 2011, SZABIST is being offering a four year (eight semesters) BE (Mechatronics Engineering). The BE program is essentially a day program and consists of (all electives and certain courses may be offered in the evening), Internship and the passing of the comprehensive exam. The maximum time limit to complete the BE degree is seven years.

A summary of the degrees being offered in mechatronics by the above mentioned universities of Pakistan are shown in the Table II. From the data of the Table II, we see that only two institutions in Pakistan are offering PhD degree in Mechatronics depicting that the research in the field of mechatronics is negligible as compared to other countries. The reason is the lack of teaching and research facilities in Pakistan and the general awareness about mechatronics in Pakistan. Also, out of 8 institutions, only 4 are offering MS degree in Mechatronics. The intake of students per year in BS, MS and PhD in the respective universities is summarized in the Table III. From the data captured by Table III, it can be seen that very little work is being done in research field of mechatronics. The induction of PhD students in mechatronics is negligible in comparison with other fully developed engineering areas.

**Table II**

<table>
<thead>
<tr>
<th>Name of the institutions offering Mechatronics</th>
<th>BS</th>
<th>MS</th>
<th>PhD</th>
</tr>
</thead>
<tbody>
<tr>
<td>College of Electrical and Mechanical Engineering, NUST, Rawalpindi</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>University of Engineering and Technology, Lahore (Main Campus)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Air University, Islamabad</td>
<td>Yes</td>
<td>Yes</td>
<td>X</td>
</tr>
<tr>
<td>University of Engineering and Technology, Lahore (Faisalabad Campus)</td>
<td>Yes</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Wah Engineering College, Wah Cantt (affiliated with University of Engineering and Technology, Taxila)</td>
<td>Yes</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>University of Engineering and Technology, Taxila (Chakwal Campus)</td>
<td>Yes</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NWFP University of Engineering &amp; Technology, Peshawar (Main Campus)</td>
<td>Yes</td>
<td>Yes</td>
<td>X</td>
</tr>
<tr>
<td>SZABIST Karachi</td>
<td>Yes</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

**Table III**

<table>
<thead>
<tr>
<th>Name of the institutions offering Mechatronics</th>
<th>BS</th>
<th>MS</th>
<th>PhD</th>
</tr>
</thead>
<tbody>
<tr>
<td>College of Electrical and Mechanical Engineering, NUST, Rawalpindi</td>
<td>75</td>
<td>35</td>
<td>1 – 2</td>
</tr>
<tr>
<td>University of Engineering and Technology, Lahore (Main Campus)</td>
<td>60</td>
<td>40</td>
<td>2 – 3</td>
</tr>
<tr>
<td>Air University, Islamabad</td>
<td>50</td>
<td>5-6</td>
<td>X</td>
</tr>
<tr>
<td>University of Engineering and Technology, Lahore (Faisalabad Campus)</td>
<td>20</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Wah Engineering College, Wah Cantt (affiliated with University of Engineering and Technology, Taxila)</td>
<td>*</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>University of Engineering and Technology, Taxila (Chakwal Campus)</td>
<td>50</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NWFP University of Engineering &amp; Technology, Peshawar (Main Campus)</td>
<td>30</td>
<td>*</td>
<td>X</td>
</tr>
<tr>
<td>SZABIST Karachi</td>
<td>*</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

* data not available
Only 8 institutions in Pakistan are currently offering Mechatronics Engineering. Out of these 8, 6 institutions are in Punjab and only one in Khyber Pakhtunkhwa and one in Sindh. In Baluchistan not even a single university is offering Mechatronics.

So the need is to create awareness about mechatronics in society and emphasize on the importance of mechatronics among the students as well as industry. So, that the industries socially pressurize educational institutions to start more mechatronics programs. In this way, more students will get enrolled degrees in mechatronics and work in industries to meet the demands of society. As shown in Figure 1, there is a need to promote mechatronics in Baluchistan zone, as there is not a single university offering Mechatronics in that region.

IV. MECHATRONICS AS A CAREER IN PAKISTAN

With the advancement of technology, the products and systems are changing rapidly into mechatronic, so, it has become essential for engineers and technicians to be “multi-craft” or “Multi-skill”. Multi-skill engineers and technicians know all or most of the different systems linked with mechatronics. They are able to perform traditional and conventional technical tasks and responsibilities, i.e., the installation, maintenance, troubleshooting, calibration and repair of equipment. Unfortunately, most of the fresh technicians have done graduation from programs that give training of only one or two of the areas that fall under the category of mechatronics.

Generally, the technicians become proficient in mechatronic systems by on-the-job training and learn by experience. However, companies, in general, want and see significantly those people who have formal mechatronic training.

A. Mechatronics Industry Survey

Figure 2 depicts the industrial map of Pakistan. A Survey containing questionnare related to Mechatronics was carried out to have an overview of the status of mechatronics and mechatronics engineers in industries where seemingly mechatronics related work was being done.

![Industrial Map of Pakistan](image)

The questionnaire was sent to many industries, mining and power centers of Pakistan. In accordance with the response and the data we received after the survey, the results are compiled and discussed in the next section.

B. Survey Results

Most of the companies that participated in the survey belong to private sector. These participants belong to the following industries:

- Oil and Gas
- Clothing
- Food Processing
- Plastic products
- Automotive

The services offered at the participating companies are:

- Training / Consulting
- Maintenance
- Design & Development
- Instrumentation
- Production
- Maintenance
- Sales

Figure 3 shows that 90% of the companies that participated in the survey have more than 30 engineers working in that company. Only 10% of the participants have less than 10 engineers in their company.

This means still there are some companies in Pakistan where there is deficiency of engineers and these companies are finding some difficulty to hire engineers.
Figure 4 shows the percentage of importance of the duties that engineers perform while working in companies. This result will help fresh engineers to get awareness so that they can expertise in these areas and tasks which engineers perform in industries.

From Figure 4, we see that Design & Development, Production, Testing & Maintenance and Management tasks are equally important in almost all the industries.

Interest of engineers at companies in obtaining masters degree is shown in the Figure 5.

Figure 5 shows only 30% engineers are interested in studying further and obtaining Masters Degree.

There are no particular reasons for not studying further and lack of interest in doing Masters but might be the jobs are too hectic that it is not feasible for engineers to study with job or might be they are too satisfied with their jobs and salaries that they are not getting interest in obtaining Masters Degree.

Survey was conducted to know the importance of the 13 subject areas in industries shown in Figure 6. The percentage of each area in the figure depicts its importance in the industry. This result will help and work as guideline for the fresh engineers to get expertise in the areas that are of more importance in industry. In Figure 6, the most important areas in industry are related to Mechatronics Engineering. So, consciously or unconsciously, industries are moving towards Mechatronics technology but there is not enough awareness that these areas lie in Mechatronics domain.

Knowledge of companies about Mechatronics Engineering is depicted in Figure 7 as follows:

Only 50% of the participating companies had adequate knowledge of Mechatronics Engineering, 30% said that they partially know about it and they have knowledge about either electronics or mechanical part of it, 20% of companies did not even hear about Mechatronics Engineering or did not like to discuss anything about it. Participating companies were asked about the advertisement of job vacancies having title ‘Mechatronics Engineer’. The results are shown in Figure 8.

The results show that only 20% of the companies said that they advertise jobs by the title of Mechatronics Engineer rest of the 80% said that there is no job vacancy in their company specific for a Mechatronics engineer.
Rather they advertise jobs as ‘Automation Engineer or Electrical Engineer’ and sometimes consider Mechatronics Engineers for this job. The number of Mechatronics Engineers in the participating companies is shown in Figure 9 as follows:

From the survey result we see that Mechatronics Engineers are not hired in the industries in appreciable number. The industries involving automotive, clothing and plastic products have very less number of Mechatronics Engineers. Only 10% of the companies have more than 10 Mechatronics engineers as their employees. Rest of the 90% has less than 10 Mechatronics Engineers and these are categorized under Automation Engineer rather Mechatronics Engineer.

In the survey, the industries were asked about the reasons of hiring Mechatronics Engineers in their companies. A mixed response was received. Some of the companies said they are brilliant and are capable of multi-tasking, they can perform the tasks of Mechanical as well as Electrical engineers. Some said they are hired just because they are Engineers like any other Engineer; there is no special reason to hire them.

Some of the companies said because of the automation skill, Mechatronics Engineers are hired. Some said Mechatronics Engineers can work as an Electrical engineer too, so they are hired for the post of Electrical Engineer.

Companies were asked whether they hire female Mechatronics Engineers or not. This was done to know if industries accept female Mechatronics Engineers. The results are shown in Figure 10.

The survey results show that 80% of the industries do not hire female Mechatronics Engineer in their companies. This is really a drawback of our country where females are competing with males in every field of life and are even excelling them but they are not provided enough opportunities to work in the industrial environment. In every Engineering institution which offer Mechatronics engineering, almost 40% of each batch comprise of female students and they are more competent but many of the industries do not accept females engineers.

In the survey, companies were asked how they would compare performance of Mechatronics Engineer with that of Electrical and Mechanical Engineers in the company. The results are shown in Figure 11, 12 and 13.

70% of the companies realize that Mechatronics are better in performance than Mechanical engineers because of their automation skills. The rest of 30% were of the view that Mechatronics Engineers are same in performance as Mechanical Engineer.

55% of the companies found Mechatronics engineers equal in performance with that of Electrical Engineers but if we see the survey results of Figure 12 and 13 collectively, we observe that as a whole the performance of Mechatronics Engineers are better than both Electrical and Mechanical Engineers i.e. 70+45=115 while Electrical and Mechanical Engineers collectively score only 85. Figure 13 shows this score result.
Figure 14 shows the result of willingness of companies to recruit more Mechatronics Engineers in future. The results depict a mixed response. 40% of the industries showed willingness to recruit more Mechatronics Engineers because of their better performance. 30% said they do not need Mechatronics Engineers in their companies while 30% of the companies were not sure of recruiting more Mechatronics Engineers in future.

The results show that 90% the companies do not have technicians that have mechatronics background. 90% of survey results show that technicians and engineers in industries require Mechatronics training to make them capable in the industrial working environment. This result is shown in Figure 16.

The participating companies themselves realized that their technicians and engineers need to develop mechatronics and automation skills to perform better yet most of them are reluctant to hire Mechatronics Engineers and advertise jobs by the title of Mechatronics Engineer. Rather they prefer to hire Electrical or Mechanical Engineers and train them with mechatronics skills. Awareness needed to be created in industries to highlight the importance or hiring more Mechatronics Engineers as they are more capable of performing the tasks that are of importance in industries.

C. Summary of the Survey

The results of the survey are summarized as follows:

1) Findings

1. R & D department of the industries are not adequately developed.
2. Very less Mechatronics engineers are being hired in the industries.
3. No job title of ‘Mechatronics Engineer’ exists.
4. Mechatronics Engineers are hired for job titles of ‘Automation Engineer’ or ‘Electrical Engineer’.
5. By doing survey we came to know people in industry with Electrical, Electronics or Mechanical background do not have complete knowledge of Mechatronics.
6. Most of the industries are not willing to hire female Mechatronics Engineers.
7. Most of the industries said that Mechatronics Engineers are better in performance than Electrical and Mechanical Engineers.
8. Technicians at the industries do not have former training of Mechatronics.
9. Technicians and Engineers have to get Mechatronics training to work in the industrial environment.

2) Recommendations

R & D department of the industries should be developed and industries should be motivated to do research projects with universities in order to provide the opportunity to the graduate students to work for the benefits of industry as well as society. A campaign should be started in order to create awareness among society and industry about Mechatronics Engineering. This can be done through arranging seminars and using electronic media. Awareness campaign should be initiated immediately.

V. RELIABILITY ANALYSIS OF MECHATRONICS INDUSTRY SURVEY

In SPSS, Cronbach Alpha is an important concept in the evaluation of assessments and questionnaires [13]. It is mandatory that assessors and researchers should estimate this quantity to add validity and accuracy to the interpretation of their data. Alpha was developed by Lee Cronbach to provide a measure of the internal consistency of a test or scale; it is expressed as a number between 0 and 1. Internal consistency describes the extent to which all the items in a test measure the same concept or construct and hence it is connected to the inter-relatedness of the items within the test. There are different reports about the acceptable values of alpha, ranging from 0.70 to 0.95. A maximum alpha value of 0.90 has been recommended. High quality tests are important to evaluate the reliability of data supplied in an examination or a research study. Alpha is a commonly employed index of test reliability.

Reliability analysis of the data related to mechatronics industry survey compiled in form of graphs is done using SPSS by computing Cronbach alpha value.

After doing statistical analysis, we have got Cronbach alpha value as ‘0.849’. From this high value we conclude that the survey data is valid and accurate and the results are reliable.

VIII. CONCLUSIONS: MECHATRONICS PERSPECTIVES

The increase in the worth of mechatronics in the world is because of the power, uniqueness and versatility of mechatronics. This makes all engineers think of being getting familiar with the basic theory and engineering practice of mechatronics. Mechatronics is such a wide field that there is no end limit to the application of mechatronics and to the contribution that is further added by mechatronics to the concept of inter-discipline. But the mechatronics engineers in Pakistan have to face many problems in seeking appropriate jobs because of the lack of awareness in the industries as well as society of Pakistan regarding mechatronics engineers. It is expected that in the years to come, Mechatronics will gain the status of most important engineering discipline in Pakistan from industrial point of view and mechatronics engineers will be in great demand.

ACKNOWLEDGEMENT

I would like to acknowledge my research supervisor for providing guidance and support to me. I would like to thank my family, friends and colleagues who shaped my experience both in educational and practical life. Without their support and encouragement, I would not be where I am today.

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The Impact of Classroom Management Strategies on the Students’ Academic Success in the Computer-Assisted Lesson

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Abstract—The present study aims to highlight that there is a direct connection between the classroom management strategies involved in the computer-assisted lesson and students’ success in retaining information and building learning skills and competences. One of the roles that a teacher must assume in order to improve the instructional process is that of a classroom manager. As long as teaching is no longer understood as information transfer, teachers must learn efficient approaches of the contemporary multileveled instructional process. The aspects discussed in this paper regard the role of an active teacher, the student-centred instruction, building long term valid skills and competences, increasing students’ awareness and participation, managing discipline as a source of responsibilization, developing a positive teacher-student relationship, acquiring and using scientifically developed teaching strategies in the technology-aided classroom.

Keywords—classroom management; cognitive theory; computer-assisted lesson; multimedia learning.

I. INTRODUCTION

Today’s modern and dynamic society is integrally based on high technologies which develop at a very fast pace, requiring a contemporary profile of adaptability and flexibility based on reliable skills and competences. This phenomenon should lead to a deep reformation of the educational approach in schools, by highlighting the importance of classroom management strategies for achieving the objectives of each learning activity. The concept of active learning should be correlated to the one of an active teacher because today the transfer of knowledge from a teacher as a central unit to students as receivers has become an inefficient way of practicing teaching. The problem about knowledge is that it changes, expand and it may even lose its relevance in the future. That is why the main goal of an instructional activity should not be knowledge, but building knowledge discovery skills. Therefore a teacher becomes active when he permanently searches for efficient strategies in making the students creatively and critically think, in guiding them to work in teams, in directing them to discover and define concepts, and in building motivation by raising students’ self-esteem through ensuring their learning success.

II. PROBLEMATIC ASPECTS REGARDING THE RELATION BETWEEN EDUCATION AND DIGITAL SOCIETY

An important aspect related to a society growing on new technology is represented by the implementation of multimedia teaching in schools. Computer-based multimedia teaching has two major benefits: it provides information from different sources, increasing the degree of learning success, and it builds skills and competences in using digital technology as a learning tool. Nowadays children have large access to computers, tablets, and smartphones, perceived mainly as entertainment devices. Their experience in using these gadgets is so visually direct, strong and rewarding that teaching based on speaking and writing loses its impact and becomes uninteresting and therefore it does not address motivation. Thus, using computers, projectors or interactive whiteboards becomes necessary when addressing the present generation of students whose thinking and learning patterns have been strongly determined by the presence of internet in their lives. When talking about increasing learning motivation or about learning success, school cannot ignore the necessity of implementing computers connected to internet in each classroom.

The main issue regarding the technology-assisted lessons is not the financial effort involved by furnishing schools with the necessary equipment. The major aspects are related to an efficient management of the computer assisted instructional activities. There are two relatively new dimensions of the present requirements for a modern teaching: student-centred instruction and the use of computing technology in the classroom. Both dimensions ask for a dramatic change in understanding teacher’s role in the classroom. The academic achievements of today’s generation of students depend on the reality and consistency of such a change. This change of mentality should be associated with the acquisitions of classroom management strategies specific to the problems the computer-assisted classroom may raise.

An effective teaching-learning process cannot take place in the context of a poor classroom management. This statement is supported by recent studies (S. Paul Wright, Sandra Horn, William Sanders, 1997) which revealed that the most
important factor directly influencing learning is the teacher, which means that any procedure to optimize school performance should aim to educate teacher effectiveness in the classroom.

The fact that the teacher influences student’s performance is obvious, yet the dynamics of the way in which the teacher can produce such an effect on the individual and collective learning is not as clear. It must be underlined that an effective teacher performs several functions related to his three major roles: a correct choice of teaching strategies, the adaptation to the specific classroom curriculum to facilitate learning, and the effective use of classroom management techniques. While the first two roles are not very different from the traditional practice, the last one is more connected to the dramatic changes in expectation both on the part of students and on the part of society.

When approaching student-centred teaching, school must not overlook students’ expectations. Instruction cannot become motivational if it does not address students’ universe of thinking and living. The reality of the current generation of students is large the presence of digital technologies in their daily activities. The age since children start having their own mobile phone, a tablet or a computer connected to Internet or wireless network is constantly decreasing. Therefore they are used to get information visually, through images. It should be taken into account that these images are made to have a strong impact through resolution, effects, dynamic and realism. Also the images are connected to some fashionable requirements which give them extra value. There are surely psychological effects of this phenomenon which influence the way their attention, memory, thinking function. These effects have changed the students’ horizon of expectations and therefore the implementation of multimedia learning assisted by digital technology has become mandatory.

III. THE POSITIVE EFFECT OF CLASSROOM MANAGEMENT STRATEGIES IN THE COMPUTER-ASSISTED LESSON ON STUDENTS’ TEST RESULTS

The present study aims to make a contribution to the awareness that it is mandatory for teachers to apply some precise classroom management strategies when using the computer as an educational tool. We interviewed a number of 50 teachers regarding how they use the computer in teaching classes. The conclusion was that they use the computer sporadically and they apply no specific strategies. The computer is generally used to make PowerPoint presentations or to watch documentaries. A significant number of teachers (36) stated that the discipline problems are more likely to occur during computer presentations.

To analyze whether the application of a set of management strategies during the computer-assisted lesson can influence students' academic success we considered two samples. For the first sample, consisting of 29 students of class 3 A, the teaching of a new science lesson was conducted by using a computer, without applying any specific techniques. In the second sample, consisting of 29 students of class 3 B, the teaching of the same science lesson was done by using the classroom management strategies efficient for the computer-assisted lesson. After testing and processing student grades the data in Table 1 was obtained.

<table>
<thead>
<tr>
<th>Results</th>
<th>5th A</th>
<th>5th B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>n_1 = 30</td>
<td>n_2 = 30</td>
</tr>
<tr>
<td>Mean</td>
<td>8.07</td>
<td>9.03</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>s_1 = 1.2576</td>
<td>n_2 = 1.0662</td>
</tr>
</tbody>
</table>

Before applying Students’ t-test, to compare the mean of the two statistical populations, we checked if the dispersions (variances) of these populations were equal or not, by applying Fisher’s exact test. We considered the null hypothesis that the two populations variances were equal. We obtained that the calculated value of Fisher test is F_C = 1.3913. From the statistical tables for Fisher test for a level of significance of the test of α = 0.05, we obtained the critical value F_Cα = 1, 8608. As F_C < F_Cα, it results, with a probability of 0.95, that the null hypothesis is accepted; therefore the dispersions of the two populations are equal. Considering this, we applied Student’s t-test for ν = n_1 + n_2 - 2 degrees of freedom.

We obtained the calculated value of the Student’s t-test of t_C = -3.222. From Student’s t-test tables for the significance level of the test of α = 0.05, we obtained the tabular value t_α = 2.0017. As t_C < t_α, it results with a probability of 0.95 that the alternative hypothesis is accepted, therefore, the application of the classroom management strategies in the computer assisted lessons improves Students’ t-test results, therefore the academic success.

The conclusion of our experiment is that the computer assisted lesson requires well-defined classroom management strategies having a scientific foundation. Teachers cannot be imaginative or inspired when managing a lesson by using computer technology. During our experiment, the teacher of class 3 B was asked to apply a given set of classroom management strategies, which are described below.

IV. RULES AND PROCEDURES FOR THE NEW TECHNOLOGY-AIDED INSTRUCTIONAL CONTEXT

This new instructional context requires well-defined classroom management strategies having a scientific foundation. Teachers cannot be imaginative or inspired when managing a lesson by using computer technology. This instructional environment must be firmly regulated by procedures. One of the most important aspects of classroom management involves establishing and implementing rules and procedures. General rules set expectations and standards such as "Respect the others". The procedures refer to specific standards of behaviour, such as how to participate in the class discussions. The research on rules and procedures highlights their importance to the effective learning in the classroom. Their effectiveness is however conditioned on student’s participation in determining, understanding and applying these
rules and procedures. Imposed rules are not as efficient as those explained and negotiated, and even written up in a contract between student and teacher. The implementation of negotiated regulations has a positive influence not only on students' behavior but also on their academic performance. Depending on students’ age, the rules should be no more than 5-10 and they should be displayed in a visible place. In the specific context of the computer-assisted classroom, rules should refer to the use of technology in a correct and fair way. The digital technology should be defined as a research and learning tool. No other uses must be accepted in school. When they are in front of a computer connected to internet, children and teenagers have the tendency to maintain their habits of using computer as entertaining and communication medium. In order to determine them to associate the computer in school with an educational tool, no deviation from this use should be accepted. This way a new behavior related to the environment will be educated in students with benefits for their acceptance and opening to the computer-assisted instruction.

A. Disciplinary Intervention

Any breach of rules and procedures should have immediate consequences in order to educate correct classroom behaviour. Yet, there is a trend regarding disciplinary measures as being ineffective and even damaging for the acquisition and development of appropriate behaviour. Partly, this view is correct when referring to inappropriate use of disciplinary strategies based solely on punishment as it is frustrating. However, research supports the need for intervention to maintain discipline through a balanced approach of a variety of disciplinary techniques. A study based on meta-analysis, led by David Quirroz and Scott Stage, in 1997, including 99 trials, 200 experimental comparisons and over 5000 students, concluded that disciplinary action results in a decrease of up to 80% of the disrupting and inappropriate behaviour in the American public schools. Studies have identified the following categories of disciplinary strategies: the reward, the punishment, and the combination reward - punishment. The reward involves recompense, praise, appreciation of good behaviour or absence of negative behaviour. Punishment implies negative consequences for inappropriate behaviour. The last category involves rewarding appropriate behaviour and punishment of inadequacy. The research shows that the maximum efficiency combines reward and punishment which create an environment that accentuates the distinction between appropriate and inappropriate behaviours by constant feedback. Identifying a balance between reward and punishment is advisable to increase discipline in schools. It is recommendable to discuss, negotiate and display in a visible place the concrete way of reward and punishment. The two disciplinary consequences must be ethical and moderate with the only intention of giving a feedback without humiliating or substituting reward for the goal of the educational process. The use of technology in school has specific rules preventing misuse of computer and internet which must be explained to students and displayed on a visible board. The disciplinary intervention should also refer to the privilege of having access to technology as students are sensitive to these limitations or rewards.

B. The Student-Teacher Relationship

Another important aspect of classroom management concerns the teacher-student relationship. Specialized articles show that if a teacher has a good relationship with her students, they are more open to accept the rules, procedures and disciplinary interventions. Theo Wubbles and colleagues conducted several fundamental studies to identify the dynamics of student-teacher relationship, revealing that there are two dimensions defining the student-teacher interaction. The identified dimensions are: Influence (Domination-Cooperation) and Proximity (Opposition-Cooperation).

Domination is characterized by clarity of purpose and strong guidance. Cooperation involves interest in the others’ needs and opinions and the desire to work as a team member. The research has determined that the correct combination for a positive teacher-student relationship is between the moderate to strong Domination (but not extreme) and moderate to strong cooperation. In short, a teacher must have the ability to establish and maintain control standards and to be firm, but open in attitude, empathizing with students, listening to their needs and understanding their world.

V. Classroom Management Strategies

A. Classroom Management Issues Concerning Students’ Active Contact With The Computer

Integrating technology in the classroom can facilitate learning and provide effective solutions for many educational issues. By using computer-based technology as a resource, students are encouraged to explore their own interests and actively contribute to the learning process, becoming able to solve authentic problems.

Currently, schools are trying to create attractive educational opportunities for all students to develop indispensable long term skills and knowledge. Investing in introducing information technology in schools supports the idea of student-centred learning as well as the effort of updating the instructional methods to the current and future requirements of society. Integrating technology in the classroom can be a solution, but raises at the same time, a number of problems.

Firstly, there are the problems related to the new environment of a classroom equipped with computer technology. The classroom space management changes significantly under these circumstances. The learning environment is no more determined by frontal teaching in which the teacher is actively engaged in the class and the student is placed at his desk, having a passive listener position. The student’s attention is also directed to the computer. This involves a significant modification in what students perceive to be his source of information. It is important to keep in mind that a computer is more stimulating and rewarding due to the following factors: it provides dynamic visual and audio information and it can be directly controlled by the student. The presence of a new inexhaustible source of information in the classroom transforms teacher in a facilitator and a manager who organizes the classroom activities and delegates tasks to students, controlling their achievement. In 2001 Cambourne
underlined that the new teacher’s role is to identify tasks to facilitate learning (2001).

The management of a computer aided lesson is determined by the number of computers in the classroom. Using a single computer can be effective only if the images can be projected on a screen large enough and positioned so as to be visible to all students in the class. In this way eloquent, diverse and attractive images can be used to illustrate the lesson content using PowerPoint presentations, simulations, videos, and documentaries. Yet, in this situation the computer has the same central role of a source of information while the student is still rather passive. His interest in lesson and understanding of its content does increase, but this only improves the level of knowledge transfer without building skills and competences. This situation is changed when the classroom is equipped with a minimum of three computers, as studies suggest, and students are asked to work in teams. Such an organization leads to a more complex learning experience. The student receives tasks and he is demanded to find solutions by working in team and by using digital technology as an instructional tool. The benefits of this learning position are immense if well-managed. There are some problems to be solved before starting the lesson: the team structure, the rotation of students at the computer, the role of each student, the rules of using the computer and the internet.

In order to make up a team, students should be selected according to their competences and given roles consequently: the computer expert, the facilitator, the coach, and the responsible with the documents. The students should be aware of the responsibilities involved by their role. This way they become more conscious of what participation and managing of learning means, which builds skills for the future when learning becomes gradually a self-directed process. Then, the student’s rotation at the computer desk should be regulated. Yet, students must accept this rule as fair and they should be given the possibility to negotiate its application with the team-mates, which increases communication and listening skills. Teachers have also to work on students’ understanding of their responsibility towards his mates. If somebody fails in fulfilling his task the whole team will be affected. Such a lesson builds social awareness, which is important in the formation of students as part of a group, especially that individualism and social isolation due to the intense use of digital technology as a tool.

Making up teams and task assignment request an attentive project management on the part of the teacher who should periodically check the development of the project by giving the team deadlines to respect. This way, besides learning, students acquire efficient project development skills. If the teacher efficiently manages a computer-based lesson, he also provides his students models of how to organize and conduct a successful activity. The students should be guided to identify the necessary stages of their work, how to efficiently use resources, how to solve problems and make decisions, how to manage time and how to stay focus on goals and objectives. This will be a valuable know-how in the present and future society in which efficient management is the key of professional success. The important thing is that students must realize that their role is not to simply receive information, but to be active part of a process in which information is searched, checked, integrated in structures and capitalized by using digital technology as a tool.

Secondly, the computer-assisted classroom in which students have direct access to internet brings up the issue of internet security. The potential risks regard accessing of inappropriate material, improper use of the school’s computer resources (file deletion, deterioration of school server, email misuse, unauthorized on other networks, changing settings and configuration files on the school computers), communication with strangers (students must learn to withhold personal information on the Internet, not to meet people they communicate with on the Internet). Therefore it is mandatory that students should be supervised when they are online. Yet, more important is to help students understand and avoid these risks by discussing them in the classroom. This way they will be more willing to accept that there are school-level Internet usage policies which are not negotiable. The involvement of parents in establishing these rules should be made visible by a school-parent-student contract. While software security, as well as monitoring and supervision of the use of the computer connected to the Internet are necessary, they have the same consequences of placing the student in a passive position. Students should be guided to understand the risks of internet misuse in in order to be able to use the internet correctly in non-controlled contexts.

B. Classroom Management Issues Concerning Students’ Passive Contact With The Computer

In most circumstances, the lesson is based on a single computer used to illustrate the content of a lesson designed to use multimedia resources. Multimedia involves the transmission of a message or information through a multi-sensory interactive presentation that combines text with images, sounds, animations and videos. Multimedia has the potential to expand the amount of information available through explanations, links to various resources, simulations, illustration, photographs and other interactive activities.

As a consequence of the implementation in schools of diverse multimedia devices in the educational process, the new concept of multimedia learning has arisen, defined by the cognitive theory of Richard Mayer. Mayer conducted a comparative research on the methods of using multimedia in teaching and concluded that students who received information from multimedia source (visual message and auditory message) learned better than students who benefited from a single traditional source (auditory message). Mayer has established the principles of cognitive theory of multimedia-based learning that teachers should take into account when planning a computer-assisted lesson: the multimedia principle (use words and images rather than words alone); the contiguity principle (place corresponding words and images near each other and simultaneously); the modality principle (use narration and animation rather than text and animation); the redundancy principle (avoid redundant material; do not add text to narration and animation); individual differences principle (individuals with low prior content knowledge and individuals with high spatial skills benefit most from...
animation and narration-presented materials). Other researchers have pursued similar experimental approaches. Kalyuga, Chandler, and Sweller (1999) also concluded that the working memory becomes overloaded if the visual system must process printed text and images (split attention effect). They found better comprehension when images were presented with auditory explanations. Similar research carried on by Lewandowski and Kobus (1993), or Leahy, Chandler, and Sweller (2003) reported identical conclusions. This represents the attestation of the fact that the instructional process should be scientifically based especially when using teaching methods involving technological aids to apply the rather new concept of multimedia learning.

The success of multimedia computer-assisted instruction depends on how teacher manages to balance the amount of information and interaction that the students’ working memory can process simultaneously in order not to under-load or overload it. The teacher should take into account that all information must be processed before meaningful learning may continue. Paradoxically, adding interesting material can hurt learning. During the process of information transfer the teacher should avoid using unnecessary texts, graphics or sounds as they actually distract students. These principles are to be applied when students are in the passive position of receiving information from a frontal multimedia source represented by the teacher using technology in order deliver his presentation. They help students keep focus and retain information at an optimal degree.

VI. CONCLUSIONS

The aim of this paper is to underline that computer-aided lesson are efficient and valuable, if teachers use scientifically based classroom management strategies.

If the teacher manages to apply a set of interconnected strategies addressing both the disciplinary and cognitive aspects of the learning process developed in the specific technology assisted environment, the instructional process can be successful. The experiment developed in an elementary school, which proved that by using adequately classroom management strategies to conduct the computer-assisted lesson, has led to an increased interests of teachers in different schools to attend professional courses in this area provided by the universities in our city, including “Tibiscus” University of Timişoara.

It is highly recommendable that schools should invest not only in equipping classrooms with modern computer technologies, but also in teachers’ professional development to ensure valuable and authentic instruction. Students may considerably benefit from the computer-assisted lesson when winning teaching strategies are used with the purpose of transferring information and building skills. Nevertheless, if technologically based lessons are not correctly managed, the instruction fails with the outcome that students will miss building up skills and competences in using technology as an educational tool with negative impact on their professional future.

REFERENCES

Software Development of Word Search Game on Smart Phones in English Vocabulary Learning

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Abstract—At present, mobile devices are a medium of learning in school that is enjoyable with educational content. They are becoming as a part of daily life with new software games, which are considered as entertainment. As we all know, a word search game has been implemented on mobile devices for decades. It facilitates English vocabulary acquisition of students. The word search game on mobile devices allows education to be delivered in a more flexible way, anytime and anywhere at the students’ own place. To this paper, a survey is conducted to target Thai students at Bangkok University, Thailand. Therefore, the word search game on smart phones embedded with the English dictionary, which helps Thai students to memorize the words is developed. Additionally, the process in developing the word search game on smart phones has been presented. It is expected that our research findings in English learning on mobile devices for Thai students will be further shared in the future.

Keywords—Educational software; English learning; mobile game; mobile application; word search game

I. INTRODUCTION

Student’s English learning involves memorization of a large number of vocabulary words and grammatical structures. New technology devices such as smart phones, personal digital assistants (PDAs), tablet computers, iPhones, and other mobile devices are invented to help in English learning. Nevertheless, these devices are often disguised as a game device because they are highly capable of playing a variety of games. However, there exist evidences that games improve student’s understanding and the learning outcomes [1]. Mobile devices, therefore, impact educational outcomes and facilitate new learning which is learner-center, situated, collaborative, ubiquitous, and lifelong [2]. Currently several games have proven to be beneficial for academic achievement because games can mainly be integrated within a classroom to improve student learning and participation [3], [4], [5]. Games involve the basic language skills such as listening, speaking, reading, and writing [6]. Game-based learning on mobile has been proposed for undergraduate research [7], [8], [9]. Some traditional teachings in classes can be replaced by games. Teachers can use the games’ metaphors and illustrations of reading and Math exercises [10], [11]. Therefore, utilization of mobile phones as a medium of learning in school has increased [12], [13]. In the work of Saran and friends [14], this work focuses on phones in language learning. The results indicate that students’ abilities to learn Irish autonomously in the pilot project were enhanced by the use of mobile phones. Students were remarked on progress made in grammar and vocabulary. They were delighted to use the instructional materials in their mobile phones in language learning. SMS may be one of the most common wireless applications used with mobile wireless phones to support teaching [15]. Another interesting work published by Thornton and Houser shows that graduate students in Japan often use their mobile devices such as smart phones and PDAs for daily sending and receiving e-mail [16]. The paper emphasizes on providing English vocabulary by three mini-lessons to students each day. Even the biggest group of students (57 percent of students) read messages once a day. However, the researchers had demonstrated that SMS helps improve student scores in classes. In addition, several mobile games have been designed for students to learn English. Word search game is one of the excellent games that are good for players to spend free time memorizing vocabulary and to enhance problem-solving skills. This type of game is an example of activity that takes a great deal of time to prepare by hand, but very little to do on the computer [17].

Word search game is known as a word find game, which is well known for helping students to recognize words. It is a game that letters of a word lay in a grid and usually has a square shape. To play this game, players search and mark all hidden words inside the grid. In the most word search games, a list of hidden words is provided. Frequently, many words are related which are easy for players to search for. Listed words may be arranged in horizontal, vertical or diagonal directions in the grid. Sooner you complete every level, higher score you will get. In searching for words, users read and memorize the words while they are playing the game that helps them learn the words and spelling, letter by letter, in the puzzle.

Unlike other word search games, in this paper we aim to develop the word search game on smart phones for Thai students in English vocabulary learning. Also, we want to understand the needs of Thai students on this kind of games. However, we want to develop a word search game for smart phones as educational media because they are wildly used among teenagers. We do not want to propose using artificial intelligence (AI) techniques to develop the application. The major design is based on our user-needs survey. There are four sections to our paper including this introduction. The brief overview of word search game is shown in Section 2. Section 3 presents the design of our word search game in details. The user-needs survey is described to support our system design and development. The usability of evaluation in developing the
word search game and the evaluation of satisfaction is provided in this section. Finally, conclusion and discussion are prepared in the last section.

II. THE DESIGN OF WORD SEARCH GAME

Our word search game is designed to play on smart phones to help students recognize English vocabulary words. Adapted from user interaction model called star life cycle of Hartson and Hix [18], only four areas of interest are identified as follows; application design, task design, physical design of interface and usability evaluation as shown in Fig. 1. This life cycle presents an evaluation-center approach; we can start developing the program at any point of the cycle while these activities are interconnected through evaluation in the center [19]. In the following part, we detail briefly on an “informal description” of the design phases.

A. Application Design Phase

In traditional classes, students are considered as the recipients, which affect both the teachers’ instructional approaches and learning strategies [20], therefore we have to get to know the needs of our students. In common, the first phase in our application development process is the application analysis. It covers the user analysis, as a better understanding of concerned users which will lead to design the best to meet users’ needs. We are concerned that the users have control over the functioning of the system. The quickest way of finding out the users’ needs is to question some representative members of the desired group. We conduct a survey to explore the needs of the students about the word search game in learning English. The survey results give important information and several facts as shown in Table 1.

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions</th>
<th>Scores and Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Have you ever played the word search game?</td>
<td>Yes (100%) No (0%)</td>
</tr>
<tr>
<td>2</td>
<td>Is it good to enhance your English by playing the word search?</td>
<td>Avg. score 4.13 out of 5</td>
</tr>
<tr>
<td>3</td>
<td>Is there any application out there that allows you to play word search?</td>
<td>No (71%) Yes (29%)</td>
</tr>
<tr>
<td>4</td>
<td>Have you ever wished that you could create your own word in word search?</td>
<td>Yes (100%) No (0%)</td>
</tr>
<tr>
<td>5</td>
<td>If you do not have internet provided, which media or device would be good for you to play word search?</td>
<td>Smart phones (54.7%) Newspaper (29.3%) Others (15.9%)</td>
</tr>
<tr>
<td>6</td>
<td>What feature or program should be within the word search game to enhance your English?</td>
<td>Dictionary (94.1%) WordPad (2.3%) Others (3.5%)</td>
</tr>
<tr>
<td>7</td>
<td>Is there any reason that will make you not to play the word search game?</td>
<td>Too difficult (57.8%) Word list not related to player (31.6%) User interface (8.1%) Other reasons (2.4%)</td>
</tr>
</tbody>
</table>

Table 1. Survey Results of User’s Needs

The quickest way of finding out the users’ needs is to question some representative members of the desired group. We conduct a survey to explore the needs of the students about the word search game in learning English. The survey results give important information and several facts as shown in Table 1. Students prefer the program with a special feature allowing them to create their word search lists associated to their topics, while some players concern for the quality of the graphical interface of the program. Additionally, the mobile devices such as smart phones are the device that students are likely to choose to play the word search game (54.7%), which is higher than newspaper (29.3%). Moreover, a feature that most players prefer to have within the word search is dictionary (94.1%). Nevertheless, if the word search game is too difficult, they will immediately stop playing the word search game (57.7%).
B. Task Design

Task analysis is a fundamental methodology to define our module in developing word search game. Procedures are determined sequentially so that each step is unambiguous and simple as shown in Fig. 2. The game is divided to three options; classical game, time trial (speed game), and our vocab. In the last option of the game, it allows users to add new vocabulary words to the word search game.

C. Physical Design of Interface

Our word search game is designed for Thai students in Bangkok University in English vocabulary learning. The chosen development environment is Java 2 Micro Edition (J2ME) on iPhone OS. Xcode is integrated for creating our game on smart phones as well. It includes the Xcode IDE, Instruments, iOS Simulator. To this game, the players have three options to select, which are classic mode, time trial, and our vocab or self-adjusting mode as represented in Fig. 3.

a) Classic mode

This mode is a common word search game. The players can select the level of difficulty of the game; easy, normal and hard; as shown in Fig. 4(a). The screen will automatically display English characters in the 9x9 characters table for players to search for hidden words. The list of random vocabulary words is shown at the end of the table; see Fig. 4(b). If the players have found any words in the grid, the players mark a box covering that word. When all existing words are discovered, the game shows the meanings of each word including pronunciation for players to listen. However, the players can click on a hint button for help when they cannot search the words. Finally, the scores of each game are calculated based on how many words are found.

b) Time trial mode:

This mode is designed to stimulate the users to play with timing. The game’s countdown timer starts from 180 to zero seconds. If the time becomes zero, the current game automatically stops. This challenges most of students to play with fun. At the end of each game, vocabulary words will be summarized with their meaning and proper pronunciation. In addition, this part provides the hint button in the cases that uses cannot search the word hidden in the table. To click this hint button, the players will lose the points. The highest scores can be recorded in the system if the users want.

c) Our vocab mode

This mode is customizable and more flexible than other modes because new vocabulary of any topics can be added into the game. The system allows the players to add new topics related to the players which are easy for them to search for. As it can be seen in Fig. 6, “Emotion” is a new topic that is arbitrarily set by a user. This mode facilitates the students to enter new words into their own database helping them to practice later. However, with the limitation of game the pronunciation of the new word added words cannot be recorded to the system.
At the end of each game, the system automatically shows total score and bonus rewarded during the play. In addition, a list of random words of the game is displayed sequentially with their meanings and pronunciation, see Fig. 7.

From the experimental results, it turns out that students in the first group who have been equipped the word search game on smart phones has the highest improvement at 21.4%. The other groups of students have lower improvement at 13.6% and 11.1% respectively. We can see that the word search on smart phones has improved the student scores twice as much as they received their vocabulary with crossword game on the papers.

The last evaluation is the user satisfaction evaluation. This evaluation is made by participants of the first group. The result is shown in Table 3. It indicates that the respondents require an English dictionary in the game with the average score of 4.26. Additionally, the students prefer to manage their own word list with the average score of 4.25. The overall interface and system design are satisfactory; the average score of 4.04.

However, some feedbacks that were suggested by students to improve the word search game on smart phones are characters on screen, comprehension of the menus, presentation of the game and content, sequence of screens and game speed.

### TABLE II. RESULTS OF USING WORD SEARCH GAME ON DIFFERENT TYPES OF TECHNOLOGY

<table>
<thead>
<tr>
<th>Group No.</th>
<th>Smart Phones</th>
<th>Types of Technology</th>
<th>No. of students</th>
<th>Test (25 words)</th>
<th>% of improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>Word Search game</td>
<td>16</td>
<td>15.4</td>
<td>18.7</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>e-mail</td>
<td>15</td>
<td>16.2</td>
<td>18.4</td>
</tr>
<tr>
<td></td>
<td>Yes (paper)</td>
<td></td>
<td>15</td>
<td>14.9</td>
<td>16.9</td>
</tr>
</tbody>
</table>
TABLE III. RESULTS OF EVALUATION OF THE EFFECTIVENESS OF THE SYSTEM (GROUP NO. 1 WITH 16 STUDENTS)

<table>
<thead>
<tr>
<th>No</th>
<th>Question</th>
<th>Avg. Score</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Graphical interface design</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Are Screen layouts helpful?</td>
<td>4.15</td>
<td>1.52</td>
</tr>
<tr>
<td>2.</td>
<td>Arrange of information on screen</td>
<td>4.05</td>
<td>1.32</td>
</tr>
<tr>
<td>3.</td>
<td>Presentation of game and contents</td>
<td>3.80</td>
<td>1.12</td>
</tr>
<tr>
<td>4.</td>
<td>Comprehension of menus</td>
<td>3.37</td>
<td>1.34</td>
</tr>
<tr>
<td>5.</td>
<td>Character on screen</td>
<td>3.51</td>
<td>1.27</td>
</tr>
<tr>
<td>6.</td>
<td>Image of buttons and icons</td>
<td>3.90</td>
<td>1.19</td>
</tr>
<tr>
<td>7.</td>
<td>Sequence of screens</td>
<td>3.90</td>
<td>1.34</td>
</tr>
<tr>
<td>8.</td>
<td>The size of the buttons and icons are appropriate.</td>
<td>3.95</td>
<td>1.23</td>
</tr>
<tr>
<td></td>
<td><strong>Average</strong></td>
<td>3.83</td>
<td>1.29</td>
</tr>
<tr>
<td></td>
<td><strong>System design</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Is this game suit to smart phones?</td>
<td>4.05</td>
<td>0.87</td>
</tr>
<tr>
<td>10.</td>
<td>Is the word search game on smart phones facilitating you to recognize the English vocabulary words?</td>
<td>4.08</td>
<td>1.31</td>
</tr>
<tr>
<td>11.</td>
<td>Did you feel the system under control?</td>
<td>4.05</td>
<td>0.67</td>
</tr>
<tr>
<td>12.</td>
<td>Variety of vocabulary words provided in the game</td>
<td>4.05</td>
<td>1.28</td>
</tr>
<tr>
<td>13.</td>
<td>How easy of making own vocabulary lists?</td>
<td>3.91</td>
<td>1.33</td>
</tr>
<tr>
<td>14.</td>
<td>How good is to create your word list in this word search game?</td>
<td>4.25*</td>
<td>1.48</td>
</tr>
<tr>
<td>15.</td>
<td>Is dictionary provided useful in play the word search game?</td>
<td>4.26*</td>
<td>0.97</td>
</tr>
<tr>
<td>16.</td>
<td>Is pronunciation provided in the game suitable?</td>
<td>4.04</td>
<td>1.12</td>
</tr>
<tr>
<td>17.</td>
<td>Is pronunciation provided in the game facilitating you to learn English?</td>
<td>4.01</td>
<td>1.09</td>
</tr>
<tr>
<td>18.</td>
<td>Game speed</td>
<td>3.98</td>
<td>1.13</td>
</tr>
<tr>
<td>19.</td>
<td>The overall design of the game is appropriate.</td>
<td>3.82</td>
<td>1.14</td>
</tr>
<tr>
<td></td>
<td><strong>Average</strong></td>
<td>4.04</td>
<td>1.12</td>
</tr>
</tbody>
</table>

IV. CONCLUSION AND DISCUSSIONS

To the development of the word search game on smart phones, we conduct a survey to explore the needs of users. The study collects the data from 46 Thai students at Bangkok University, Thailand. An evaluation was carried out to the students to get feedback on the effectiveness and software design. We found that most Thai students positively preferred to play the word search game on smart phones if they can manage their own vocabulary words. In this paper, we try different techniques to compare with our word search game. Based on table 2, the result does not indicate that either word search on paper or e-mail attached with crossword vocabulary had less attraction to Thai students, but students participating in using our game got the best improvement. In addition, two special features that students preferred to have within the word search game on smart phones, while they are playing, are an English dictionary and its English pronunciation. In the future, the feedbacks should be also applied to improve the final game.

ACKNOWLEDGMENT

The authors would like to acknowledge the cooperation of students at Bangkok University participated in our research and voluntarily responded to questionnaires. Thanks also goes to Mr. Apiwat Nokted and Mr. Takrit Limwiras, who voluntarily developed the final version of the word search game on Iphones.

REFERENCES


Abstract — We make a proposal to teach the concept of function using mobile computing. This proposal is based on research that has support in education theories such as Constructivism and Problem Solving Learning. In the first part we show the difficulties that undergraduate Computer Science students have in the first semester of Engineering while working with that mathematical concept. And application to be used by the students anywhere and anytime in mobile devices is designed to process data and is intended to show them the concept of function in a problem solving situation. The proposed activities are part of the education methodology used in the research and within this paper we show the diagnostic questionnaire as one of the methodological tools and its results supporting the designed activities and its application to mobile devices.

Keywords— mobile computing; technology; constructivism; function.

I. INTRODUCCIÓN

Mobile devices have made great progress in recent years and are influencing all activities. For this reason groups like New Media Consortium, EDUCAUSE and Learning Initiative point out through their projects Horizon Report [1]-[3], the use of mobile devices in education as one of the developing research lines in recent years.

Additionally, there is "educational" software on the market, especially built for mobile devices and developed for different purposes: fun, acquiring proficiency in a subject, present information about a course, solving puzzles, etc. These materials are disorganized and there is not a study, about their A. Problem Statement

In the absence of contextualized mobile computing applications that support teaching and learning processes, we take advantage and measure usability provided by M-Learning to develop a teaching proposal for the topic of function, as a case of study.

It is also considered that the Mobile Computing could support and enhance the teaching-learning process, as current students have a mobile culture Kurlovskey [4], which implies that they have prior knowledge that should be exploited as mentioned Ausubel [5].

influence in the Teaching-Learning Process (TLP). Disciplines like Mathematics Education allow researchers to investigate how to get inside a classroom with these devices linking technology and theoretical work on learning.

One goal of this work is to take advantage of both disciplines, Mobile Computing and Mathematics Education, in order to teach calculus, focusing on the concept of function.

In different researches regarding the difficulties students have in learning mathematics, authors note that one issue is due to the way how the content is structured in the classroom, preferentially oriented to the purely mathematical aspect, based on exercise and algorithms management without a link to real-world and science problems. This leads to a lack of interest of students in the study of mathematics because they don’t perceive its use in their studying process as mentioned by Aravena [6], [7], and Biembengut [8].

Artigue [9] states:

"... According to the difficulties found, the traditional teaching and in particular, university education, even if they have other ambitions, tends to focus on algorithmic and algebraic practice of calculus and evaluate the acquired skills in that domain. This phenomenon becomes a vicious cycle. To have acceptable levels of success, it is assessed what students can do better, and this is, in turn, is considered as essential by students because that is what is assessed ...
"

"If I had to reduce all of educational psychology to just one principle I would say that: the most important factor influencing learning is what the learner already knows. Ascertain this and teach accordingly"

B. Theoretical Aspects

In this section we point out the concepts involved in the construction of the tools used in this research.

At first Mobile Computing is described and its relation towards education, which gives rise to M-Learning. Later education methodologies employed and finally some learning problems that were addressed in the research.
1) Definition of Mobile Computing

There are several definitions for Mobile Computing systems, in this paper we take the approach outlined by B’Far [10]:

"Mobile Computing Systems are Informatics Systems that can be moved easily in a physical way and whose computing capabilities can be used while moving" (p. 3).

According to this definition mobile informatics systems distinguishes themselves from other computer systems, taking into account the differences between the tasks they are designed to perform, how they are constructed, and how they are used. This identifies four characteristics of mobile devices: mobile user, mobile device, mobile application and mobile network.

A mobile user is defined under the following conditions of mobility:

- Being on the move, at least occasionally, alternating between known and unknown locations.
- The user's attention is not focused primarily on the computational task performed. When in motion requires attending other activities.
- Require short times of response from a system with a high degree of interactivity.
- Change frequently or abruptly between tasks.
- Require digital access to information anytime, anywhere

On the other hand we have the characteristics of a Mobile Computing System, which is known as mobility dimension by B’Far [10]:

- Location awareness,
- Network connectivity quality of service (QOS),
- Limited device capabilities (particularly storage and CPU),
- Limited power supply,
- Support for a wide variety of user interfaces,
- Platform proliferation, and
- Active transactions.

The location can be seen on two levels: to obtain information about the location of the device and how this information is used in the system functionality.

On the other hand the information technologies based on Internet, has been involved in all human activities including education, giving rise to what is known as E-Learning. This is defined as the use of Internet technologies to provide a wide range of solutions that improve the process of obtaining knowledge by Chuanto [11]. The development of E-Learning techniques has given rise to other related activities such as T-Learning, U-Learning, M-Learning, (television, ubiquitous and mobile, respectively). The latter is described as the intersection of distance learning using the Internet (E-Learning) and Mobile Computing.

M-Learning is divided into two categories: first, the actor is independent of his context and location, only makes use of the mobile device for learning, such as listening to music in English to learn the language; in the second, the actor is placed in a context that is necessary to carry out the learning process. This second category is known as context-aware mobile learning Chuanto [11].

The context required for the M-Learning is, in the information used to characterize the learning situation in order to be relevant to the interaction between student and mobile application.

Also, three levels of context are identified: computer, user and physical.

It is worth noting that the mobile application as a research tool proposed in this document complies with the dimensions of mobile computing and of context-aware M-Learning.

2) Problem based Teaching

In this article "Problem-Based Learning" (PBL) is used because some of the aims of the research is to address calculus problems and meet the guidelines of the Instituto Politécnico Nacional (IPN).

According to that described by García [12] the PBL complies with the following aspects.

- It has particular impact on the student, being a working active methodology.
- Allows the development of thinking skills, from the standpoint of critical and analytical, which are consolidated and endure over time and are open to other disciplines.
- Looks for a comprehensive and plural development in students.
- The protagonist of the Teaching-Learning Process (TLP) is the student.

Students work in discussion and reflection groups.

C. Mathematics Education

In Mathematics Education the fact that work in the classroom is contextualized has gained importance. This means that the concepts should be studied in a real situation instead of an abstract one by Solokowski [13].

On the other hand we also have Realistic Mathematics (REM Realistic Mathematics Education) which is based on the interpretation of the Mathematics of Freudenthal as "a human activity". From this perspective, students must learn...
Mathematics in order to mathematize an issue from a realistic situation and his own mathematization (i.e the context of the problems must be mathematically true for the student) by Freudenthal [14].

It's about learning Mathematics through rediscover the concepts involved within real problems, similar to how these were discovered for the first time in history. Reverse the process of teaching first formal and methodological aspects of mathematics and later its implementation. Seeking to address these issues in parallel, described in [15]-[17].

D. Objective

Evaluate, with a technological and educative methodology, the use of Mobile Computing in the TLP of Calculus using an innovative application that take advantage of the Mobile Computing potential.

II. METHODOLOGY

In order to accomplish the objective these methodological tools were used:

A. Diagnostic Questionnaire.
B. Application Design.
C. Activities Design.

A. Diagnostic Questionnaire

The diagnostic questionnaire consisted of nine questions and the tenth is on student opinion. This, was applied to 69 freshmen engineering and it was rated between 0-5, zero was assigned to the problem that was solved incorrectly, while the five for the correct answer. If no data it means that the student did not answer the question. The questions focused on review both the conceptual and the algorithmic part of the students.

The questions are divided between the algorithmic and those requiring the concept, we observed that most of the students show deficiencies related to the concept.

The problems are numbered from one to nine, in several of them are asked questions marked with the letters a, b, c, d, e and f.

The first problem, by having two subsections is divided into 1a and 1b.

The diagram shows a circle and a fixed point P on the circle. Lines PQ are draw from P to points Q on the circle and are extended in both directions. Such lines across a circle are called secants, and some examples are show in the diagram

(a) How many different secants could be draw in addition to the ones already in the diagram?

(b) AS Q gets closer and closer to P what happens to the secant?

The second problem has not subsections, so in this case is just the number 2.

Water is flowing into a tank at constant rate, such that for each unit increase in the time the depth of water increase by 2 units. The table and graph illustrate this situation.

\[
\begin{array}{c|c|c|c|c|c|c}
\text{Time}(s) & 0 & 1 & 2 & 3 & 4 & 5 \\
\text{Depth}(y) & 0 & 2 & 4 & 6 & 8 & 10 \\
\text{Difference} & 2 & 2 & 2 & 2 & 2 & 2
\end{array}
\]

What is the rate of increase in the depth when \( x = \frac{2\frac{1}{2}}{2} \)?

The third problem has five paragraphs, hence it is split into 3a, 3b, 3c, 3d, and 3e.

The graph below represents \( y = 3x - 1 \).

(a) What is the value of y when \( x=a \)?
(b) What is the value of y when \( x=a+h \)?
(c) What is the change in y as x increases from a to \( a+h \)?
(d) What is the average rate of change in y in the x-interval a to \( a+h \)?
(e) Can you use the result (iv) to obtain the rate of change of y at \( x = \frac{2\frac{1}{2}}{2} \)? At \( x = \bar{x} \)? If so, who?

The problem number six has three subsections therefore appears 6a, 6b, and 6c.

The graph of y for certain equation, for \( x=0 \) to \( x=6 \), is shown below.
What is the average rate of change of \( y \) with respect to \( x \),
(a) From \( A \) to \( B \)?
(b) From \( B \) to \( E \)?
(c) From \( A \) to \( J \)?

A total of 12 responses were reviewed, with each subsection. It is important to note that these 12 questions that were asked in the diagnostic questionnaire are algorithmic questions.

The following problems with their subsections are: 4, 5a, 5b, 5c, 7a, 7b, 7c, 7d, 7e, 7f, 8a, 8b, 8c, 9a, 9b, 9c. These problems are of algorithmic type or using the memory.

What is the formula for the rate of change for the equation \( y = x^n \)?

What is the rate of change formula for each of the following equations:

a) \( y = 3x^2 \)?
b) \( y = 4 \)?
c) \( y = \frac{2}{x^2} \)

Explain the meaning of each of the following symbols:

(i) \( \delta x \)
(ii) \( \delta y \)
(iii) \( \frac{\delta y}{\delta x} \)
(iv) \( dx \)
(v) \( dy \)
(vi) \( \frac{dy}{dx} \)

What is the relationship between \( \frac{\delta y}{\delta x} \) and \( \frac{dy}{dx} \)?

In each of the following, calculate the rate of change at the point indicated, and explain the significance of your answer:

(i) \( y = x^2 - 4(x + 1) \) at \( x = 1 \),
(ii) \( y = x^2 - 4x + 1 \) at \( x = 2 \),
(iii) \( y = \frac{1}{x} \) at \( x = 0 \)

III. RESULTS

In this section we present the results of the diagnostic questionnaire applied to the group of 69 freshmen engineering of first semester of Calculus.

The responses were organized into categories according to the strategy they used to solve the problems of the diagnostic questionnaire, these categories are described below.

Category called Substitute: This is one of the most common mistakes, the student substitute a value in an expression whether or not that was asked in an exercise.

Category called "Confuses concepts": When a student answers a question with a different concept, that may be correct but the learner is confusing two concepts.

Category called "Reduce its size": This error only occurs in Question 1 of the diagnostic questionnaire, since students state that the secant line reduces its size.

Category called "Same": This error only occurs in the question 7g. The student states the average change and the derivative are the same.

The results obtained are shown in the following graph in Figure 1.

![Frecuencia de calificaciones](image)

Fig. 1. Diagnostic Questionnaire Answer Graph. \( y \) axe shows the number of answers with its grade in the range.

By taking the average of the ratings, only the ones responded well (rating between 1 and 5) we have the following. The algorithmic questions have an average rating of
4.39 and the concept questions 3.96. This means that the students who answer correctly found easier the algorithmic questions.

The graph in Figure 2 shows the percentage response rate for each question (right or wrong). Where the average of the questions answered incorrectly is greater for the group of concept questions than the group of algorithmic questions. (46.98% and 30.48%, respectively)

This difference is increased with the analysis of the difficulties experienced by the students to respond. The error detected more frequently is that students substitute values in the expressions provided to them no matter what the exercise they were asked to respond. This happened both in Question 2 as in 3e.

The second most common mistake is to confuse the concepts they were asked.

![Fig. 2. Show how algorithmic questions are correctly answered more frequently.](image)

IV. APPLICATION DESIGN

The application has the ability to acquire data under controlled conditions by the student and stores that data considering the time they were captured for granting independence in the form of use to the student and thus encourage innovation and independent learning, which allows a significant learning.

In the case of the camera, the most frequently feature found in mobile devices of students in Escuela Superior de Cómputo (ESCOM, IPN) in a previous study, it is possible to "paint" on it, similar to augmented reality, different base curves on the image to approximate the behavior of the object in the picture (Figure 3).

![Fig. 3. Interface that allows “measure” over a taken picture.](image)

The student should consider that the data provided by the application are in pixels and must convert these, if required, to a standard metric unit.

In addition to allowing the student to obtain the algebraic expression of the different curves drawn on the image, it is possible to perform measurements in the units specified, setting the conversion between pixels and units established.

The application allows the student to take measurements with the different features of the device, compass, microphone, accelerometer, etc.

For example, the level of the device can be used to measure angle changes according to time and draw the respective graph. See Figure 4.

![Fig. 4. The application allows the graphical view of the taken measurements](image)

The application also stores the data on the device for later analysis, share data with peers and teachers using standard formats and communicating with Moodle.

After training students in the use of the application, which is intuitive, a problem to be solved in groups is proposed. These proposed problems are referred to as activities. Each activity has instructions for the student and the teacher, questions to be solved, these activities
can be obtained from the web using a Moodle server or also to be printed on paper in order to have them on hand

**ACTIVITY: WATER LEAK**

**Motivation:**

After class two students stop by and watch a pipeline on the garden with a water leak, they say to each other:

- Look, a water leak
- Yeah, and they tell us to save
- Imagine that we could use that water as a weapon and could destroy a starship

They laugh and go report the water leak.

**Problem**

A water container having an orifice which generates leak is in the school. How full should be the container and the water to reach dipping an object that is located a certain distance as shown in the figure. Find the rule correspondence between the height of the water level and the place that should be the object to be wet.

**Questions**

Before starting with the activity answer the following questions according to your own experience.

- If the relative position between the container and the object is given. What should be the water level from the orifice in order to wet the object?
- Which path will follow the trickle?
- How the container shape changes the path of the trickle?
- The path of the trickle is affected by the water volume contained?

What kind of container will you use?
Changing the container width modifies the distance of the object to be wet?
How does the orifice position affects the reach of the trickle?

**Analysis**

Once you have experimented with the videos we propose you to label some distances involved in the problem in order to answer some qualitative questions.

**Analytic Expresions**

Suposing that the path of the trickle is a parable determine the constants \((a, b)\) of the following expression for a given moment

\[
\text{Base of the container} \quad b_r
\]

\[
\text{Water height from the orifice} \quad h_x
\]

\[
\text{Horizontal distance of the object to the base of the container} \quad x
\]

\[
\text{Vertical distance of the object to the orifice in the container} \quad y
\]

The distance \(h_x\) is a data that we can’t control because it changes according to the water leak, it changes through time. Same happens with distance \(x\). These are dependent variables. On the other hand \(b_r\) and \(y\) are variables that we can fix.

An activity example is described in Figure 4.

Use your mobile device to discover the rule of correspondence between the water level and the place that should be the object to be wet.

1. Propose
2. Shoot a video.
   a. Shoot a video of the described situation with your mobile device taking into account that the shoot let you perform measurements.
   b. Once you shoted it determine the shape of the trickle and how it changes through time.
   c. Repeat the shooting with different containers in order to establish how its shape influences the path of the trickle.
   d. Perform the necessary tests to answer the stated questions.
\[ y = ax^2 + b \]

How can we rewrite this expression involving time?

What is the relation between constants \( a \) and \( b \) with \( h_2 \) or \( b_r \)?

Results

Write a final expression that could solve the original problem, i.e., if I have a container (height and width, if needed both or one of them) and an amount of water, in which position should be the object to be wet as soon as the container starts leaking.

Conclusions

To conclude argue with your classmates about how this problem reflects the concept of function: domain, image or range, correspondence rule, dependent and independent variables and functions composition.

Fig.5 Activities format. Activity sample

V. ANALYSIS

The observations made to students while they were solving activity shown in Figure 4.

Now we present the conclusions reached by the group of students about the activity applied. To solve it the group was divided into 7 teams.

Team 6 concluded that the amount of water is an important factor influencing the pressure on the orifice and this is reflected in the distance of the water.

Team 6 also noted that they weren’t able to express the function algebraically they just got conclusions regarding the practice and knowledge obtained. But this allowed them to understand what was really happening instead of the sole algebraic expression that did not tell them anything. This team commented that using different applications within their phone to solve a math problem is something totally new. Exemplified the fact that they are used to take video or take photos to things outside of what they work at school, noting that most of them have used the camera to take a picture to the board, instead of taking notes.

Team 2 indicated that the function is decreasing as the pressure at which water leaks depends on the height of the object and the shape of the container.

For this team to use their phones was something different and interesting because they solve a math problem using applications included in their mobile devices and the application installed by the teacher helped them a lot, they could draw a graph and measure the distance between the object and the vessel containing the liquid. This makes mathematics realistic, not abstract.

Team 5 said that the scope of the trickle to the object depends on the pressure with which it leaves the container and what is obtained is a decreasing function as this is due to the height of the liquid that wets the object and the loss of pressure as the liquid is ejected.

Team 7: concluded that the function being sought depends upon the amount of water and the container that serves as an experiment, it was also noted that it is decreasing because water within it, is depleted.

VI. CONCLUSION

In this first phase of the research that has been developed and shown in this article, we note the importance of the use of Mobile Computing in Education, specifically in Mathematics Education, currently young students have access to Mobile culture, so that the application designed and the activities formulated were directed to use what the student knows. On the other hand the design of the application and the proposed activities were aimed to work the deficiencies found in undergraduate Computer Science students of first semester, as a result of applied a diagnostic questionnaire, where when contrasted with the literature found great similarity, and students prefer to solve algorithmic issues to situations where the concept of function is involved more realistically.

The impact of working with mobile devices allowed the student to solve the activity using the application installed on their phones in different moments of resolution, such as drawing the coordinate plane and graph a parabole corresponding to the water leak, but this was achieved by the students because they shot a video when the water container was emptied through the orifice made in it.

The usability of their phones was a fundamental key, just like the portability of these.

The impact of mobile computing that was evaluated was the Usability part of M-Learning and found the following: Having worked with the activities and the designed application we performed an evaluation questionnaire and one on the usability and found that the students were able to develop different skills such as reflection, communication and discovery.

In relation to learning obtained, it was more significant, it was not mechanical.

It is considered that the contribution of Mobile Computing consisted of a comprehensive development of the student in order to achieve learning that is not based on memory.

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Simulation as a resource in the Calculus Solving Problem

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Abstract—This article is derived from the research project and developed at School of Computer Sciences of the National Polytechnic Institute of Mexico. The article reports on the problems found among engineering students with respect to their resistance to using different representation registers when solving optimization problems in the Calculus Learning Unit. Use of such registers could help the students to build mathematics knowledge and to solve calculus problems. As a didactic strategy, simulations are used in an electronic environment in order to support the students by fostering their use of tabular, graphical and algebraic representation registers. Interviews are undertaken of six of the professors who gave the calculus courses, and a diagnostic questionnaire was applied to 68 students prior to and after working with the proposal. As for the theoretical framework, the work reported by Duval and Hitt is salient in this report, particularly their emphasis of the fact that working on activities by way of one single representation system is not sufficient. From the first responses provided by the students, one can conclude that the algebraic register is preferred by the majority of students. It is however used in a mechanical fashion without affording any meaning to the content of the problem and to the process of solving it. Another conclusion reported is that implementing tasks in the classroom in which the mathematics activity requires coherent use of different representations is necessary.

Keywords—simulation, representation register, Calculus, Solving problem.

I. INTRODUCTION

The study reported in this article uses the reference of a cognitive focus based on the registers of semiotic representation of Duval and their effect on the learning of mathematics notions, particularly on solving the optimization problems worked on in the Calculus Learning Unit for second year engineering students. Hence first a review was undertaken of aspects of the representation registers, after which the three registers used in the study reported in this article, namely the graphical, tabular and algebraic registers, are documented.

II. THEORETICAL ASPECTS

A. Background

As pointed out in [1], the semiotic representations are representations that employ signs, which can be expressed in natural language or in algebraic formulae or in graphs or in geometric figures. However those semiotic representations are the means through which a person can externalize his/her mental representations in order to make them visible or accessible to others. Those semiotic representations also make communication possible.

Duval [1] focuses on and establishes the fundamental importance of issues the likes of:

- The ability to change registers of semiotic representation, which is necessary in the learning of mathematics.
- The importance of coordinating different registers of semiotic representation. He explains that many of the difficulties experienced by students can be described and explained as a lack of coordination among representation registers.
- Considering conceptual knowledge (comprehension) as the invariant of multiple semiotic representations.
- Based on different representation registers, defining specific independent variables for cognitive contents and organizing didactic proposals in order to develop coordinated representation registers.

On building mathematics concepts, Duval [1] establishes that given that each representation is partial vis-à-vis the concept it represents, interaction among different representations of the mathematics object must be considered absolutely necessary for its formation.

As for the work per se of the graphical, tabular and algebraic representation registers, as well as of the problem, as is pointed in [2]-[4], who underscores that visualization enables statements to be understood and activities to be carried out, and although it does not lead to the correct
answer, it does enable the person solving a problem to delve deeply into the situation being solved. The author moreover states that visualization constitutes the link to seeking the solution to the problem raised.

The foregoing researcher [1]-[4] also points out that mathematical visualization of a problem plays an important role, and involves understanding the word problem by bringing into play varying representations of the situation in question, thus making it possible to undertake an action that will possibly lead to solving the problem.

Technological progress has wielded a notable influence on the development of theoretical notions that are the basis for understanding different representations of mathematics objects and their role in building the concepts. Today, with the advent of such technology it is important to study different representations of objects [5].

B. Computer simulation in the context of Learning

Technology in education is most simply and comfortably defined as an array of tools that might prove helpful in advancing student learning and may be measured in how and why individuals behave. Simulation is extensively used for educational purposes.

Simulation is the limitation of the operation of a real-world process or system over time [9]. The act of simulating something first requires that a model be developed; this model represents the key characteristics or behaviors/functions of the selected physical or abstract system or process. The model represents the system itself, whereas the simulation represents the operation of the system over time.

Simulation is used in many contexts, such as simulation of technology for performance optimization, safety engineering, testing, training, education, and video games. Simulation is also used with scientific modelling of natural systems or human systems to gain insight into their functioning. Simulation can be used to show the eventual real effects of alternative conditions and courses of action. Simulation is also used when the real system cannot be engaged, because it may not be accessible, or it may be dangerous or unacceptable to engage, or it is being designed but not yet built, or it may simply not exist [10].

Key issues in simulation include acquisition of valid source information about the relevant selection of key characteristics and behaviours, the use of simplifying approximations and assumptions within the simulation, and fidelity and validity of the simulation outcomes.

Simulations in education are somewhat like training simulations. They focus on specific tasks. The term 'microworld' is used to refer to educational simulations which model some abstract concept rather than simulating a realistic object or environment, or in some cases model a real world environment in a simplistic way so as to help a learner develop an understanding of the key concepts. Normally, a user can create some sort of construction within the microworld that will behave in a way consistent with the concepts being modeled.

The "classroom of the future" will probably contain several kinds of simulators, in addition to textual and visual learning tools.

III. RESEARCH QUESTION

Will detection of the obstacles that hamper learning among students, such as breaking away from the modes of thought that are typical of algebraic functioning, and of the difficulties related to symbolic language and graphic signification of a concept contribute to a comprehension of the concept of function and optimization and their use in the academic subject of calculus?

Will use of simulations to work with optimization problems, as a didactic tool and strategy, enable professors to organize their teaching activities and manage student learning, as well as course planning by conjugating topics of study and didactic matters?

IV. METHODOLOGY

For the documentary phase of the research, a review was undertaken of the specialized literature in the fields of semiotic representations, use of representation registers, the importance of technology and the concept of function and optimization.

Six professors from Escuela Superior de Cómputo (ESCOM), all of whom were giving the Calculus Learning Unit course, were interviewed. A questionnaire was designed and applied to 68 students who were taking the calculus course, and whose previous coursework included algebra, trigonometry, geometry, analytical geometry and calculus at the high school level.

In order to determine the depth at which contents are dealt with and the manner in which they are taught a review was also undertaken the ESCOM’s study plan and program [6]. Moreover simulations were made of problems that had been validated and reported in the projects show in [7][8].

The methodological orientation stands within a qualitative perspective, which means that the qualitative aspects of the experimental process were fundamentally observed. This was carried out through the following phases:

- Determination of the sample of professors to whom the questionnaire would be applied.
- Design and application of student questionnaire.
- Analysis of results.
- Discussion.
- Proposal of activities for using technology-based simulations, as a strategy.
- Determination of findings and conclusions.

A. Findings and Analysis

Based on the data obtained in the specialized literature, a review was carried out of the academic work. In order to accomplish this, six professors who give the Calculus
Learning Unit course were interviewed and 68 students were asked to answer several questions and solve one optimization problem.

Professors who took part in the interviews pointed out the following:

- When solving optimization problems, the students are unable establish the functions that would enable them to work and solve the situation raised in the problem.
- The students are quite accustomed to using the criteria of the first and second derivative in order to find the maximums and minimums, but are unable to derive any meaning from that manner of working. Their work is too mechanical.
- They must use graphic language to make the optimization application explicit.

The questionnaire applied to the students is shown in Figure 1.

![Table I](image)

Instructions:
Answer the questions and solve the problem. Write out the entire process used in order to produce your solution.

2. What is your basis for solving optimization problems? Explain.
3. Do you use the support of a table when solving optimization problems? Explain.
4. Do you use the support of a graph when solving optimization problems? Explain.
5. Solve the following problem:
   - A container in the shape of an uncovered straight circular cylinder has a surface area of $3 \pi r^2$. What height $h$ and radius of the base $r$ will maximize the volume of the cylinder?

Fig. 1. Questions and problem solved by a sample of 68 students.

The results of the questions were compiled in tables, in which the responses provided by the students were included and after quantifying those responses a percentage was obtained. Table I contains the answers provided by the students to question 1.

**TABLE I. ANSWER FOR QUESTION 1.**

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always because I apply the theory</td>
<td>24%</td>
</tr>
<tr>
<td>Sometimes because of the type of problem</td>
<td>44%</td>
</tr>
<tr>
<td>Never because the problems are very difficult</td>
<td>32%</td>
</tr>
</tbody>
</table>

The majority of students felt that they can apply the theory depending on the degree of difficulty of the problem. For the students, both strictly algebraic exercises and situations found within a context are deemed to be problems.

Table II contains the answers given by the students to question 2.

2. What is your basis for solving optimization problems? Explain why

Table II shows that 100% of the students use the algebraic register to solve optimization problems, given that 24% use the criterion of the first derivative in the algebraic expression and 76% use the criterion of the second derivative. Both are algebraic procedures, and this coincides with the assertions made in [2], [3] and [4]. Moreover they only consider the function through the algebraic expression when the function can be represented by way of different registers.

Table III contains the answers given by the students to question 3.

3. Do you use the support of a graph when solving optimization problems? Explain why.

**TABLE III. TWO CRITERIA USED BY THE 68 STUDENTS IN ORDER TO SOLVE OPTIMIZATION PROBLEMS.**

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use the criterion of the first derivative in the function</td>
<td>24%</td>
</tr>
<tr>
<td>Use the criterion of the second derivative in the function that I found</td>
<td>76%</td>
</tr>
</tbody>
</table>

Table II shows that 100% of the students use the algebraic register to solve optimization problems, given that 24% use the criterion of the first derivative in the algebraic expression and 76% use the criterion of the second derivative. Both are algebraic procedures, and this coincides with the assertions made in [2], [3] and [4]. Moreover they only consider the function through the algebraic expression when the function can be represented by way of different registers.

Table III contains the answers given by the students to question 3.

4. Do you use the support of a table when solving optimization problems? Explain why.

**TABLE IV. ARGUMENTS EXPRESSING WHY THEY DO NOT USE TABLES WHEN SOLVING OPTIMIZATION PROBLEMS.**

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>0%</td>
</tr>
<tr>
<td>No because I use tables to produce graphs and I don’t need the graph</td>
<td>62%</td>
</tr>
<tr>
<td>No because there is no certainly that a table will [help me] obtain a result</td>
<td>38%</td>
</tr>
</tbody>
</table>
From Table IV one can see that none of the students use tables, and the arguments they offer refer to how unsure they feel about using tables to solve an optimization problem. Moreover 62% of the students feel that tables are only used for graphs, thus proving yet again that they do not consider graphs as a means of representing a function and even less so to determine the solution of an optimization problem.

Table V contains the answers provided by the students to the problem.

5. Solve the following problem:

A container in the shape of an uncovered straight circular cylinder has a surface area of $3 \pi \text{ m}^2$. What height $h$ and radius of the base $r$ will maximize the volume of the cylinder?

| TABLE V. ASPECTS THAT ARE EXCLUSIVELY OF AN ALGEBRAIC NATURE AND THAT WERE USED TO SOLVE THE PROBLEM THAT WAS GIVEN TO THE 68 STUDENTS. |
|---|---|
| **Answer** | **Percentage** |
| Students made no attempt to solve the problem because they could not remember the formula needed to calculate the volume of a cylinder, and did not know how to determine the expression needed to calculate the derivative. | 15% |
| Students determined the formula needed to calculate the volume of the cylinder, but did not know what to do with it | 32% |
| Students determined the formula needed to calculate the volume of the cylinder and that of the total area of the cylinder, but were unable to express the function (as an algebraic expression) in terms of one single variable. | 36% |
| Students wrote the algebraic expression in terms of one single variable and calculated the derivative, but were unable to correctly carry out the algebraic operations. | 17% |
| Students correctly solved the problem by calculating the derivative and by carrying out the correct algebraic operations. | 0% |

Overall 85% of the students worked with algebraic registers; no student used tabular or graphical registers to solve the problem.

It is clear that the students have serious trouble working with algebraic registers, troubles that range from not recalling the formula needed to calculate the volume of a cylinder through not clearing the problem correctly, which led them to being unable to find the algebraic expression needed to use the criteria of the first and/or second derivative and arrive at the correct solution to the problem. These findings coincide with those pointed out in [1]-[4].

B. Proposal with simulations

In this section, a proposal is put forth for working with all three registers graphical, tabular and algebraic by using simulations in order for students to be able to visualize the situations raised. Only one of the simulations undertaken is shown here.

Several simulations on the optimization topic were worked on, in which the concepts of variation can be developed.

Simulation’s problems in Flash helps achieve greater understanding of what happens in real applications [7]. Below the reader will find an explanation of how the simulations work.

A first screen is presented as an introduction to the problem (Figure 20). Just like any other Flash animation, it can be maximized until it covers the entire size of the screen. The simulation begins by clicking the **Start** button.

![Initial simulation screen](image)

Fig. 2. Initial simulation screen.

The simulations are done with Flash, and here two problems are presented.

C. The Sheet-metal Problem

We have a rectangle that has a base of 30 cm and a height of 10 cm.

An open rectangular box is to be built for the rectangle and for this cuts are required at the corners of the box.

How should the cuts be measured in order to obtain the greatest volume?

What is the greatest volume?

The first screen provides a description of the problem (Figure 3). The student can go to the solution screen by clicking the **Solution** button.

![Word problem and data](image)

Fig. 3 Shows the text of the word problem, as well as an image that contains the data.
The solution begins with the word problem and a breakdown of the data, thus revealing the possibility of solving the problem. (Figure 4).

At any time during the solution sequence, students can move forward by clicking (Solution) or go back to the previous screen by clicking (Back).

![Figure 4. Deducing the algebraic expressions extracted from the data.](image)

The (Conclusion) button leads the students to the last screen that contains the final results of the problem, along with a brief explanation of how the solution was reached (Figure 5).

At this point students can also go back to review the entire solution of the problem by using the (Back) button or they can start over by using the (Start again) button.

![Figure 5. The table filled in with the data obtained, as well as the maximum point on the graph.](image)

D. Professors in the Sample Suggested that the Following Teaching Strategies be Adopted

After having worked with the simulations, the professors in the sample stated the following:

- The relationship that exists among the graphical, tabular and analytical registers can be seen.
- Problem solving of optimization problems improved.
- Use of technology through design of simulations enables them to modify their classes and adopt other teaching strategies.

E. Answers provided by the students to the questions posed, and after having used the simulations.

Overall, 78% of the students felt that the problems they solved using the three representation registers enabled them to make sense of the problems they were solving. The 87% pointed out that the graphs made it possible to see that the functions have maximums and minimums, and they recognized that those points represent the values requested in the solution of the problem.

V. Answering the Research Question

Will detection of the obstacles that hamper learning among students, such as breaking away from the modes of thought that are typical of algebraic functioning, and of the difficulties related to symbolic language and graphical signification of a concept contribute to a comprehension of the concept of function and of optimization and its use in the academic subject of calculus?

Study findings indicate that one of the obstacles that hinders student learning is the scarce use of learning strategies.

By working with problems within a context and having the support of technology, in this case simulations, the professors were able to realize that several learning strategies exist for students. Thus by detecting their existence a whole range of possibilities opens for students to be able to make sense of their work and stop working mechanically, solely with the use of formulae.

Is the use of tools that enable professors to organize their teaching activities and manage student learning, as well as carry out course planning by conjugating topics of study, professor time management, didactic matters, forms of evaluation, a strategy that will enable professors to contribute to enhancing the quality of engineers?

Use of problem-based simulations within a context enabled the professors to have an alternative landscape and to consider class planning as an essential aspect.

Use of other learning strategies has the number one goal of fueling thought processes concerning the practice, turning them into systematic processes. Another goal is to promote incorporation of concepts derived from the Didactics of Specialized Disciplines in order to improve the quality of teaching offered.

The work flow is based on the following: determining the class problem, designing the didactic actions, preparing materials, application and observation, analysis and visualization of conflicts.

Professors in the sample subscribe to the idea of developing varied and multiple didactic actions aimed at promoting learning that have a greater degree of signification. The methodological eclecticism proposed makes it possible to
formulate different actions that are able to meet the needs of each working group.

VI. CONCLUSION

In view of the lecture freedom, the manners in which professors teach have to do with their beliefs. Generally the teaching manner at the level of high school and higher education at the IPN is by presenting the theory, algorithm procedures, solution of exercises and problems, practice using graph calculators, some verification work, but without getting into demonstrations. And all of this is, of course, to the extent that the professors feel that their students need those tasks.

The epistemological approach (disciplinary knowledge) of the course should make it possible to integrate prior structured learning from academic periods at the high school and higher education levels, so that they can be recovered at this level. The objective of the foregoing would be to significantly deal with the concept of variation, including its different techniques, procedures and applications at a level of conceptual depth that makes it possible to raise and solve problems in context, problems that involve important use of algebraic functions as well as the derivatives of those functions.

Engineers take on the tasks of designing and building. And this is why, at the beginning, drawings, graphs and diagrams were a resource inherent in their work. In our training of engineers, use of geometry must be recovered so that the level of visualization they achieve will enable them to develop projects expeditiously.

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Use of Virtual Reality in Teaching Fractions at Elementary Level

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Abstract— The learning difficulties of the mathematical concept of fraction is a topic that has been studied by different mathematical educators, but still is a relevant topic today, because despite the proposals that have been made to improve learning, they have not been used for all teachers besides those few that are involved in the use of the technology. Besides that there is little educational software that is based on research and is validated to be taken to the classroom. This article shows a virtual system that has been created for the student to interact with it in order to connect his knowledge with his play skills, skills of discovery, reasoning, communication among others and may have a significant learning of fraction.

Keywords— learning, elementary education, technology, virtual reality.

I. INTRODUCTION

It is hard learning fractions with natural numbers for elementary school children, students see fractions as a pair of numbers, one on top of another, which are meaningless. [1], [2]. Although the “Secretaria de Educación Pública” in the 2011 program [3] states that students solve different problems according to their school reality with the use of fractions, the test results as performed by the “Evaluación Nacional del Logro en Centros Escolares” (ENLACE,), [4], cast disapproving results in this topic.

Some of the reasons why this problem occurs, deal directly with the ignorance of the meaning of how fractions operate, designing unclear situations by the teacher, poor reading comprehension of different problems by the student [1], [2], [5]-[7]. Besides the lack of interest in it, the lack of imagination of the student to be able to make a sketch of the problem, insufficient time for teaching the subject and little or no support from parents.

For the above reasons this work focused on supporting learning of fractions, particularly the concepts of partition and distribution to primary school students, a system was designed using the methodology Metric 3.0, which allows the student to learn the topic of fractions, by observing actual problems with the use of virtual reality (Sherman and Craig, 2010). Worked subjects were:

• Partition
• Distribution

II. RESEARCH QUESTION

How much intervention in the teaching and learning of fractions in partition situations through "Didactic Scenarios" and the use of virtual reality helps notions acquisition necessary for the understanding of the fraction?.

III. JUSTIFICATION

In Mexico, Educational Reform was implemented, [8], one of its objectives is to attack the difficulties in understanding mathematics, as given in the case of learning fractions. But which resources has the teacher that help him/her plan lessons and meet the objective of this reform?

For that purpose it was also created a virtual system, which is based on the design of a proposal for teaching fraction through Didactic Scenarios, [9]. Giving guideline to interrelate two disciplines, education in mathematics and computer science.

It is intended that the virtual system be a complementary tool, supporting the learning of the fraction, especially in the concepts of partition and distribution to elementary school children, a methodology is proposed which allows the student to learn fractions by observing real issues with the use of virtual reality. The system increases the complexity of the problems and how the student is assessed. Problems addressed fraction as part-whole, the partition and distribution.

IV. THEORETICAL ASPECTS

A. Studies of ICT for teaching

Currently, in the educational context is possible to design and develop interactive technological materials.

Some results of research state that computer science programs can support the construction of mathematical knowledge in students. As is the case of Ruiz [10].

Harris, [11] states that technology gives the teacher more flexibility to meet the different needs of students with different levels of skills, who may be sharing the same class, using software that can be adapted to the teaching and learning as well as to the particular conditions of each student or group.
While in traditional education the teacher gives a lesson at certain speed and level. Technology allows the teacher to divide the group into teams and work with everyone at their own pace.

Meanwhile, Galbraith and Haines [12], indicate that multimedia tools allow the use of audio, images, graphics, animation and videos, which are much more efficient than linear media (like books) to capture the interest of students and increase their educational process. Multimedia allows students to grasp meanings in different ways. It also helps to develop their ability and interest.

B. Constructivism in learning fractions

According to the constructivist concept the child learns when he/she is able to develop a personal representation about an object of reality or content to be taught, through the modification of their knowledge and interpretation of new knowledge integrated into what he/she already possessed. [13].

Goffree [14], mentions educational basis for teaching mathematics, which must be based on solving real-world problems, therefore, specific situations should be designed for the child to develop their own meanings. Creating a model of a real situation will allow that the student investigate the situation and apply this model in the solution of other problems.

Kieren [1], defines the part-whole relationship as a whole that is cut evenly, using the idea of fraction to quantify the relationship between the whole and a designated number of parts. Regarding partition there are situations that derive in activities to divide integers, identify divisible units, obtain different but equivalent representations arising from the sense of identity or of the same, which is basic for the construction of the different meanings of fraction.

Lamon [15], defines the partition as an operation that generates quantity, based on intuitive activity and informal knowledge of the child about equitable partition, consisting in equal parts determination. Such operation has multiple stages: marking objects, cut and clearly indicate the portion that corresponds to each person.

Based on a constructivist approach, the "Didactic Scenarios" represent different application areas of fractions that conducive an atmosphere for peer interaction, where there is exchange of ideas and discussion of their points of views.

C. Virtual Reality

Virtual Reality is a technological system, [16] based on the use of computers and other devices, it must meet four characteristics:

Virtual World is the content, or set of features, of a medium that can exist only because of its creator or transmitted in a way that can be shared with others.

Immersion, feeling of being in an environment, is the participants feeling of being in the virtual environment.

Sensory feedback about the virtual world that is presented to the senses of the participants.

Interactivity. The virtual world responds to user actions.

Virtual Stage is any object in an environment, for the purpose of this work is defined as a 3D scenario that has all the characteristics of virtual reality.

V. EXPERIMENT

A. Objective

The aim of the study is to recognize the importance of designing a virtual system to help overcome educational and cognitive difficulties when working with fractions, in distribution situations. The system includes the design of virtual scenarios.

B. Method

For the development of the teaching proposal through "Virtual Scenarios" for teaching and learning distribution with fractions, an elementary school was chosen belonging to the public education system, located in within the urban area of Mexico City. We worked with a group of third grade, their ages are between 8 and 9 years.

In relation to the virtual system, it was developed to support the teaching of fractions based on 3D virtual scenarios, in order to improve student understanding in this matter. It has two types of different scenarios, the first focuses on the basic concept of the partition in the subject part-whole and was chosen because this issue is critical for learning fractions. The second scenario covers matters related to distribution.

The system was developed web-based because the facilities for updating the various elements of the system, its speed and because is cross-platform. It is based on client-server architecture in which the load is divided into three parts or layers with clear division of functions: one for the presentation layer of the system or user interface, one for the calculation, where the rules of the platform are located and the other for storage or persistence of users data and learning objects.

In the research various methodological tools were used such as initial and final questionnaires, interviews and teaching activities. This article shows one of the teaching activities, which was the second didactic scenario entitled "The Restaurant", composed of different objects made in blender 2.62 program, designed to recognize partition and distribution strategies as well as the comparison between equivalent fractions.

C. Implementation of didactic scenario “The Restaurant”

Group was organized as follows:

Virtual Table 1 = 2 people, share 1 pizza.
Virtual Table 2 = 8 people, share 2 pizzas and then 2 pizzas.
Virtual Table 3 = 6 people, share 2 pizzas and then 1 pizza.
Virtual Table 4 = 4 people, share 1 pizza.
Virtual Table 5 = 3 people, share 1 pizza.

D. Virtual Reality System

The virtual reality system is to recreate in a computational environment the didactic scenario “The Restaurant”, as shown in Figure 1.

Fig. 1. Didactic Scenario “The Restaurant”

It was based on the idea of Broken Family worked by Streefland, [7] because its use eliminates the abstract quality of participants unnamed and thus student is not only capable of dividing objects easily, but can produce portions linking the names of the participants, and offers a family atmosphere.

We worked with Franco family, composed by Ms. Laura, Mr. Noé, their sons Paty and Javier, also mentions two family friends Beto and Nancy with whom they share some experiences. The dolls used to represent the family were identical so to differentiate them was placed a label with the name of the character they represented. Figure 2 shows the Franco family and friends.

Fig. 2. “Franco Family”

Activities observed: “Accommodating people”, “Take orders” and “Deliver food”, but also the user can design an activity.

VI. RESULTS

The distribution of the number of people at each table and the distribution of objects to deliver generated that the party assigned to each member of the tables 1, 2, 3 and 4, were equivalent. After delivering the pizzas they wrote in a section of the computer system the amount of pizza for each member of their table.

Virtual Table 1 - Jaqueline 1/2
Virtual Table 2 - Aaron 2/4, 1/2 or 4/8
Virtual Table 3 - Fernanda 3/6
Virtual Table 4 - Mariana 2/4
Virtual Table 5 - Angel 1/3

The members of the virtual table 2 were divided into two groups of 4 and each group is dealt two pizzas. So it is up to
each 2/4, but in writing the fraction that belongs to Aaron, who is one of the members of the table, decide to write two equivalent fractions.

They were asked: “who ate less pizza?” Some answers were "Jaqueline", "the octaves ones". The team of the table 2 responds "no, is the same as has Jaqueline". The members of the table 5 argue that they ate less and compare parts of one of the members of the tables 1 and 5.

They were then questioned “who ate more?” They said "We (table 2) and the table of Jaqueline", "Not true because we all ate the same, less than that table (table 5)" "because they are equivalent to 1/2".

The virtual scenarios allowed that the students simulate being in a restaurant and work with virtual pizzas, cut each one and make the distribution of the slices, thus they were able to compare the numbers and to establish what were equivalent fractions and what were not. This is how they responded to questions.

VII. CONCLUSIONS

Now that the technology is more accessible to students, interdisciplinary production is important, as is done in this study between Research in Mathematics Education and Computer Science. The union between a scientific discipline with technology, can help the design of educational proposals to improve the teaching and learning of mathematics.

Didactic scenarios help the student to be able to visualize a problem of everyday life in a classroom, plan media like books, try to represent them through images.

With the development of the virtual system to support the teaching of fractions, the student was able to interact more with the objects of the problem presented, and that the system took into account the different ways in which students work or represent a fraction.

The system can cut objects and have them overlay, this helps the student that make cuts, to be able to check that deliveries are made equal before giving an answer to the problem. This was achieved by means of two algorithms, the first one identifies the lines made by the student on the object, in order to know how many objects (parts) will be, with this creates a number of objects equal to the parties, the second eliminates necessary vertices of each object so that remain only the objects traced with lines (cut).

It was noted that the recreational skill development of the students allowed them to build the concepts of partition, distribution and equivalence of fractions, in addition to solving problems.

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Actor-networks, a project in Engineering Education

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Abstract - Actor-network theory represents a way to look at things, very different from traditional approaches. Convinced that actor-networks can provide an excellent mindset to deal with innovation in engineering education we present a concise background on the topic oriented to this knowledge area. We deal with knowledge, learning, contexts, and actor networking within situated cooperative environments. We deal with the articulation of planned approaches and policies, providing ideas to explore contexts in which we can improve people’s involvement and design some innovative strategies and artifacts. We address the conciliation of sensibilities that normally wouldn’t be able to cooperate. We try to imagine a space of translations and negotiations that facilitate the formulation of problems as a combination of detours and extensions, constructing alignments to a goal.

Keywords – Actor-network theory, alignment, innovation in engineering education, translation, extensions and detours

I. INTRODUCTION

We can detect some tensions in the area of Engineering Education and we believe the answer should be through the negotiated alignment of different factors, like in a confluence of requirements. In fact, each tension provenance means a will to make things better, so these tensions represent positive inputs to the aligning process. One of the challenges is to make the causes of these tensions work together, in order to create value and enhance results in practice. Knowledge, learning, and actor networking, are some of the elements that need to be considered to construct such an alignment. These three elements don’t belong to the same category, but they are crucial to the process and they need conciliation. This conciliation is our main driver to indirectly contribute to the results we intend. This conciliation demands cooperation, requires planned approaches and depends on policies. In this paper we intend to speculate on a possible design of such an approach to facilitate both alignment and conciliation in the process of engineering education. We begin by “burning” some ideas exploring the conciliation of wills and addressing some ANT concepts. We than explore the conciliation in terms of an ANT framework. Then we extend our ideas trying to explore a modus operandi. Finally we extend again our modus operandi into an action proposal. This action proposal is very simple and intends to be mainly illustrative. Finally we draw some exploratory conclusions and statements.

II. BURNING IDEAS

Rather than adopting problem solving as the model for theorizing learning processes in engineering practices and education, researchers on this field should view theory construction as sensemaking [1]. In our approach, valid for students, teachers and professional practitioners, we would translate theory construction into conciliation, as we need to integrate what and why, problem formulation, problematization in ANT terms [2], with the how, problem solving. These two processes reshape each other, in the sense they construct alternative realities that trigger innovation, they ‘socialize’ [3] between themselves and create knowledge. These alternative realities constructed by this “socialization of things” can be addressed as ongoing extensions and detours in a pathway of evolution. We use the term socialization coined by Nonaka in an ANT way, that is, we are interested in the play of hybrid actors, not only human.

The combination of innovation and learning in a context of engineering design, formulating problems, constructing requirements, defining specifications, designing and doing things should explore conciliation and is a reflective practice [4]. Socialization is a key step in the knowledge creation process. It is in the core of knowledge creation as externalization is a closing, an output, of the same process, the beginning of another cycle. Socialization and Externalization represent two modes on the knowledge creation process [3]. The interplay and shift between these two modes depends on processes of translations. Taking advantage of network effects, we are ‘socializing’ and creating opportunities that trigger the creation of new knowledge, facilitating innovation. But for this network to be social is not enough. That is why we considered the “socialization” of things instead of people.

In fact we may say that technology and society are two interwove systems that reshape each other [5]. If we look at this interplay we are able to understand things in a different way. The attempt of conciliating these two realities is mediated by our knowledge, our filters, the way we look at things (paradigms), the way we translate our “realities”, and finally our situation, or context of our action.
The approach we need should provide the alignment of technology and society but for that effect should not rely on a usual social network. Our approach favors the construction of actor-networks (networks of things) that interact constantly [6]. One of the differences between a common social network and an actor-network is that in this late one actors are hybrids and not just humans (rules, equipment, processes, dependences of factors, restrictions, concerns).

In this sense the process of innovation is a process of translation that should mediate the engineering education process. Let us say that accuracy in ‘our’ translation is not what we fight for, on the contrary, the more creative our translation is, the more powerful it could be in terms of innovation. And translation is the kernel operation in any actor-network up to the point we can say that an actor network and translation are the same.

Learning is a necessary process in this system. But as John Locke (1979) [7] said, "No man's knowledge can go beyond his experience", which means that we need to address knowledge as action, and not as a repository of concepts. Locke almost alerts to the fact that you learn by doing, by reflecting on what you do, the way you do it, how and why. Learning is an integrative process, travels in networks, is driven by purposes, and allows sensible action. The knowledge virtuous cycle imposes that practice brings people and things together, instigates this ‘abstract socialization’ and facilitates the construction of new knowledge that in turn improves the ability of doing things better.

Creativity is highly dependent on cumulative tacit knowledge. Individual innovation begins with internalization, via combination, externalization and socialization [3]. Sustainability, either economic, environmental, and in engineering design, requires continuous innovation, supported by well-planned systems of knowledge management and learning, managed in integrative ways in situated spaces. Actor-networks are such a space (milieu) where transactions to render possible this chain of action (translations) occur and flourish. Actor-networks act as dynamic spaces of negotiation where the alignment of different influences (technological, organizational, and material) is continuously crafted. The type work produced is quite diverse, looking for alliances, enrolling and discarding actors (due process), managing black boxes, increasing size and align, are some of the activities explored in the Actor-network Theory (ANT). The actors enrolled are teachers, students, developers, researchers, users, learning systems, companies, organizations, regulations, laws, and policy makers to reference only a possibility and give an idea of the heterogeneity addressed.

ANT supports relations with material (relating things) and semiotic (working with concepts) without distinguishing between them. There is no either or situations, all things are integrated and conciliated.

From an actor-network perspective, every innovation involves a reconfiguration of the actor-network of actors through the enrolment of new actors and the discard of others. Innovation means translations crafted in the interacting of social and natural processes (things), playing with displacements of content and context, in ways that change practices and create the new. In this sense innovation is a complex process of co-evolution/co-production. Just as new ideas and concepts have to be inscribed into materials, practices, or products to make them durable and mobile, new technologies have to be translated into artifacts in order to gain sustainability, and new practices inscribed in behavior to establish standards.

III. CONCILIATION

Knowledge is a transient essence, in continuous transformation (translation), created in interactive processes among actors that only exist in action, inscribed in actors. Being intrinsically built by ongoing relations between hybrid actors, actor-networks can inscribe forms of knowledge in permanent evolution. In this sense we can adopt strategies of alignment oriented to goals. The management of such knowledge spaces (milieu) as depicted in Figure 1 is not however a traditional management, it is a complex responsive process [8]. Stacey argues that complexity theories are difficult to apply to management action and they can only ‘serve as a source domain for analogies’ [8]. Even Deming, known for the importance of metrics in quality once said, “you can't measure everything of importance to management. And you must still manage those important things.” [9]. ANT also goes in a similar way when defying the general and academic notion that statements and “laws” are accepted by their resilience to tests (validation). ANT is not based on validating tests, not on essential statements and not even on generalizations of the truth [15].

Stacey assessment represents a very interesting approach we loosely couple with ours. But instead of absorbing from the complexity realm, we propose an inspiration of ANT. In fact we are translating an academic approach into the rich dynamics of ANT, conciliating both influences.

IV. MODUS OPERANDI

This conciliation occurs in a rupture space, an actor-network that evolves in a cyclic way and works as milieu to the articulation of two operations – association (joining new elements, new actors, and related to due process) and substitution, breaking with some of the presented proposals [10] and proposing something new and different. It is the
articulation between these two operations that enrich the negotiation space and generate new proposals, with alternative new solutions. These new alternatives are aligned with the goal in the sense that they emerged within a situated context and actors are scrutinized by a due process. Figure 2 represents this situated context and the referred due process with which we intend to purify the space, not the actors in them. This purification is an alignment with the goal of the system, something that could be seen as effectiveness. The representation in Figure 2 is simple, abstract and metaphoric. In our approach, the goal or the result of the alignment is to improve learning conditions for the engineering mindset, which means enrolling more than pure technological actors.

As Professor Allan Bromley, formerly Yale University dean, once said: “… in the average engineering project, the first 10 per cent of the decisions made effectively commit between 80 and 90 per cent of all the resources that subsequently flow into the project. Unfortunately, most engineers are ill equipped to participate in these important initial decisions because they are not purely technical decisions. Although they have important technical dimensions, they also involve economics, ethics, politics, appreciation of local and international affairs and general management considerations. Our current engineering curricula tend to focus on preparing engineers to handle the other 90 per cent; the nut-and-bolt decisions that follow after the first 10 per cent have been made. We need more engineers who can tackle the entire range of decisions” [11].

Inside the situated context of Figure 2 we can see a ladder as a simple representation of the basic operations in an Actor-network. This representation is a Program of Action (PA) and registers the evolution of two types of translation, already addressed in the beginning of this section. The AND translation/negotiation, along the horizontal axis, means agreeing and enlarging the critical mass of the network, reinforcing the network’s aim. The AND translation is an association, in fact it joins new actors. The OR translation/negotiation, along the vertical axis represents alternative proposals, disruptive (creative) translations that create new courses of action. The OR translation is a substitution. These OR translations are the ones explicitly related with innovation, or the ones through which innovation emerges. But that doesn’t mean that you cannot innovate by agreeing, exploring the AND progression.

Innovation is made of chains of these operations of translation, transforming through displacements, grabbing new actors (due process), while discarding some of them, passing through OPPs. In these progressions extensions and detours are experienced and architected. In an ANT context where actors are hybrids and can range from individuals to machines, passing through immaterial things like rules and laws, these extensions can be virtualization strategies able to allow us to experiment new proposals and the development of new problematizations. Problematization inscribes in this context in different ways, allowing new formulations of existing problems and new problems, and gathering allies to focus on a new goal for the system – double loop learning [4]. Extensions can also be the translations from one type of process to another, meaning the two types of translations explained [13]. New realities are normally and most often constructed through the extension and renewal of already existing ones.
The concept of detour (from the Actor-Network theory) also means a strategic movement to explore alliances with other actors to envisage action with a purpose in a collective mobilization. In order to enroll other actors, OPPs needs to translate their common interests, collectively constructing a meaning for the action to take. It is important to understand that detours often propose a deviation from the original problematization, breaking with eventual previous plans.

According to Urry [14] all social relations maintain distances and are never static, evolving through circulations. There are always many circulations of actors in the translating process. In that sense social relations are developed through groupings of circulating relationships “relations are not fixed or located in specific places, they are constructed through ‘circulating entities’” [15]. Circulating entities result in multiple ‘connections’ that cannot be conceptualized in terms of the dichotomies. All social relationships involve complex patterns of immediate presence and intermittent absence at-a-distance, which places technologies of the virtual in an excellent position to define situated learning conditions.

“ANT is not a theory of the social, it is a theory of a space in which the social has become a certain type of circulation”, or better, ANT it is not a theory at all, but if it were a theory it would be “a theory that says that by following circulations we can get more than by defining entities, essences or provinces” [15]. In ANT terms and mindset the analytical focus is detoured from structural prescription to process deconstruction [16].

ANT deals with spaces of translation, with extensions, detours, and compositions, operated in terms of ANDs and ORs, as we have already seen, and not through structures. Sometimes longer and longer detours are necessary to dismantle obstacles, reformulate problems and construct new proposals [17]. Extending is necessary, but also risky.

In fact, extending too much can promote dissociations that threaten the network durability, stability, and alignment.

In fact the “secret” idea is to capitalize to a center [18], reinforcing alignment, exploring durability and stability. To achieve that we need to arrange (discover, enroll) actors that speak on behalf of other actors, representing them, and translating their interests and motivations into aligned actions with aligned goals. These actors, the already mentioned Obligatory Points of Passage or OPPs, are crucial to the building and sustainability of actor-networks. This representing role of the OPPs implies translation processes that, in ANT terms, we call calculation centers, or spaces to which action must capitalize. A special case of OPP is the Immutable Mobile (IM). IMs are particularly good on finding strategies and ways to capitalize to a center [18] and they are very important actors to make things happen and, in situated conditions, provoke the emergence of innovation. IMs act as innovation triggers.

V. PROPOSAL

In terms of exploring our idea, defining strategies to deal with innovation in engineering education, we proceed in terms of “In the making, rather than ready made” [19]. Our approach is tentative and will try to enroll more people interested, able to make their own detours and extensions.

Trying to apply the conceptual framework we described we begin by emphasizing that in a situated learning community, that is, in a specific teaching class, we should begin to explore the comprehension that we are in a networked space of things. This network space should not be social confined. A lot of environmental elements and even inside group elements should be considered as actores, because they do act, limiting, or allowing operations and detours. To identify the relevant actors, hybrids by nature, in such a situation is fundamental to depict formulations and solutions.

Counter steering in terms of the dichotomy of formulating and resolving, we need to stress the crucial importance of conciliation. Conceiving conceptual exercises in which students are invited to formulate and reformulate problems, together with the exercise of resolving the correspondent situations is very important.

Joining new elements to the problems, new actors into the network, can attain reformulation. For example in a typical technological problem, if you promote a reformulation based on some simple economic details, you could help on creating a systemic view and a helpful sensibility to contingency.

Exploring the AND translation, that is joining new actors, we change the problem, creating a new space of interaction in which you can entail substitutions, using the OR
transformation. Articulating both translations, AND/OR, you address new problems, you exercise reformulation and you create new things. Really important is to explore new elements interacting together (technological, social, material, conceptual).

Some of the extensions to explore are based on virtual strategies. Virtual strategies allow the experimenting side of things with limited resources and lower risk, and if you explore exercises on problematization, formulating and reformulating and resolving, you are addressing the scientific and conceptual side of the student’s minds. Both strategies address what Allan Bromley so clearly addressed as an essential need (see section 4).

We should work on planning by identifying the relevant actors in a situated context, limiting the borders of the system, identifying contingencies, grabbing all the necessary elements and details, and only then pass to the next recurrent step, which is design. Remember the actors to identify are hybrids, not only humans, not only technological. The design we mention can be the formulation of a new problem, or the reformulation of an already formulated problem.

What is important in planning is not the plan but the reflexive path of knowledge creation that lets us internalize the detail and the whole in the different configurations and restrictions. This reflexive path entitles you to act in a situated context of action. These knowledge paths need tools to help on grabbing information about details.

The Wiki success is related to an interesting model of decentralization of the production, distribution of production responsibility. But in this decentralization you should care for the value.

Google page ranking model is excellent, innovative, probably the best, but it lets us find not the best, but the most well known [10]. The selection is made of tastes, opinions, and trends, that is, no assessed materials. Can we imagine a system that retrieves quality content? First of all we would need to define in an objective way what is quality information (quality knowledge), a fact that most reviewers of International Journals well demonstrate that is difficult and probably utopic. But lets imagine that it is possible, we need to decentralize in a situated quality, that is, we could not address the common web user but a selection. And this selection, being diverse, needs to have literacy on the subject or, even better, expertise. The idea is to have a search system in which you have not one hundred pages retrieved, but only one. If possible not even one page, but half a page, half for the best answers and the other half to explore educated guesses about the subject.

In fact there is nothing wrong with the page rank model, except that it should be segmented, using configurations that would allow the searcher to select the communities where from the information would be retrieved.

With this example we intend to stress that innovation in engineering education must be directed in different paths: learning contexts, socializing technics, educated practices, integrative and aligned policies, an information infrastructure, and supporting tools. All in one the learning contexts can comprehend all the things mentioned. But the design of tools to provide learning contexts should be performed by the members of the engineering education community (including students), as these tools provide an excellent edge to innovation.

And we should always recognize that a clear input for innovation is the detour, now in the sense of opening our minds and think differently, exercise lateral thinking [20]. So we need to motivate and enroll students on risking about the ways they generate ideas. We are frequently mind mapped to valuate reasoning’s that give us more of the same, maybe this situations are more controllable and less demanding, but we should promote, the contrary, out of the box thinking [21].

But in the sense that reinforcing innovation in engineering education should not be a collection of samples and experiences without direction and purpose, we need to reinvent policies able to trace the sense of global and systemic view, and to entail a common alignment.

Policies need infrastructure and in that sense some shared information management artifacts should be designed and developed. For example, a repository of ideas, experiences, and lessons learned is an obvious part of such a global system.

We need a composition of all the elements, infrastructure, policies, practices, tools, extensions, detours, in a conciliation way, that is, an actor-network should be our space of translation/negotiation.

Children play and experience a high level of creativity in playing. Playing is a space of translations and negotiations with a specific goal. It would be interesting to exercise the same degree of liberty that children experience at playing. Managing the goal exercising extensions and detours, we could enroll the actors in a situated learning space with the same kind of motive children have, to explore ludic situations in an aligned goal. To design technological problems with such characteristics could be a strategy of mobilization and enrolling. The fact that the actors, people, things, and variables of the problem, are hybrids could extend the formulation and reformulation and solving of technological problems into an extended, highly creative activity. The actor-network paradigm could help on these constructions of socio-technical spaces of professional reality.
VI. CONCLUSION

First of all our reflection intends to be centered on a way of thinking, and not in specific solutions to a specific problem. We tried to formulate a conceptual way to discover new solutions, as these should always be situated in specific contexts. The explored way of thinking can keep the pace with the variety of eventual solutions that real life brings us. It is an approach particularly concerned with change, alternative proposals, and the construction of something new. It is not a specific way of doing things, it is much more a state of mind to be able to discover and construct new realities.

Section 5 needs to be extended to become relevant, so our idea is work in progress. This paper intends to enroll more people in this type of approach. With more people we can develop communities exploring the potentialities of ANT in this specific domain of innovation in engineering education. If the paper is a contribution to this goal I would feel completely rewarded.

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Applying Robots as Teaching Assistant in EFL Classes at Iranian Middle-Schools

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Abstract - Since its invention, robots have been developed for various purposes and needs, quite similar to personal computers in their early days. However, with the advancement of technology, it is anticipated that in near future one of the cutting-edge technologies to be used in “language teaching and learning” is robotics. Humanoid and/or animal shaped robots will soon gain more attention as a fancy tool for 1st and 2nd language teaching in mid-schools/high schools around the globe. At CEDRA, we are currently exploring the design and application of educational service robots to initiate and pioneer Robotics Assisted Language Learning (RALL) in Iranian schools. With the proliferation of computers and mobile devices, Computer Assisted Language Learning (CALL) and Mobile Assisted Language Learning (MALL) have been in the limelight for 2nd language instructional theories for about a decade or more. However, utilizing robots to support language teaching and learning can certainly enhance today's conventional techniques. Robots not only have the features and interfaces already being employed in CALL/MALL, but are also capable of autonomous movements, visual/voice recognition, and physical/environmental interactions when equipped with various sensors. Although computers or mobile devices also can be capable of nonverbal communication employing cyber characters/videos, robots are notable in their capacity for nonverbal communication, such as facial expressions, gestures and actions, while coexisting with users in a real environment such as the home/classroom. Additionally, robots are different from computers and mobile devices in a way that they have a friendly appearance and are successfully capable of keeping social relations. This article covers an overview of the subject and our current activities/findings in the interdisciplinary field of RALL in the English as a Foreign Language (EFL) classes and as a case study in the broader filed of Social Robotics in Iran.

Keywords - Social Robotics, RALL, 2nd Language Teaching/Learning, Educational Technology.

I. INTRODUCTION

In recent years, novel applications of Robots in the form of Socially Assistive Robots (SAR) have been observed and explored as teaching assistants in a variety of arts and science courses. Since robots tend to capture the interest and imagination of younger students, they have been applied as useful assistants for the teaching of mathematics and physics [1]. This and many other examples clearly show that the use and applications of robots is no longer limited to traditional engineering departments and manufacturing industries, but is distributed across a variety of socially important fields like humanities and medicine. As a result of this novel approach to robotics, the use of robots by non-engineering/non-technical instructors has been referred to as a “robotic revolution” [2]. Due to the rapid development of information and communication technology; teachers, material developers, and educators are trying to keep up with the dramatic changes in our electronic environment [3-6]. Recently working on Computer Assisted Language Learning (CALL) and Mobile Assisted Language Learning (MALL) has taken a great leap in the realm of second language acquisition [6-10]. However, since the mid-2000s robots have also been explored as helpful and innovative tools that have come to the aid of language teaching and learning [11-14]. The work presented here focuses on the study of the adaptable social, interactive, and cognitive aspects of robot behavior in an assistive context designed for the young students/individuals seeking to learn English as a 2nd language. In addition to serving as a social and assistive tool, these robots shall also be capable of providing detailed reports of student progress to teachers/instructors. We shall explore and present a new system based on the Robotics Assistive Language Learning (RALL) that tries to provide a more flexible and customizable protocol through motivation, culture, encouragements, and companionship to middle school/high school students in their English language courses in Iran. Initial results indicate that this approach can engage the students and keep them interested in interacting with the robot, which, in turn, increases their positive behavior when it comes to language learning and practice. Even though robots today are generally developed for special purposes, it is hoped that in the near future and with the mass production of humanoid robots.
along with costs reduction, great changes will be brought about in the art of language teaching/learning process with the use of robotics technology.

II. SHAPING OF ART WITH TECHNOLOGY

Teaching and learning a language is known to be an interesting art. This art combines science and culture with geographical location to produce a person with greater communication capabilities in demand. As an example, taking a look at the language learning process, learning and retaining vocabulary is known to have a great effect on language proficiency. Furthermore, lack of lexical knowledge has been considered as one of the main obstacles to effective communication [15]. Throughout the recent history of language teaching methods, from audio-lingual method to Communicative Language Teaching (CLT), vocabulary was deemphasized and considered of little importance. However, recently more attention has been paid to the investigation of incidental and intentional learning of vocabulary [16], use of visuals for better retention [17-18], application of computer in vocabulary learning/teaching, and the use of MALL for vocabulary learning [7-10]. Nonetheless, very few studies have attempted to design and evaluate vocabulary learning with the help of a robot [13]. Their study has concentrated on vocabulary development of a toddler and no studies have been focused on the vocabulary learning and retention of junior/high school students using robotics technology thus far.

A. How Robots Can Help Language/Vocabulary Instruction

The oldest writing systems are known to be between 5,100 to 5,500 years old, [19]. The oldest cave paintings used in communication dates back more than 40,800 years [20]. Humanity was expressed through visual imagery rather than written words for more than 35,000 years. Also, Human desire has always been to replicate itself starting by carving static statues through mechanical dolls to play music in the mid-1700, and present day robots [21, 23-27]. Even today, with complex writing systems at our disposal, people still process visual images more rapidly than text. In the context of studying vocabulary, this has inspired new methods of learning new words, one which turns away from traditional methods and seeks to engage the student’s memory in a variety of ways. Humanoid Robots as moving and performing visual objects can be highly effective in transfer of knowledge and certainly enhance the vocabulary learning process for young students. Developing an extensive vocabulary and using the words accurately in speech and writing is a challenge faced by many foreign students learning English as a Second Language (ESL).

With humanoid robots as teaching aids, a novel approach to language learning can be anticipated so that young students are able to not only learn new vocabulary words, but commit them to long-term memory with the ability to recall and use them accurately. This is due to the attractive nature of robots that can be programmed to employ and combine definitions with interactive examples to reinforce the new word the student has just learned. By developing and utilizing their intelligence skills through the use of robot, one can expect students to be able to more easily remember new vocabulary. As an example, robots can be readily programmed to play a charade game with students.

B. How Robots Can Increase Vocabulary Retention in Young Students

It is well recognized by all scientists that “communication through language” has been the greatest achievement of the human species. Yet, we are unable to communicate if we lack the vocabulary to do so. Young Iranian EFL junior high school students like many other foreign students learn new words largely through example and experience, and not by learning definitions from a dictionary. They learn new words through communication with their environment. However, at a certain age, less of their vocabulary learning comes naturally, and more of it comes through formal education, learning lists of new words in a classroom setting. Obviously, in order to retain new words and use them correctly, they need to practice them extensively. Utilizing various methods of learning new vocabulary, students are better able to remember and use them correctly. This is due to the fact that the more often the word is used, the more easily it transfers to the learner’s long-term memory. Short-term memory has a small storage capacity and simply holds information temporarily. To ensure that the new word is stored in the student’s long-term memory, new methods must be used. It is through the following features and characteristics of robots that make them an ideal teaching aid to support and enhance language instruction alongside teachers: Repeatability: the ability to repeat an action many times without getting tired/restless, Humanoid Appearance: with a human like appearance robots can be well accepted by students as real teacher assistants which can help to engage and motivate students as well helping to reduce their anxiety level which plays a crucial role in the learning process, Intelligence: this feature help robots communicate effectively with human and computers through artificial intelligence, programming, and Wi-Fi systems which preserves many advantages of the previous media for instruction, Sensing Capability: gives robots the ability to sense surroundings and awareness of its environment by light/camera sensors (eyes), touch and pressure sensors (hands), chemical sensors (nose), hearing
and sonar sensors (ears), and even taste sensors (tongue). Flexibility: the ability of being adjusted to the specific level of the learners, Interaction: their ability to interact with students effectively and greatly impact the language learning process, Body Motion/Mobility: the ability to move and use appropriate gestures when speaking can also greatly enhance the language learning process, Adaptability: robots have the flexibility to be programmed and are capable of being readily adapted/adjusted to the specific level of the learner.

Robots as teaching aids can help defining the new vocabulary and practice them effectively with the student so that he/she can understand the sense of what is being conveyed. This method obviously is superior to cramming a vast amount of information into his/her short term memory, as it provides the learner with the opportunity to fully integrate new words into his/her own vocabulary and retain them for long term use.

A recent trend in vocabulary teaching/learning has been to apply multiple ways of learning new words, such that students can perceive the input through as many channels as possible in order to reinforce the new vocabulary in his/her mind. Therefore it is important to include a variety of stimuli in teaching. One should also recognize that what works the best for one student may not always work as well for another (Dunn and Griggs: “Learning style is the biologically and developmentally imposed set of characteristics that make the same teaching method wonderful for some and terrible for others”) [22]. Since students learn in a variety of ways, it is important to include multiple methods a student can take in their study of vocabulary. While some students with equipped with RALL may get motivated and gain quicker and more in depth knowledge from conversation practice and interactive experience with robots, other students may benefit just as well from visual stimulation, tangible objects and/or flashcards. Due to different learning styles, each student may benefit more from a specific type of information. With RALL system, which will be discussed in further detail later, many different options are available to the student.

The main concept behind the development of RALL in vocabulary teaching/learning is the idea of artificial intelligence and robotics which are interlinked with the instructional material and are made to perform the role of the native speaker in the classroom. With conventional methods, there is more emphasis on written definitions and examples. Images are occasionally used, especially in EFL or ESL texts, but not to a comprehensive degree. Most often they are used to depict objects, scenes, or easily illustrated actions or emotions.

C. What is RALL?
In countries which English is considered a foreign language, various methods are being used to help the learners become exposed to real-life environment. Direct collaboration with a native speaker has been proven to be the most effective way of instruction [6]; however, in the absence of a native speaker, utilizing computer or mobile based applications in the classroom may seem the second best choice. Yet, due to the limitations of computers and mobile systems in engaging students and providing an interactive environment other sources of technology have been looked into. Among the fastest growing technologies that have proven to be of benefit to the language learning process are robots. For example, while the idea of creating multiple forms of examples for each word is appealing, it is also a terrifying task. Teachers often lack the time and patience that is required to create meaningful examples for long vocabulary lists. By employing a Robotic system as teaching assistant and resource available to them, they will be able to teach vocabulary in new ways, using the previously programmed humanoid robot to reinforce the vocabulary lessons they give their students in the classroom. Robotics Assisted Language Learning (RALL) does not seek to replace teachers in the area of vocabulary instruction, but rather to assist and supplement their lessons and reinforce the material that is being learned by repeated practice. RALL can offer this help in a variety of ways. While similar concepts have been studied, only a few systems have been developed such as intelligent methodology for language teaching and learning [5-6, 11]. Depending on the number of words saved with premium content in the RALL’s base computer, multiple methods to teach a new vocabulary can be experienced in classroom/home environment with the humanoid robot acting like a live talking dictionary. Like any fine human teacher RALL provides the student with the option to question and request vocabulary explanation. Robot assistant may provide the learner with not only the word and its definition, but also an example sentence, an audio clip of the word’s pronunciation and description. Robot descriptions and audio/interactive entertainment serves as a memory aid to further reinforce the meaning of the new word in the student’s memory. It is well known by the experts in the field that the brain processes visual interactions with moving objects or human more rapidly, and some people are better learners than others, when live interaction reinforces the meaning of the word. An intelligent RALL system equipped with voice command/recognition and vision capability can provide an opportunity for discussion, and prompt students to
think of the word or concept in their native language and make associations with the English word. One other option for RALL can be the advanced quiz capability. Teachers or students can create quizzes based on pre-set word lists, or create their own unique sets of words. Learners can have the option of quizzing themselves using words, images, definitions, or example sentences. These RALL quizzes reinforce the words the student is learning, and will continue to re-use the same words until they have been answered correctly. With such an integrated system, it is easy for students to create quizzes that match with the words they have been studying.

A well designed RALL system is ideal for use by a variety of individuals: junior high school students, teachers, ESL and EFL students, and students who are studying vocabulary for a variety of standardized tests. For teachers, it has many advantages, as it is an interactive tool and can be used to stimulate classroom discussion and reinforce concepts and words learned in class. It is believed by the researchers in the field that the more opportunities a student receives to practice new vocabulary in multiple formats, the better he/she will be able to retain it. We believe that exposure to the vocabulary by the RALL system may increase the likelihood of retention, which in turn improves the student’s overall vocabulary bank and improves his/her ability to communicate effectively.

III. THE RALL METHODOLOGY

A. Participants
This study attempts to examine the effect of a RALL system on the vocabulary learning and retention of Iranian EFL junior high school students in a private school in Tehran. Fifteen female students between 12 and 13 years of age, studying in their first year of junior high in a private school will participate in the RALL study group. They will all participate in a placement test beforehand and all those who are at the beginners’ level will be chosen for the study. The students are then assigned to the RALL class. This class will be using the English book devised by the ministry of education for 7th graders and the vocabulary taught and tested will be taken from that particular book. The treatment will take 5 weeks.

B. The Robot Instrument
The present study will use the following instruments to collect the necessary data. The main instrument used in this study is a kid-sized, autonomous, programmable, humanoid robot NAO developed by Aldebaran Robotics (Fig. 1), [23]. We have renamed this robot to NIMA (a Persian name) for better interaction with Iranian students.

The height of the robot is 57.3 cm, width and depth of 31.1 cm and is 27.5 centimetres, respectively. It also weights 4.3 kilograms.

The robot used for this study was the Robocop version of NAO which has the following features:

- Body with 21 degrees-of-freedom with key elements as electric motors/actuators.
- Sensor network, including 2 cameras, 4 microphones, sonar rangefinder, 2IR emitters and receivers, 1 inertial board, 9 tactile sensors, and 8 pressure sensors.
- Various communication devices, including voice synthesizer, LED lights, and 2 high-fidelity speakers.
- AMD GEODE 500MHZ CPU (V3.3) (located in the head) that runs a Linux kernel/supports Aldebaran’s proprietary middleware (NAOqi)
- Second CPU (located in the torso).
- 27.6-watt-hour battery that provides NAO with 60 to 90 minutes of autonomy, depending on usage.

Fig. 1. The NAO (NIMA) Robot [23].
Motion: NIMA is capable of Omni-directional walking and whole body motion. It also has a fall manager that protects it when it falls. He can walk on a variety of floor surfaces, such as carpeted, tiled, and wooden floors.

Vision: NIMA has two 920p cameras which can capture up to 30 images per second, and can track, learn, and recognize images and faces. The first camera, located on NIMA’s forehead, scans the horizon, while the second located at mouth level scans the immediate surroundings. The software lets you recover photos and video streams of what NIMA sees, but eyes are only useful if you can interpret what you see. He can recognize who is talking to it, with the ability to be developed for more complex features.

Audio: NIMA uses four microphones to track sounds, and its voice recognition and text-to-speech capabilities allow it to communicate in the default languages that are defined on its system. One of the main purposes of humanoid robots is to interact with people. Sound localization allows a robot to identify the direction of sounds. The NIMA robot can also apply the following applications; all of which can be useful in the language learning process.

- Human Detection, Tracking, and Recognition
- Noisy Object Detection, Tracking, and Recognition
- Speech Recognition in a specific direction
- Speaker Recognition in a specific direction
- Remote Monitoring/Security applications
- Entertainment applications

Connectivity: NIMA currently supports Wi-Fi and Ethernet, the most widespread network communication protocols. In addition, infrared transceivers in the eyes allow connection to objects in the environment.

Software: The Choreographer is the visual graphical programming language of the robot. It allows the creation of behavior and movements on the NIMA robot. It also has a tool in which created behavior can be tested on a stimulated robot before trying them on the real robot.

A series of pre-tests, post-tests, anxiety tests, attitude and motivation tests will be administered to all participants prior and after each session and the results will be compared and reported accordingly.

C. Design, Data collection and Analysis
This study attempts to use a quasi-experimental design in order to obtain the desired results. The use of the quantitative data in immediate, short term and long term post tests will help the researchers to reach accurate results regarding the retention of the vocabulary items.

Fig. 3. The lesson plans are devised in a way to enhance the most interaction between the students and the robot.

Fig. 4. A model of the RALL classroom in Tehran, IRAN.

Also, considering the importance of different factors such as motivation, anxiety, and attitude on the process of learning, the researchers will use previously used

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questionnaires in order to be able to make precise conclusions regarding the process of learning. Our study attempts to evaluate the use of robots in the classroom and its effect on the language learning process. The NIMA robot programmed by the robotics group shall play a number of games and tests with the students and the data will be recorded (Fig. 3). For each session a lesson plan will be devised. The lesson plans are focused on vocabulary; however, the teacher will be teaching all the material that is in the book regarding each lesson (i.e. grammar, reading, writing, pronunciation). One hundred vocabulary items taken from the 7th grade junior-high school book will be emphasized on (Fig. 4). The RALL lessons are planned prior to the class and they will be practiced beforehand with the robot in the CEDRA’s robotics instructional laboratory in order to check and recheck the use of the robot, and to eliminate any possible software problems that may occur. The data obtained from the participants pretest and post-tests (by using SPSS 16 software) will be analyzed using dependent sample t-tests to see if there is any improvement in terms of vocabulary learning among learners. Finally, to evaluate the attitudes, anxiety, and motivation of the learners a descriptive analysis with along content analysis will be used to analyze the results of the questionnaires.

IV. CONCLUSION

Exploring Human-Robot cooperation for English language teaching and learning in Iranian schools have been the main objective of this study. Initial experiments, empirical experience, and a review of recent literatures clearly indicate that a combination of Human-Robot instruction as Teacher-Assistant module will form an intelligent cooperative system that will offer enhanced capabilities over conventional English language teaching methods. Nonetheless, a human-robot cooperative strategy in teaching is also necessary to perform all tasks that cannot be readily executed by just the human-based language instruction. The methodology focuses on applying the robotics assistive language learning (RALL) technology to aim at providing personalized assistance, motivation, and near native companionship to young students in Iran as English language learners. With the features and characteristics embedded in many humanoid robots such as repeatability, adaptability, sensing, appearance intelligence, interaction, and mobility, the RALL system can establish a productive interaction with the learners, and serves to enhance their interest, motivation, and collaboration in specific tasks/exercises and problem solving abilities.

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Towards a New Mobile Educational Model

Adaptation of the Method for Engineering Learning Systems MISA

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Abstract—the development of mobile technologies and wireless networks encourages more research on Mobile Learning. Reviewing irregular verbs on a bus or organizing a training schedule on a Smartphone is becoming more common today. Mobile learning complements and enhances existing learning systems. Its development has been slowed in the early 2000s by both technical limitations and lack of dedicated teaching models. This article focuses on educational issues and proposes a solution by adopting the Method for Engineering Learning Systems MISA. Our work aims to identify basic elements, key characteristics and dimensions for developing the appropriate content for mobility. These elements are the basis for customization of the MISA method. Indeed, the different steps of MISA are governed by operating principles which ensure greater consistency and flexibility. Taking into account the specifications of Mobile learning in the development of these principles, we can adapt MISA to design a mobile learning system.

Keywords— mobile learning, e-learning, MISA, pedagogical scenario, learning activities, connectivism.

I. INTRODUCTION

The Internet today is a window into its users’ perceptions, their ideas and their way of life [1]. This is enhanced by the development of wireless networks and mobile devices. These technologies are influencing our social habits. Learning systems can only follow these changes to better support learners, their needs and their preferences. This is possible today with mobile learning or learning through mobile devices. Mobile Learning is a new paradigm that has been the subject of countless research projects during the past decade. The first work performed was completely techno centered. It focused on the use of new mobile technologies and the users’ attitudes towards these technologies, where after it focused on the application of existing learning theories (e.g. theory of activity). Currently, we are more interested in teaching and learning problems of mobile learning in order to formalize this paradigm by new models and methods.

For this purpose, we have chosen to apply the Method for Engineering Learning Systems (MISA) to a mobile learning context. The choice of this method is due to its flexibility and its ability to design different learning systems through its various principles. MISA defines multiple operating principles governing the management of instructional design process, namely progression principles, customization principles, general orientation principles and axes coordination principles. Each principle specifies different groups of subjects dealing with pedagogical approaches, scenarios and learning activities, modes and media delivery, etc. Adapting MISA to the design of a mobile learning system returns to customizing these principles by adding topics dedicated to mobility.

This work aims to analyze the mobile learning to highlight the main features and key characteristics of a suitable content for mobile terminals. Furthermore, it explores opportunities offered by this new concept and dimensions to consider when developing a mobile learning system. This done, we will present our vision of adapting the MISA method by exploiting the elements already defined. These specifications will be integrated through the operating principles of the MISA method to adapt it to our mobile environment.

II. MOBILE LEARNING

Mobile learning is defined as "the use of mobile devices that can connect to the Internet for educational contexts" [5]. Despite its clarity, this definition raises many questions as we seek to identify the main characteristics of mobile learning. Indeed, this paradigm is not only based on the use of new technologies, but also reveals new features and dimensions for consideration. Wang, Wiesemes and Gibbons associate three qualifications with this definition to delimit the mobile learning concept: mobility, the use of mobile devices, and communication exchange among participating communities [5].

Highlighting these qualifications presents mobile learning as a way of learning imposed by and for the satisfaction of the learners’ increased need for mobility in the 21st century. This covers their continuous movement between different environments and across multiple subjects and disciplinary contexts. Mobile learning provides specific educational content via mobile devices. These devices extend learning beyond formal educational settings, through personal experiences at the workplace, while traveling, or in the waiting room of a doctor to take just a few examples. They allow more interaction and promote learners’ communicative nature. They also meet their need for exchange and collaboration thus building understanding among participating communities.

A. Rationale for mobile learning

The mobile phone has become the first media in the world with 4 billion subscriptions (Ahonen, 2010) [21]. A report by Wireless Intelligence in 2010 accounted for 547.5 million subscribers in Africa [6]. The use of mobile devices in principle varies between emails consultation, social networks
and web research. Predictions state that by 2020 the majority of Internet users will connect via mobile technology [21]. Added to this the growing need for lifelong learning and knowledge acquisition at the appropriate times; mobile technologies prove to be an effective solution to our knowledge society. Predictions have also been made regarding Long Term Evolution (LTE) 4G-engaged devices sales, to rise by 202.5% to 275 million units in 2013 compared to 2012 [2].

The rationale for mobile learning, according to Tapscot, is that 21st century learners have "grown up digital" and that they "expect it." [5]. Today's young people adopt mobile technologies for different tasks in their daily lives. Mobile devices allow them among other to share ideas on micro blogs, seek instant information on forums, take notes and configure notifications for important appointments.

On its part, the evolution of automatic summarization tools can facilitate the content delivery throw mobile devices. [4] highlights the role of these tools for managing the vast available online literature. The process of summarization reduces the complexity and length of the original documents, providing the visibility of the subject matter and key ideas of the work. Some tools quality is comparable to that of the human extracts [4].

Indeed, with the advent of Web 2.0 and the move towards Web 3.0, education must follow these technological advances and evolve in parallel. This becomes possible with mobile learning that promotes the movement towards connectivist approaches where educators, learners, networks, connections, media, resources and tools no longer constitute a single entity. This new emerging entity has the potential to meet the needs of individual learners, teachers and even society [1].

Studies on the perception of students and educators and their readiness to use mobile learning have been conducted [7] [22]. Contrary to what one might expect, the results show that these two main actors of the learning process are not conservative toward mobile leaning. Rather, they are willing to explore and try new technologies.

Mobile technologies allow today's youth to determine what they want to learn and develop their own learning objectives using their own devices. They give them the opportunity to train their learning communities and use the methods and means that suit them best. The current changes are such that learners are no more than consumers of knowledge. Teachers in turn, must increasingly focus on contextual knowledge, problem solving skills and creative processes [19]. In this context, the mobile learning introduces new learning situations that promote these competencies.

Mobile learning encourages the introduction of connectivist approach. Indeed, for the inventors of this approach, George Siemens and Stephen Downes, "The existing learning models no longer reflect the reality that we live in our digital society. We are developing new knowledge constantly while exchanging, sharing and critiquing through social networks and blogs. This state of generalized connection is a learning process in itself, which is difficult to satisfy by linear pathways and unilateral transfer of knowledge and memorization from a set of limited and predetermined corpus of data" [16].

Connectivist approach is based on five components: communication, collaboration, motivation, creativity and integration. The principles of mobile learning and its specificities match largely the components of this approach through the features offered by mobile technologies insofar as they allow instant communication between different information resources. This ensures a greater exchange of ideas and resources through community, creativity in new learning activities introduced such as mobile tagging, geolocation, multimedia, etc.

New technologies often sold as “revolutionary” are used to do the same old activities. [5]. A review of the use of mobile devices in the majority of mobile learning projects confirms this statement. Therefore we do not really enjoy the potential of mobility. The latter provides continuity in the learning experience through different contexts and allows the design of new learning situations adapted to learners' daily life. It is necessary then to determine the main characteristics of mobile learning that distinguish it from other learning formats in order to realize its potential.

B. Mobile learning key characteristics

Based on a literature review of the work dealing with mobile learning and findings concerning the results obtained, we have identified a set of specifications for a mobile learning system. It is a learning style that provides content suitable for limited features of mobile devices, for the mobile context of learners and their need for speed and relevance in obtaining information.

The mobile learning system is:

- **Informal, contextual, situated and authentic**: since mobile technologies extend learning in more stimulating environments than classrooms and allow learners to investigate real problems in which they are involved. They also facilitate obtaining relevant information in context to make connections between formal knowledge and personal experience. Experience shows that young people learn more effectively in such conditions [14].

- **Immediate, appropriate, just in time, everywhere and anytime**: the learner can view a simulation of the photoelectric effect in a physics course or do an online search of a painting during a visit to a museum. The data are obtained when and where necessary as required by the learner.

- **Personalized**: Mobile learning promotes effective learning. And it lies to its ability to recognize diversity, difference and individuality in the way it is developed, provided and supported. It takes into account the context and history of each learner [12].

- **Personal, individualistic, and learner centered**: young people have special relationships with their mobile devices creating an environment that reflects the identity of the owner, his lifestyle and his interests. The
extension of these technologies for learning context develops this environment even more and makes it more personal and complete. "It's not what you know, it's the device you know" says Nicola Louise who argues that learners have more confidence in using their own technology which has great impact on the learning process [9].

- **Complementary**: Mobile tools are considered an extension to other learning tools [17]. Furthermore, only certain types of content and activities are appropriate for these devices. A series of studies of mobile learning indicate that these tools are used effectively to stimulate interest in the first delivery of content to increase motivation and monitor learning [17].

The technical limitations of mobile devices make the educational content:

- **Short, simple and interactive**: learners should be able to benefit from their small fragments of time for learning. Viewing conference videos, making a quiz or posting a question in a forum during a trip by train are examples of possible activities with mobile devices. We can notice that the mobile learning projects using SMS and Podcasts have been the most successful.

- **Targeted and specific**: mobility must guide and support students and teachers in new learning situations where and when this is necessary. The content must be adapted to the context, providing information on the location and focus of interest according to the learners’ preferences [17].

Finally the application or service developed for mobile learning should be:

- **Attractive and easy to use**: It should possess a pleasing visual design, a suitable interaction style and a certain agreeableness to give pleasure to interact [13]. It must have something ‘sticky’ to encourage students to return [10].

III. ADAPTING MISA METHOD FOR A MOBILE ENVIRONMENT

The main limitation of mobile learning is the lack of teaching strategies and methods by which it can be integrated into the formal learning process. A UNESCO report notes that this paradigm has been long considered an extension of e-learning which has diverted researchers to create a new pedagogy for mobile learning [10]. In addition, the majority of researches are based on student feedback about the use of mobile technologies and their interaction and attitude towards the Mobile Learning approach [11]. We must now abandon the reuse of existing theories and the focus on the use of new technologies. It is necessary to develop design methods for the learning process to fit the use of mobile learning and promote learners’ mentoring. Rather, we must consider the methodological and didactic issues to develop appropriate pedagogical models.

From the following, we will detail our vision for the formalization of mobile learning. We will present both the requirements to be met in order to obtain an effective conceptual model of mobile learning and mobile tools associated with each of them. This will determine the maturity of mobile learning through its ability to meet these requirements.

A. Considerations in designing a mobile learning system

To design mobile learning situations, we must ask what teaching strategies work best for which technological tools. We should also highlight what distinguishes mobile learning as the fact that it is based on the mobility of learners across time, space and content that is centered on the context [15].

Mobile learning is learning which must adopt a specific pedagogical approach taking into account the components of the learning process (Table 1).

It should promote the potential of Web 2.0 in terms of exchange and collaboration (Table 2).

The mobile learning system allows introducing the connectivist approach to education systems and promoting existing approaches across multiple teaching activities enabled by mobile technologies (table 3).

Mobile learning must be designed as an extension to other learning formats. The main activity being done in-class or online, mobile devices can be used to enliven, enrich and add variety to traditional courses. Several mobile features help meet this characteristic. It cites podcasts, Reminders, Mobile blogging, etc.

Mobile learning should be designed to promote learners’ skills in terms of communication and collaboration.

Mobile learning must take into account the criteria for effective learning:

- **Learner-centered**: Built on the skills and knowledge of learners, allowing them to reason from their own experience.
- **Knowledge centered**: The program is built on a solid foundation of knowledge validated, taught effectively and with an inventive use of concepts and methods.
- **Evaluation centered**: The evaluation should be adapted to the ability of learners, offering diagnostic and formative guidance built on success.
- **Community centered**: Successful learners form a supportive community, sharing knowledge and help less gifted students.

<table>
<thead>
<tr>
<th>TABLE I.</th>
<th>ASSOCIATED MOBILE TOOLS TO A LEARNING PROCESS COMPONENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Components</td>
<td>Mobile Tools</td>
</tr>
<tr>
<td>To inform/to find out: resources to consult</td>
<td>Multimedia (Podcasting, Photos), Mobile RSS, Mobile social networks, SMS, etc.</td>
</tr>
<tr>
<td>To interact: Communication and collaboration tools</td>
<td>Mobile photos/video/Voice, Blogging, SMS, Flux RSS, Social Networks, Forums, etc.</td>
</tr>
<tr>
<td>To motivate and activate: Organization tools</td>
<td>To do lists, Notes, Calendars, Reminders, SMS, etc.</td>
</tr>
</tbody>
</table>
During the implementation of a mobile learning system, the learning experience should be divided into a sequence of activities and for each activity specify the following. [14]:

- The location of the activity: classroom, lab, internal or external.
- Adaptive technology and available technology.
- The content: text, diagrams, videos, etc.
- The amount of data to be manipulated.
- The necessary timing schedule of the activity.
- The technical requirements of the activity.

We have designed a scheme (Fig. 1) to describe the process of a standard learning activity with the use of mobile technologies. We have detailed the different steps in order to identify those that can be implemented on mobile devices. The main activity being done in-class or online, we have associated a set of appropriate mobile tools to other activities.

**B. Adapting the method for Engineering learning systems MISA**

Mobile technologies influence the teaching and learning process. Educational systems must follow these changes and develop design methods and modeling taking into account mobility. For this we chose the method for engineering learning systems MISA.

MISA is a generic method of instructional design. It facilitates the construction of varied scale learning systems, from a single learning unit to several courses including a variety of modules and learning activities. MISA offers guarantees of consistency and makes visible the various processes. It provides templates that focus efforts and minimize design time [18].

The method is based on a philosophy consisting of the decomposition of the learning system in four areas, namely the field of knowledge, the instructional field, the learning materials field, and the delivery field. It describes six phases and four axes. The phases are:

- Defining problem and customizing MISA
- Defining preliminary solution
- Building learning system architecture

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**TABLE II. ASSOCIATED MOBILE TOOLS TO WEB 2.0 EXCHANGE TYPES**

<table>
<thead>
<tr>
<th>Exchange types</th>
<th>Mobile tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>One to one</td>
<td>SMS/MMS, E-mails, Mobile blogging, etc.</td>
</tr>
<tr>
<td>One to Many and Many to One</td>
<td>Mobiles Forums, Mobile Community Networks, Podcasting, Mobile Micro blogging</td>
</tr>
<tr>
<td>Many to Many</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE III. ASSOCIATED MOBILE TO DIFFERENT PEDAGOGICAL APPROACH**

<table>
<thead>
<tr>
<th>Pedagogical approach</th>
<th>Principals methods</th>
<th>Mobile tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behaviorist</td>
<td>Rapid feedback and monitoring</td>
<td>Mobile quizzes, Mobile reminders, etc.</td>
</tr>
<tr>
<td>Constructivist</td>
<td>Collaborative learning, Experiential learning, Problem-based learning, Project-based learning</td>
<td>Mobile micro-blogging, Mobile collaboration, Mobile Maps application, Mobile social networks</td>
</tr>
<tr>
<td>Individualistic</td>
<td>Personalized programs, Modular education, Learner self-management</td>
<td>Mobile check-lists, Rubrics, Quizzes, Mobile wikis, Podcasting, etc.</td>
</tr>
<tr>
<td>Connectivist</td>
<td>Interaction network, Online community, Social learning</td>
<td>Mobile bookmarking, Mobile social tagging, Podcasting, Mobile blogging, Mobile forums, etc.</td>
</tr>
</tbody>
</table>
Designing instructional materials
Producing and validating materials
Preparing delivery of the learning system

The four axes are:
- Knowledge and competency axis
- Instructional axis
- Media axis
- Delivery axis

Phases and axes of the method are regulated by operating principles governing the different steps of the method.

These principles are of four types namely the general orientation principles, axes coordination principles, customization principles and phase progression principles. MISA uses the thirty five documentation elements (ED) concept, which is the methodological product of the different steps. Depending on the complexity of the learning system, the instructional designer can retain only seven documentation elements.

The choice of the MISA method as a method of designing a mobile learning system returns to its flexibility and consistency. MISA can be customized to suit the instructional designers’ needs regardless of the size of the organization, the type and scope of the designed learning system or the available human, material, and financial resources. Designers do not have to produce all documentation elements or go through all the steps of the method. This flexibility and consistency is largely based on the four groups of operating principles previously mentioned. The diagram (Fig. 2) below shows the MISA method and its operating principles [20].

MISA provide four types of models: the knowledge and competency model, instructional model, learning material model, and the delivery model. The knowledge model defines and structures the knowledge as well as skills to be acquired by learners. Such a model promotes learner-centered and knowledge-centered approaches which are more suitable for mobile contexts and for effective learning systems.

Adapting MISA to a mobile context modifies its operating principles. At the general orientation principles and customization principles in particular we should note the recommendations and specifications appropriate for a Mobile Learning system. We must consider different teaching approaches introduced by the mobile learning, including connectivism and the types of activities that it generates. One must also consider the constraints presented on delivered content, the tools used, interactivity and sharing between users. We should respect dimensions as detailed previously as the complementary, informal and contextual characters of mobile learning.

Indeed, every principle of MISA method treats a group of subjects as shown in the Following.

The general orientation principles specify the theoretical approaches behind MISA. They offer varied pedagogical approaches in the construction of the learning system, and its delivery mode and support media. These principles are set at the beginning of each axis of the method. This group of principles contains four sub principles; instructional model orientation principles, material development orientation principles and delivery orientation principles.

- **Instructional model orientation principles** cover seven different topics: the type of learning event Network, types of learning scenarios, collaboration principles, instruments and resources, evaluation of learning, scenarios adaptability, and integrative concept.
- **Material development orientation principles** guide the media materials to ensure consistency while designing the learning system. They focus on four topics: the types of materials, their support, their interaction and their forms.
- **Delivery orientation principles** concern especially human resources needed to use the learning system, tools and means of communication, services and operating environments. They concern eleven groups of subjects: mode delivery types, means of communication, tools, delivery periods, delivery time, delivery locations, composition and groups’ management, evaluation objectives, assessment actors, trainers and facilitators, and learning system evaluation.

The principles outlined above were summarized and modeled by GMOT knowledge and competencies modeling tool for better visibility. The figure (Fig. 3) shows the different operating principles of the MISA method [19].

Our approach aims to apply the features and specifications of mobile learning already mentioned to these different principles of MISA.

Indeed, in a mobile context the general orientation principles take into account pedagogical approaches introduced by mobile learning, including connectivism. This approach generates new forms of activities, collaboration and evaluation. In addition, the content delivered via mobile devices should be brief, concise and interactive which will increase the granularity of learning units. These constraints will influence learning event network types, learning scenarios types, collaboration principles and learning evaluation.

Also, these constraints will introduce new types of resources privileged by mobile devices such as simulations, synthetic schemes, guided tours, etc.
Mobile Learning as defined previously encourages the presence of multimedia resources, digital media and dynamic interactivity between users and materials. The specification of the materials development orientation principles will be influenced by these constraints which will also take into account the adaptation of interfaces to high interactivity of materials required by the different learning situations and the technical characteristics of Mobile Learning. It will also specify the high level of assistance required by mobile users.

Mobile Learning is a situated and private learning. These characteristics must be taken into account in the implementation of the delivery orientation principles. Delivery should be based, in addition to learners’ needs and preferences, on the context (e.g. using GPS). It must not invade the personal space and privacy of users and respect the schedules and delivery periods selected by the user. Instructional designers must consider the community concept of mobile learning (through social networks and blogs for example) in the definition of the composition and groups’ management.

Customization principles enable the instructional designer to follow an itinerary that is custom-built for each project. Prior configuration of documentation elements at the beginning of the project or after the first phase is done according to the pedagogical approaches, delivery methods and scope of the learning system. In a mobile context, these principles will enable promoting, mobile learning educational approaches and strategies.

Customization principles enable the instructional designer to follow an itinerary that is custom-built for each project. Prior configuration of documentation elements at the beginning of the project or after the first phase is done according to the pedagogical approaches, delivery methods and scope of the learning system. In a mobile context, these principles will enable promoting, mobile learning educational approaches and strategies.

In the figure (Fig. 4) we have presented a part of the changes to be applied while specifying general orientation principles group subjects of the MISA method. The figure shows some new scenarios and tools generated by the use of mobile technology in the learning process.

Highlighting constraints that must be considered when developing the operating principles of MISA method is a first step in the adaptation process of MISA. Indeed, each specification must be analyzed to determine how it will influence the method’s phases and axes. The various principles of MISA must consider the characteristics of mobile learning, its basic elements, and the learning style that introduces...
CONCLUSION

According to Gardner Inc. Smartphones sales increased by 46.9% in the third quarter of 2012 compared to the third quarter of 2011. The mobile devices use varies between GPS coordinates, payment by credit cards, data transfers, tasks organizing, communication, etc. [2]. These devices are becoming a daily presence in the life of people who want to be “always connected” [3]. Their advanced features allow using them in a learning context, giving users a possible solution to the continuing need for learning in a society increasingly mobile.

Mobile learning offers novel opportunities for existing educational systems. It allows immersion learning in the personal space of students who become not only consumers of educational content, but creators of new situations and learning activities.

Mobile learning theorization projects and studies are multiplying. They use various approaches and methodologies. Research has also begun to explore the
perceptions and readiness of learners and educators for this new concept. The establishment of a pedagogical model integrating mobility as an essential component of learning is now a necessity.

Hooft calls to rethink what happens at school in the field of education. The school has become a process rather than a defined space and a fixed time entity [8].

Mobile learning seeks to restructure and develop learning systems to meet the increasingly growing need for mobility needs and lifelong learning. This learning style will extend teaching through new contexts. It takes into account the mobility of learners and communicative character that requires ongoing collaboration and exchange as well as the need to obtain relevant information where and when it is needed.

Highlighting different features and pedagogical considerations is only the first step of the process of theorizing mobile learning, which has proven to be indispensable for the delimitation of the problem. It is also a crucial step to adapting the method for engineering learning system MISA. The different steps of this method are governed by operating principles. These principles allow flexibility and adaptability of the method by giving greater freedom to the instructional designer. They also enable applying our own recommendations and guidance to design a mobile learning system.

Our work focuses on identifying these recommendations and guidelines for the execution of each task of the method according to the context of mobility. These specifications will incorporate appropriate new pedagogical types of learning scenarios, learning activities, new forms of collaboration and exchange.

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On Some Aspects of Process Management and Human Resource Management Interaction at the Customs Authorities

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Abstract—the name of article is “On some aspects of process management and human resource management interaction at the customs authorities”. Main stakeholders such as European Commission Directorate-General Taxation and Customs Union, World Customs Organization, universities and world customs administrations are looking for better training support mechanism, how to create contact points for university and customs internal training and to create qualitative business training programs in the customs area. In spite of different activities, for the time being concise and clear mechanism does not exist. Another problem lies in condition that training requirements do not underlie processes and job descriptions. Training organizers - customs authorities training centers and universities, developing own training programs follow the goals and objectives of staff development strategy, it becomes apparent that interaction of job descriptions and occupation standards is relatively little and do not supplement each other. The aim of research is to describe the mechanism of existing and potential human resource management and process management mutual interaction and mutual influence. To achieve the goal there has been set a task to study the specifics of job description formation at customs authorities, describe the significance of occupation descriptions to provide work at customs and their legislation, analyze the role of occupation standards to provide training needs. As a result of research proposals have been submitted about the improvement of process management, job description and occupation standard mutual interaction mechanism. Research is based on comparative analysis of literature and practical experience of customs authorities.

Keywords— customs authorities, process management, job description, occupation standards.

I. INTRODUCTION

Human resources are one of the main factors necessary for every organization especially in public sector. To create environment where employee is capable and wants to act to achieve organization’s goals and accordingly execute organization’s mission and strategic goals. “The contemporary architecture of company processes allows more flexibility, however it is more demanding with respect to knowledge potential and empowerment of employees. However it remains extremely important how to grasp the formulated strategy, how to distribute it and integrate into company processes and how to ensure their synergies within the framework of existing managerial competencies.”[1] One of the key requirements for good functioning and adequate compliance with assigned mission for Tax and Customs Administrations (TCA) is successful human resource management (HRM). Tax and Customs Administrations require clear rules and procedures, also rely heavily on IT infrastructure and processes, but also need motivated and well-trained Professional staff able to respond to the increasing complexity of laws and international agreements, the growing demand of the society in terms of providing adequate services and effective law enforcement. This focuses on the attention that should be given to the HRM and justifies the demand for professional qualifications, responsibility and reactivity that characterize the Tax and Customs Administrations. HRM is the linking pin between objectives, processes and measuring the results. If the objectives are not clearly communicated, understood and adopted by staff the results will be most likely be poor. One of main aspects of Tax and Customs Administrations’ HRM seems to be training and development. The aim of implementing training and development is to make TCA staff more professional by means of a continuous and systematic training process that will increase their knowledge and abilities in order to contribute to rendering efficient services and guaranteeing achievement of goals and mission. Organizations are increasingly looking for staff that is able to perform more functions and that have high level of training. Training is evermore a permanent process of support, not only for learning better practices, but also for sustaining development, the administrative career, full exercise of competences of positions and a change of attitude. Thus it is very important to create a permanent link between processes and training. “Education is a complex, dynamic and heterogeneous activity that can be evidenced in the multiple processes, phenomena and institutions worldwide that have agreed that “education” is not a simple discrimination between educational events or not, however it is possible to identify spaces for formal, non - formal and informal, where this tripartite covers the universe of educational processes of people.
Despite of the various positions on the differentiation between formal, non-formal and in formal education, it can be understood the formal and non-formal as products of intentional and systematic processes." "All learning activity undertaken throughout life, which results in improving knowledge, know-how, skills, competences and/or qualifications for personal, social and/or professional reasons." "Universities are participating in continuous education for society, however, there is currently a resizing university task undertaken throughout life, which results in improving intentional and systematic processes. "All learning activity understood the formal and non-formal as products of time being concise and clear mechanism does not exist. At the positions shall be grouped starting from the highest, middle-moment EC is developing a proficiency guidebook where level managers and ending with ordinary workers' positions at the ports, airports and land. However, there is a great number of positions at customs authorities in EU member states, EU candidate countries and potential candidate countries. This activities allows to raise many issues – for example - according to what principle is it possible to group positions and moreover to make a proficiency list for every group of customs officers, and furthermore how shall this handbook interact with national, WCO or maybe internal occupation standards if such would be formed. For example, in 2002 Lithuanian customs was reported to have job descriptions of officers which include only general qualifications requirements, obligations, rights and responsibilities, there are no detailed knowledge and skills which are necessary for descriptions at every career stage of customs officer. Consequently, in Lithuania, according to the example of Italian customs, qualification requirements of officer were developed and fixed to career levels [5].

Another problem lies in condition that training requirements do not underlie business processes and job descriptions. Training organizers - customs authorities training centers and universities, developing own training programs follow the goals and objectives of staff development strategy, it becomes apparent that interaction of job descriptions and occupation standards is relatively little and do not supplement each other. Besides, development of occupation standards and changes in them take a long time and resources to provide current occupation standards continuously. Also it should be mentioned that as educational institution or organization is an open system. Open systems are complex systems which take information, material and energy from the external environment and transform these resources into knowledge, processes and structures that produce goods and services. Due to this, complex systems are usually out of balance: in spite of the seeming stability, the system is constantly changing. [6]

The aim of research is to describe the mechanism of existing and potential human resource management (HRM) and process management mutual interaction and mutual influence. To achieve the goal there has been set a task to study the specifics of job description formation at customs authorities, describe the significance of occupation descriptions to provide work at customs and their legislation, analyze the role of occupation standards to provide training needs. As a result of research proposals have been submitted about the improvement of process management, job description and occupation standard mutual interaction mechanism. Research is based on comparative analysis of literature and practical experience of customs authorities. Empiric research is substantiated by the open source information and statistical data of Latvian customs.

II. PROCESS MANAGEMENT ADAPTATION POSSIBILITIES IN HUMAN RESOURCES MANAGEMENT AT THE CUSTOMS AUTHORITIES

Authors believe that Latvian joint TCA - State Revenue Service (SRS), should be presented as a positive example regarding the improvement of institution work management, specifically creating job descriptions on the basis of process management system. (See Fig.1.)
Within the process management system it is possible to determine the quantitative indicator of process implementation, therefore, adjusting corresponding tools it is possible to precisely observe not only individual work but also the work amount of whole institution, objective mechanism develops knowing process costs. On this basis it is possible to evaluate the work of each employee and department so optimizing the work of institution as a whole. For example, SRS intended to improve and develop process management system in order to optimize departments and to account implementation costs, setting clearly defined goals, actions, outcome (outcomes) and fruitful indicators to each process and introducing accounting of all process implementation and costs [7]. As soon as quantitative indicators of work record system change, meaning, the amount of specific process implementation changes, the administration of customs authorities has the justification to make changes in the number of workplaces and thus possibly in descriptions of workplaces.

According to the image provided by the authors, in case of necessity to change processes it might be necessary to introduce changes in workplace descriptions while it may cause the necessity to change a certain number of job descriptions.

Internal documentation of institution in the area of human resources management should be structured according to the mutual compatibility principle, namely, if the processes are identified, process activities and sub-activities, process outcome (outcomes), fruitful indicators, for the implementation of each process there should be determined necessary knowledge, professional experience and skills which accordingly should be used in job descriptions and occupation standards. Depending on occupation standard it is possible to identify the level of necessary occupation and education for each workplace.

As shown in Tab. 1 since 2000 SRS as public agency is focused on formal educational needs and higher education delivery from universities. In 2000 only 43% of SRS employees had Graduate Diplomas but in 2012 already 93% notwithstanding of the decrease of number of employees due to public finance crisis. As from 1994 Riga Technical University is delivering providing training programs at a BA and MA level. This programs are accredited according to World Customs organization Curricula and professional standards.

On the basis of Latvian education system common European system of training could be created. Core European Curricula and core competency framework for customs is critical to enabling coordination and harmonization of the competences and standards across the customs profession. Mainly educational standards for higher education should be developed for EQF level 7 (MA level) which targets broader strategic and managerial knowledge. This level is also critical to innovation and research as it would provide both professional and scientific courses which include skill specializations and customs knowledge. Some training needs are satisfied with training courses. As for 2010 SRS employees participated in 4,799 training events, but average training duration was 7.5 hours per employees. As for 2011 there was 5,353 seminars and courses and average training duration was 8.8 hours. According to evaluation research 77% of employees was satisfied with training quality. The SRS statistics in 2012 shows increase in trained persons by 44%, but at the same time average training duration decreased and was as 6.67 hours. This shows instability in internal and external training courses and seminars and leads to the necessity of standardization of training on the basis of job descriptions and occupational standards.[8]

### III. SIGNIFICANCE OF JOB DESCRIPTIONS TO SECURE CUSTOMS WORK

Job description means that a job has been assessed not the person to whom description has been given, what should the person be like working in the corresponding position and what should the person do. Job description in fact is a document describing job content. Only after the employee and the person in charge from the institution have signed the job description it may be considered as an agreement about the job content between employee and employer.

Job description should include:
- professional responsibilities required to do the job;
- range of issues that must be known to do the specific job-required vocational education, professional experience and skills;
- rights and responsibility for the process and results;
- job subordination and cooperation necessary to do the job;
- job position according to the job classification system;
- physical requirements necessary for doing specific job;
- special work conditions.

<table>
<thead>
<tr>
<th>Year</th>
<th>Staff employees</th>
<th>Higher education</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>4676</td>
<td>2106</td>
</tr>
<tr>
<td>2005</td>
<td>5019</td>
<td>4617</td>
</tr>
<tr>
<td>2010</td>
<td>4176</td>
<td>3883</td>
</tr>
<tr>
<td>2012</td>
<td>4069</td>
<td>3784</td>
</tr>
</tbody>
</table>

### TABLE I.
It is advisable to arrange responsibilities in job description in order of implementation as this is how the responsibilities are obvious and comparable to other job descriptions. Job description is a legislative text with its stylistic peculiarity, which is described by formality, precise and clear definitions, plain and consistently used terms and possibly short and brief expression.

It is possible to make qualitative job description only if all the professional responsibilities necessary to do the job, which result from goals and objectives of institution, have been described. Rights and responsibilities reviewed in job description about the process and results emerge from laws and regulations according to which employees of corresponding institution or company act. Job subordination and cooperation necessary to do the job are like the result of professional responsibilities necessary to do the job.

On preparing job descriptions the following considerations must be taken into account:

- nature of the work must correspond and agree with business processes, it means with the goals and objectives of an institution;
- job descriptions should be as standardized as possible;
- line manager has to participate in creation of job description or has to be informed about its content.

Traditionally it has been accepted that job description helps in job organization and management, job assessment, employee recruitment and training. Human resource management experts and managers try to obtain that everything written in job description should be measured. Recruiting employees on the basis of such “measurable” job description employer cannot be subjective but objective. Given such a “measurable” job description it is possible for an employer to compare if the respective employee works as much as another employee who does the same job. Analyzing job descriptions it is possible to find out which employee needs the training and what kind, thus creating training programs it is necessary to formulate what the student will know and be able to do after finishing studies which also is a measurable thing.

The authors believe that only in case job descriptions are made based on process management system it is possible to gain measurable and comparable results selecting, training and evaluating employees. Thus changing the process job description will change that will indicate on the employee whose job responsibilities will change and who will need additionally to learn innovations, to evaluate if the employee corresponds to the job description and if there will be necessity to recruit new employees.

In Latvian SRS customs authorities job description of field customs officer is the sum of those workplace descriptions where the employee can work, theoretically it comes out that the higher the position the more there are equal work places, thus there is less need for the customs officer to work in different work places it means that the job description will be with little range of responsibilities and vice versa the lower the position the more there will be work places where it will be necessary for one employee to work and thus range of responsibilities reviewed in job descriptions will be much wider it may be even said that the customs officer will be more “universal”, for example in Latvia at the small customs post “Vientuļi” in different seasons and times of day customs responsibilities can be done by only one official who will work in more work places and will be on shift assignment basis. Making job descriptions, which are made on the basis of processes and process activities, several job descriptions can be described as standard ones.

Two types of job descriptions are distinguished in Latvia officer and employee job description. Job description of officer is a document which defines job title, position in the framework of institution, obligations, rights, responsibilities and requirements necessary to do the job. For the civil service job description is obligatory [9] but the labor law [10] does not stipulate job description as obligation. At the moment in Latvia state and municipality institutions the content of job description is regulated by “Officer job description development procedure”. Job description should specify the title of institution, the title of department, the title of officer’s job and the category of job qualification, the subordination of officer’s job, job responsibilities, job rights, education necessary to do the job, professional experience necessary to do the job, cooperation necessary to do the job and responsibility for the work process and results[11]. While in other normative document it is stipulated that “The system of job classification is made to develop the system of salary and also to promote human resource management and development”[12]. The basis of job qualification system is job catalog of state and municipality institutions. Job catalog is systemized summary of created jobs in the institution. Job catalogue describes job families and subfamilies, standard profiles and a description of basic responsibilities for the corresponding jobs. The corresponding functions of a job are arranged into functional groups – job families and subfamilies. Job family is the amount of jobs which according to the basic function have similar job tasks and basic responsibilities. Job subfamily is the amount of jobs with narrower but according to the basic function clearly separable specialization. In family and subfamily jobs are divided into levels which describe the main differences between jobs in one family according to the complexity of obligations, responsibility and management functions.

Until the year 2000 in Latvia job descriptions were made and assessed on the basis of regulations “About the intellectual job evaluation and determination of qualification category basic methodology”, whereas the evaluation indicator system included such indicators as: A1. Education; A2. Professional experience; B1. Job complexity; B2. Mental strain; B3. Cooperation; C1. Responsibility for the work process and results; C2. Responsibility for decisions [13]. Now this regulation has been divided into two, namely, developing job description in civil service the description of officer’s job should be followed, but the new “Regulations about the intellectual job evaluation and determination of qualification category basic methodology for the state budget financed institution employees” [14] are as the basis for the remuneration system.

SRS has divided its activities into three levels – level of objectives, processes and process operations so each task has
IV. PECULIARITIES OF DEVELOPING JOB DESCRIPTIONS AT THE CUSTOMS AUTHORITIES

Developing workplace and job descriptions fundamental differences of both terms should be understood which may be mistaken. “Job – official status, post (usually high-level), position (at the institution, company)” and “Workplace – adequately equipped and arranged place and environment for performing duties”[17]. As a positive example for respecting the usage peculiarities of both terms is the Latvian SRS, where each employee, apart from the position in institution’s organizational structure, occupies a position which has been stipulated in institution’s internal instructions, but the term workplace has been found only in the context of customs control point technological chart [18]. The basic principles of developing job descriptions at customs in Latvia are shown in Fig.2.

![Fig.2. The basic principles of developing job descriptions at customs in Latvia](image)

The aim of standard technologies is to unify and coordinate operational principles of customs, frontier guard and sanitary border inspection in the whole country. Standard technology in the form of description shows the specifics, amount and order of service activities involved in border control. A definite place in work process has been allocated to commercial entities – banks and broker companies. In Latvia standard technology has been developed for highway, railroad, port and airport border checkpoints [19]. Each type of customs control point standard technology is influenced by conception of coordinated border management, in some cases one stop border post and process management which are correlated and complementary factors.

The most disruptive obstacles present themselves simply as lack of coordination between government agencies at the border. This lack of coordination leads to poor data sharing, duplicative procedures and a level of inefficiency that results in delays, product deterioration, and overall reduced profitability.

In order to address this degree of disorganization, a country must undertake initiatives to increase interoperability at the border. This interoperability is often referred to as coordinated border management (CBM) or integrated border management (IBM). These terms, while seemingly different, both focus on the same goal: increasing trade efficiency. Increased efficiency improves productivity, reliability, and profitability for all parties involved. Furthermore, to achieve the goal of efficient trade flows across national borders, a country must address pivotal elements of coordination, including, but not limited to, data flow (accumulation, sharing, and dissemination), authority and responsibility at the border, existing trade infrastructure (physical, technological, and organizational), legislation and regulation of border activities, and funding availability for project development.

This process can seem daunting and resource-intensive at times; however, implementing CBM does not need to be complicated and/or expensive. There are many ways to increase border interoperability, from streamlining data flows to developing an electronic single window. CBM is attainable and coordination between agencies is the way forward [20].

It would therefore be the great advantage of a carefully balanced IBM approach to be able to accommodate the interests of almost all involved at the border: travelers, transporters, border staff and security services. Also for the security concerns of the member states further away from the border, such a mechanism could prove a sufficient safeguard to maintain the trust needed for the open borders of Schengenland [21].

Coordinated border management is the organization and supervision of control activities of border agencies with the aim to perform joint work by facilitating legal movement of passengers and goods at the same time maintaining safe borders and meeting national requirements. Coordinated border management conception consists of two components; the first is inland border management system, which includes coordination of events within one institution and among all one state institutions which are involved in the process of border management, and the second is the international border management system where neighboring countries, customs union member states and trade partners cooperate. As an example of coordinated border management in Latvia is “Interdepartmental agreement about the organization of institution’s activities and cooperation at the border crossing points”, to ensure “coordinated operations at the border crossing points, where border control, customs control, veterinary inspection, phytosanitary inspection, food safety, quality and classification control have been performed” [22]. More and more emphasis is placed on the second component – international “coordination” in cross-border activities. Usually international coordination intends exchange of information.
among customs authorities of different countries. In some cases establishment of one stop border post between neighboring countries is possible. One stop border post is a widespread practice in the world. WCO has grouped this concept as:

- customs control has been carried out in a common territory where both countries’ customs institutions are located in one or separate buildings;
- customs control country of export administration carries out customs formalities simultaneously (or almost simultaneously) with country of importation customs administration which can forecast “virtual integration” where border agencies have the responsibility to deal with mutual electronic data transmission to prevent information duplication and to carry out the inspection of passengers and cargoes in the name of another country using mutual recognition regime. Agreement about joint control at merged border posts or one stop border post. Until the accession of Latvia to the European Union (until the year 2004) such agreement was concluded, for example, with Estonia about the establishment of Ainaži – Íkla border post [23]. Basically such agreements are possible only at highway and railway merged border posts, because common border with other country in ports and airports does not exist. Until 1995 joint border control existed between Spain and Portugal [24] typical “Virtual Customs Border Post integration” exists between Norway and Sweden [25].
- international law stipulates sovereignty and the principle of territority thus countries have authorities to develop and adjust laws in the area. If special agreements have not been concluded other country’s laws and regulations cannot be adjusted automatically. One stop concept implementation stipulates that state authorities and people who cross border and workplace in the annex of technological chart with clearly marked border control. There should be building and site drawings in the name of other country using mutual recognition regime. Agreement about joint control at merged border posts, because common border with other country in ports and airports does not exist. Until the accession of Latvia to the European Union (until the year 2004) such agreement was concluded, for example, with Estonia about the establishment of Ainaži – Íkla border post [23]. Basically such agreements are possible only at highway and railway merged border posts, because common border with other country in ports and airports does not exist. Until 1995 joint border control existed between Spain and Portugal [24] typical “Virtual Customs Border Post integration” exists between Norway and Sweden [25].

Process - correlated and mutually interacting set of activities which transforms investment into a result. Processes are structured activities which are carried out to do the job and achieve the goal. Primary goal of customs in a traditional model, according to the customs authorities’ institutional rating [27], is to increase fiscal revenue, as one of the main functions of customs is to ensure budget revenue, but in the last decade in technological chart depends on the standard technology and infrastructure of customs control point. Workplaces are unified, for example, customs control point technologies of Zilupe, Indra and Kārsava railway station are similar but are not identical with the technologies of highway, airport and port. Highway customs control point technologies of Terehova, Grebņeva, Pātarnieki and Silene are identical but customs control point Vientuļi differs a little, because the infrastructure of customs border post Vientuļi does not allow to perform certain activities, meaning, it is not properly technically equipped, which has been done at the other external highway points.

Workplace description may be defined as a review of process activities in each workplace. The principles of workplace description development have been schematically shown in Fig. 2. For example at the customs control point Vientuļi there are three positions – 1) customs field officer, 2) acceptance of documents (general inspection), execution of documents, correction and issue of documents, 3) physical control of cargoes and vehicles [29]. Depending on the intensity of cargo and passenger flow during a year, a week and a day it is possible to forecast the optimal number of customs officers at the customs control point and thus spread them over workplaces.

The authors conclude that workplaces at customs control point are standard, for example, customs field officer regardless of customs control point type everywhere will be the same, but the position “Physical control” will be different for each type of vehicle – railway, transportation, air and sea transport. Talking about classification of position and other issues of work organization there are two different strictly separated concepts – position of customs field officer and workplace of customs field officer, because in the job description it might be stipulated that duties also in other workplaces have to be done.

V. THE ROLE OF OCCUPATION STANDARDS IN SATISFACTION OF TRAINING NEEDS

The research shows main gaps in training provisions – managerial and strategic knowledge needs and advanced operational competences. Occupation standard has been created not for the position but for the occupation, so it is important to understand what the occupations for people employed in the customs area are, as over the time the occupation of customs officer has significantly changed (tax and duties collector) and has become the occupation where the knowledge of many fields has to be applied in practice (information technologies, engineering, etc.). First thing that comes into mind to people working at the customs is occupation – customs officer, but during two thousand years, since this occupation was mentioned, the range of customs officer duties has become very diverse, they have to perform jobs of different complexity and degree of responsibility. Not for nothing there is introduced professional qualification which may be divided into levels and which is defined as theoretical and practical qualification which gives the possibility to perform job of certain complexity and degree of responsibility [30].
Occupation standard is a document that defines essential requirements of professional qualification, which is needed to perform main tasks in a respective occupation [31]. Occupation standard can be used not only by educators but also by employers, it might be especially useful for human resource managers and specialists who use occupation standards to develop job descriptions and define requirements to applicants for the position corresponding to the occupation, perform profession and functions audits in companies, evaluate positions, create remuneration and employee evaluation system [32]. Creating programs for vocational education, defining goals and objectives of a program as well as the content of subjects and expected results, the information has been obtained from the occupation standard about the things to teach, why teach and what attitudes should be advanced so that the new workforce would correspond to the requirements of the labor market. Professional qualification exam content is worked out on the basis of knowledge and skills indicated in the occupation standard. To ensure and assess quality of vocational education institutions one of the evaluation criterions is theoretical and practical training of vocational education program and qualification practice content conformity to the occupation studied, it is, occupation standard [32]. Within one profession occupation standard includes the necessary information about the requirements of the labor market for employees of corresponding occupation, thus it acts as a tool with the help of which labor market is able to summarize common and specific requirements of industry for a group of employees and hand it in to the educator in a concise form. Occupation standard, in its terms, is an agreement for a specific period of time between employers and educators about the work content of an employee and necessary skills and knowledge.

However, two significant documents in the area of human resource management actually do not interact with each other, meaning, occupation standard development mechanism acts on its own. Of course, educators (internal and external) and top managers from customs authorities are interested in a qualitative customs officer occupation standard but the cooperation mechanism still is not clear.

The authors believe that taking process management system as the basis, where processes would be classified into management processes and key processes which would be divided into control and service processes, it is rational to adjust two qualification levels to the customs officer occupation, namely, ordinary customs officer, who performs operative work and customs manager who not only manages current works but also organizes, plans and manages the work of the department. The World Customs Organization has named occupation standard in English as “Strategic Managers/Leader” and the other as “Operational Managers/Leader” which corresponds to the study program of Riga Technical University “Customs and Tax Administration” professional Bachelor and professional Master’s study programs and “Customs authorities’ unit manager” occupation standard in Latvia. Taking peculiarities of potential process division at customs authorities and professional qualification division as a basis the authors offer new approach to the principles of occupation standard development at customs authorities, namely, the occupation “Customs expert” has occupation standard which is at a lower level of qualification than occupation “Customs authorities’ unit manager” or “Operational Managers/Leader” occupation standard. It would be substantial to assure if the customs operational side would be included in customs expert occupation standard or key process service and control processes. The authors can affirm that there can be no dispute among workers at the customs authorities on the issue if the manager of a department needs to manage operational work or not. Therefore occupation standard “Customs authorities’ unit manager” will stipulate to know key processes with control and service processes and management processes which will determine other level occupation standard. See Fig.3.

It may be concluded that it would be useful in any country to stipulate also single occupation standards for entrepreneurs who fully or partly base their business providing services in customs area and those would be customs brokers, declarants, economic operators or differently named occupations depending on the delegated authorities of corresponding country to provide services or work in the area.

![Fig.3. Principles of occupation standard development according to the process management](image)

See Fig.3. The authors would like specially to emphasize that entrepreneurs should know the service processes of customs authorities in the same amount, quality and even interpretation as customs officers, but it would not be acceptable to know the control processes, because the control is the function only of customs authorities. Therefore establishing the necessary occupation standard for the employees working in the customs area it is expected to have a good knowledge of business and partly customs area.

VI. CONCLUSIONS

Synchronization of occupation standards both of service providers in the customs area and customs profession may promote labor market inclusion for customs officers. Thus created single education process based on occupation standards would allow providing system mobility and convergence.

Development of occupation standards ensures the possibility for training providers to act according to the needs of TCA as an employer, which arise from the goals and objectives of an employer, in occupation standards and job descriptions should be included section “responsibilities”, thus the authors do not see any problems defining responsibilities in both
documents, define them equally according to the processes. The same applies to the sections “knowledge” and “skills”. Occupation standard should be very flexible document, which together with the job description would react to the changes – as soon as in the occupation standard and in any of the customs officer’s job descriptions change section “responsibilities”, there is a change in occupation standard section “knowledge” and “skills”; changes also corresponding customs officer’s section “knowledge” and “skills”, so it is a real mechanism how to determine the circle of those employees who would need new “knowledge” and “skills” performing direct duties. Thus it would be as an indicator to recognize if a representative from customs profession is needed in a certain position or a person from another profession.

Synchronizing requirements on selecting employees, evaluating their compliance to the position, assessing their performance in a definite period of time, developing training programs in a professional level of education and in the issues concerning further professional education, everybody, human resource management specialists and managers from customs authorities, has to act according to the same identically formulated indicators - knowledge and skills.

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The Microsite
An effective and low-cost marketing communication tool used for addressing the target group of prospective applicants for admissions to higher education institutions

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Abstract—This paper deals with the analysis of microsites as a low-cost marketing communication tool used to effectively address prospective applicants for admissions to higher education institutions. The paper contains the analysis of the microsite www.ustav44.cz, which has been created to promote the Department of Marketing Communications at Tomas Bata University in Zlín. Specifically, it has been created to promote the degree course in Marketing Communications. The authors of the paper describe the individual stages of the microsite design as well as its implementation and launch, including a subsequent analysis of its functionality and overall effectiveness within a selected target group. Based on the survey results, a proposal outlining how to improve particular user elements of this microsite and how to improve the microsite as a whole has been developed. The final part of this paper contains general instructions and basic tips that may help readers create a microsite of a similar type.

Keywords—marketing communications, online marketing, online communication tools, website, microsite, higher education promotion

I. INTRODUCTION

In the initial part of the paper, its authors will deal with the profile of the Department of Marketing Communications at Tomas Bata University in Zlín and the degree course in Marketing Communications. They will also provide an analysis of a selected target group, i.e. applicants to the Bachelor’s degree course in Marketing Communications, focusing on basic demographic indicators and the current situation of the applicants to the given degree course.

In the following part, the authors will deal with the theoretical specification of the term “microsite”. Microsites may be used as an effective and low-cost marketing communication tool. The aim of the paper submitted is to provide evidence that microsites may be used in a purposeful way not only to present products, services, or particular businesses and companies, but also to promote higher education institutions and the degree courses offered by these institutions. The authors will specify basic theoretical starting points to be able to define what a microsite is, to explain how it is used in the field of marketing communications, and to describe basic types and forms of microsites, their functions, the tools used, as well as the pros and cons of microsites, in particular their shortcomings as regards communication possibilities. The theoretical starting points will be directly interconnected with the authors’ practical experience gained while developing the microsite www.ustav44.cz, created to promote the Department of Marketing Communications at Tomas Bata University in Zlín. Its primary aim was to increase the awareness of the public about the specialization of the Department and the activities conducted by its staff and students, as well as to increase the number of applicants to the aforesaid degree course. The paper contains a description of the preparation stage of the microsite design (the visual style of the site, its textual and information content, setting up communication channels for the microsite, etc.) as well as its implementation and launch, including a subsequent analysis of its functionality conducted through a quantitative and qualitative survey (the microsite traffic, user access to the microsite www.ustav44.cz, the effectiveness of individual communication channels used within the microsite, Eye tracking, etc.).

The final part of the paper contains an analysis of the problems identified within the survey and proposals outlining possible solutions to improve this microsite. Therefore, the paper may be considered an instruction manual containing a number of helpful tips for those who intend to develop a microsite of a similar type.

II. THE PROFILE OF THE DEPARTMENT OF MARKETING COMMUNICATIONS AT TOMAS BATA UNIVERSITY IN ZLÍN AND THE DEGREE COURSE IN MARKETING COMMUNICATIONS

The Department of Marketing Communications is part of the Faculty of Multimedia Communications at Tomas Bata University in Zlín. The University was named after Zlín’s legendary shoemaker pioneer, visionary and world-famous entrepreneur Tomáš Baťa (1876 – 1932) [1].

In 1997, the Zlín-based Faculty of Technology, which was part of Brno University of Technology, launched the new Institute of Advertising and Marketing Communications, which was transformed into the Faculty of Multimedia Communications in 2002. So, the Faculty of Multimedia
Communications was founded as Tomas Bata University in Zlín’s third faculty, holding its name until now [2].

The Faculty of Multimedia Communications provides the following degree programmes and courses: the degree programme in Media and Communication Studies and the degree course in Marketing Communications; the degree programme in Visual Arts and the degree course in Multimedia and Design; and the degree programme in Theory and Practice of Audio Visual Arts and the degree courses in Animation, Production and Audio Visual Arts (and the specializations in Film Photography, Editing and Sound, and Directing and Screenwriting) [3].

In cooperation with the other departments at the Faculty of Multimedia Communications, the Department of Marketing Communications provides the degree programme in Media and Communication Studies and the degree course in Marketing Communications. This degree course aims to equip its future Bachelor and Master graduates with theoretical knowledge and practical experience so that they could become fully-fledged team members and so that they could build successful careers in commercial as well as non-commercial businesses and institutions, in communications agencies, as spokespersons, or experts in the field of marketing communications.

The Bachelor and Master graduate profile, produced by the Department of Marketing Communications, is considered by its staff a key factor influencing the graduates’ careers. Therefore, within the development of study plans, the profile is constantly being improved and updated. Particular emphasis is laid upon a multidisciplinary approach to the field, which is the reason why subjects covering the following areas are taught, e.g. economics, marketing, psychology, sociology, aesthetics, arts, etc. Nevertheless, particularly subjects covering individual areas within marketing communications are taught, i.e. advertising, public relations, sales promotion, personal selling, direct marketing, sponsoring and others [4]. The Department of Marketing Communications aims to continuously improve the quality of the teaching and learning process, to adapt its offer to the current market demand, as well as to respond to the latest European and global trends in teaching marketing communications [5].


Nowadays, there are growing concerns that the number of secondary-school students will soon decrease significantly, which is caused by the fact that the numbers in the age group being referred to are low. This will not only dramatically affect the educational structure within this age group, but it will also affect further and higher education, as well as the overall market situation influenced by the integration of job seekers in the labour market.

The following graph (Graph no. 1) depicts a population curve showing the number of newborn babies (in thousands) in the CR between 1990 and 2008. The curve shows that most babies, about 131 thousand, were born in the CR in 1990. Since then, their numbers have declined every year. There was a significant decrease in the number of newborn babies in the CR between 1993 and 1996, when their numbers even fell by about 31 thousand. Therefore, a significant decrease in the number of applicants for admissions to higher education institutions should be expected in years to come. The situation did not improve until 2008, when the number of newborn babies in the CR again began to rise gradually. At that time, about 120 thousand babies were born. However, this positive trend will not be reflected in the growing numbers of higher education applicants until 2027.

Graph no. 1, Population curve – the number of newborn babies in the CR between 1990 and 2008 (expressed in thousands)

On one hand, it is impossible to clearly identify what the overall impact of the decline in the number of newborn babies in the CR will be. On the other hand, it is possible to provide evidence showing that this fact will significantly affect higher education due to decreasing numbers of applicants to particular degree courses, as is shown in the following graph (Graph no. 2).

Graph no. 2, Population-based cohorts showing those enrolled on higher education institutions, higher education students and higher education graduates in the CR (Demographic changes to the average size of the relevant age cohorts between 1990 and 2020 expressed in thousands) [6].
In the 1990s, the Czech economy as well as the whole society went through significant transformational change, which also had an impact on the higher education system. New private and public higher education institutions were gradually established, new and up-to-date education programmes were offered, and new educational levels became available. Graph no. 3 depicts the current student population at individual Czech higher education institutions.

Graph no. 3, Student numbers at Czech higher education institutions in 2012 (expressed in thousands)

Population decline among students entering higher education also affects TBU in Zlín. In the academic years 2010/2011 and 2012/2013, their numbers decreased by 1,012.

In 2012, a total of 637 applications to the full-time mode of study and 297 to the part-time mode were submitted to DMC and its degree programme in Media and Communication Studies. Out of the total given above, 520 full-time and 246 part-time applicants came to sit the entrance examination. As follows from the above, there are sufficient numbers of applicants interested in the degree programme in Media and Communication Studies, considering a total of 98 students admitted to the full-time and part-time modes of study.

Currently (i.e. in the academic year 2012/2013), there are 169 full-time and 156 part-time students studying the Bachelor’s programme in Media and Communication Studies at DMC. At the Master’s level, there are 108 full-time and 97 part-time students studying the degree programme. In total, DMC has 530 students.

It may be assumed that population decline among students entering higher education will result in an excess of supply over demand. Thus, individual higher education institutions will be put under more intense competitive pressure and their efforts to address as many prospective applicants to their degree courses as possible will be intensified. Although the situation may be viewed as negative, it also has a positive effect on higher education. In this way, higher education institutions are being forced to improve the quality of the degree programmes and courses offered, and to adapt their offer to the current market demand – the demands of prospective employers (businesses and companies). This may help their graduates improve their employment chances in the labour market and so make individual degree courses more attractive. As competition increases among higher education institutions, another important area should be mentioned, i.e. higher education promotion, including the promotion of individual degree programmes and courses. Its aim is to provide prospective applicants not only with extensive information relating to the study system, graduate profiles, the activities conducted by the given higher education institution, etc. Also, particular marketing communication activities pursued by higher education institutions to promote their degree courses will contribute to a distinct differentiation from their competitors. In this way, a unique and unmistakable image of a higher education institution or a particular degree course may be created. And this is one of the primary aims of TBU in Zlín and its Department of Marketing Communications. It is just the microsite www.ustav44.cz, analysed in this paper, which represents a wide range of the DMC communication activities aimed at its target group.

IV. THE MICROSITE – AN EFFECTIVE ONLINE MARKETING TOOL

Communication in the form of a company’s website may be considered a basic and the most common type of Internet communication used by businesses nowadays. A company’s website aimed at external users has become a standard marketing communication tool. Its aim is to provide information to the company’s regular and potential customers, as well as to other interest groups, to build relations with various target groups, and to create an environment for mutual communication [7].

When creating an effective website, several important factors must be taken into consideration, e.g. the purpose and objective of the website, its target group, the website content and graphics, but also the website visibility, its accessibility, usability and controllability, user interactivity, evaluation of the website effectiveness, etc. The following scheme clearly indicates basic elements and processes necessary for the successful creation of a company’s website:
The microsite – is a special type of company’s website. Microsites are usually created to serve a specific purpose, such as promoting a particular product or a particular product line, a limited category of services, or special events (in our case it was the promotion of DMC as one of the FMC departments). Usually, microsites are not very extensive. In most cases, their graphics and objectives are different from those of the company’s website. Also, microsites usually have their own website address [8].

Microsites offer more specific advantages:

1. Low cost – this applies to both creating a microsite and its subsequent running.
2. Limited extent – a microsite visitor can quickly find important information about the business or company, about a particular product, service, event, etc.
3. Easy navigation – finding information within a microsite is easy for its visitor, as it only contains a limited number of sub-pages (about 5).
4. Direct customer hit – microsites may be enhanced within search engines through particular words. Thus, customers are not flooded with unnecessary information on other products or services. Microsite traffic may also be boosted, for example, via contextual advertising, mailing, targeted banner advertising, viral campaigns, or using various social networks (e.g. Facebook, Twitter, LinkedIn, etc.). What appears to be very effective is incorporating a competition/contest or an interactive game into your microsite (the so-called Advergaming) [9].

As regards their content, microsites may be aimed at various areas. Therefore, three basic types of microsites may be distinguished:

1. Product microsites: The aim of product microsites is to inform customers about a particular product or service.
2. Microsites promoting a brand: This type of microsites aims to build a positive brand image and to extend the target group of customers.
3. Advisory service microsites: These microsites are created to provide useful information to their users, which is the reason why they are such a popular type of microsites [10].

Taking into consideration the content and nature of the microsite www.ustav44.cz, we can say that it is a combination of a microsite promoting the DMC brand and a microsite providing advisory services to applicants to the degree course taught at the Department.

As has been partially described in the previous chapters of this paper, there were several essential factors motivating us to create the microsite www.ustav44.cz:

1. Increasing numbers of competitors, i.e. the establishment of new public and private universities and higher education institutions providing more and more specialised degree courses, including media and marketing communication studies.
2. Population decline and the expected decrease in the number of students throughout the CR, which will gradually lead to increased competition among Czech higher education institutions and universities to attract their prospective students.
3. The official websites of TBU and FMC provide limited space for the presentation of the aforesaid degree course, and prospective applicants can only find basic facts and general information relating to the study opportunities at DMC on these websites.
4. As a medium, the Internet is inexpensive when compared to other media types. And it offers some more advantages, such as quick and easy updates of information, interactivity, and considerable popularity within the target group (young people), which uses the Internet quite often.
5. The quality of the degree course, linking theory and practice, maintaining good relations between the DMC staff and students, as well as its graduates, are factors allowing us to assume that the microsite will get attention through viral marketing and positive WOM spreading. In this way, a free synergistic PR effect may be created.
Basic objectives of the microsite: www.ustav44.cz:
1. To build a positive image of DMC
2. To improve public awareness of the opportunities to study the degree course provided and of other activities conducted or joined by DMC
3. To increase prospective applicants’ interest in studying at DMC

V. THE MICROSITE www.ustav44.cz (THE MICROSITE DESIGN AND CREATION, ITS GRAPHIC AND TEXTUAL CONTENT)

Considering the target group, our aim was to create a modern and dynamic microsite. Therefore, the vertical spatial principle was used to create the microsite www.ustav44.cz. It is one of the new, visually appealing and current trends in the area of website creation.

We aimed to build a well-arranged site that would be easy to control by its users, interactive and rich in content. The textual as well as graphic content of the microsite was created with regard to the target user group. In the first place, the microsite uses the language used by its target group, which gives its users a much more personal impression. Moreover, on this microsite, those interested can learn a lot of essential information not only about the degree course, the structure of study and the subjects taught within the course of study, but also about the activities conducted by the Department, about its students’ achievements or about student life in Zlín.

VI. THE STARTING POINTS FOR CREATING OUR MICROSITE

Within the execution of the case study, a decision was made to use the so-called parallax scrolling for creating the website layout. Parallax scrolling uses a one-page website layout. This technique is often used to create a microsite, as it is visually appealing and easy to develop. However, there is a problem connected with parallax scrolling websites. Using web analytics for measuring the usage of such websites is complicated, as one-page website traffic is more difficult to measure. This is caused by the fact that the percentage of click-throughs is low in this case. Clicking through the menu cannot be considered a link or path to another webpage. It is a mere “shift” or repositioning within one particular webpage. This problematic situation was solved by using the button labelled “More Information”, allowing the user to switch to a separate webpage providing official information. Thus, the interaction between the homepage and this page could be measured. Also, the button labelled “Application Form” was used. By means of the bit.ly tool, outgoing traffic from the microsite to the University’s online application system was measured. This was necessary due to the absence of measuring incoming traffic within the University’s online application system.

VII. THE VISUAL STYLE

For creating the visual style, basic components of the corporate design were used, i.e. the logo and the corporate font Berlin. The other components were rejected, as they were considered useless and too complicated as regards the links to the official website. Also, photographs directly related to the aforesaid degree course or the premises of the Department of Marketing Communications were used. The choice of colours was influenced by the identification of prospective applicants for admissions with the microsite as well as with the Departmental premises. Therefore, the colour prevailing in the premises of the Department (rgb(178, 211, 77)) was used as an important element. This was not absolutely essential to achieve our primary objective. However, with regard to the efforts to create a relation between the Department and its individual communication activities, it was necessary.

VIII. THE TEXTUAL CONTENT

All texts are based on the official texts, the study plans and the current situation at the Department. What we aimed to do was to rewrite the official texts, usually not very interesting, in a manner that would enable young teenagers to understand easily the following: what type of degree course is provided, what is studied within the course, what subjects are taught and what activities can be joined by students studying at the Department of Marketing Communications. As regards the textual content, the headline and the Facebook og tag were the most distinctive elements. Nevertheless, these two short pieces of text have provoked most controversy. Specifically, it was the following headline: “Marketing Communications? WTF?”. The generally well-known acronym WTF was used to refer to a prospective applicant for admission who has no experience in marketing communications and who has no idea what the degree course is about. This acronym was not used pointlessly. It was used on the basis of a survey conducted among first-year Bachelor students over a period of several years. These students were asked what the term marketing communications represented to them, or perhaps, what was the first thing coming to their mind in that connection. And as you can probably guess, a number of variations of “WTF” occurred.

The other piece of text that has provoked a lot of controversy was the Facebook og tag saying: “A field you will enjoy. A way to make money.”. The aim of this piece of text was to attract attention as well as to reflect the current situation in the labour market and the graduate market in the CR. In other words, a degree course representing the ideal combination of an enjoyable field and excellent graduate prospects is the right choice for each student nowadays.
IX. THE COMMUNICATION CHANNELS

As no financial resources were available for distributing the given microsite, the following communication tools were used:

**Primary:**
Facebook (the official Departmental profile + the profiles of the implementation team members)
Twitter
A banner placed on the official website of FMC TBU in Zlín

**Secondary:**
Direct mail to secondary schools in the CR and Slovakia
Sending out a press release
Email footers created for the staff members at DMC

X. THE CAMPAIGN MEASUREMENT AND BASIC ANALYSIS RESULTS

Due to the fact that the entire communications campaign was primarily focused on the digital environment, it was easy to set up the measurement parameters in the initial phase. The measurement was primarily performed to monitor user access to the website www.ustav44.cz. Nonetheless, two more objectives were later added in order to make the effectiveness measurement of the given microsite as relevant as possible. The two objectives added consisted of the following: asking the users for more information and measuring outgoing traffic to the University’s online application system. This is also connected with the problem dealt with in the chapter entitled THE MICROSITE www.ustav.44.

Our measurements were based on using a tracking code from Google Analytics. This website tool was used as the most effective data source. Also, the bit.ly tool was used to measure outgoing traffic to the University’s online application system. One more research method – Eye tracking – was used, although it was not our primary intention. Media outcomes and a possible increase in brand awareness could also be measured within the evaluation. However, this was not our primary aim.

As regards website analytics, it was necessary to distinguish among individual traffic sources and links to the given microsite. This was solved in a standard way, i.e. by using UTM link-tagging. The so-called UTM codes are widely used today and are still considered the easiest way to identify different traffic sources. This applies to tagging those links that are directly distributed by the “client”. In our case, it was the implementation team.

Within the Eye-tracking method, it was found out that the most serious problem associated with microsites might be the so-called false-footer effect, i.e. the problematic situation when a user enters the site, scrolls down the page and, in certain parts of the page, thinks that s/he has reached the bottom of the page, but in fact, s/he has not.

XI. THE EFFECTIVENESS OF THE INDIVIDUAL CAMPAIGN TOOLS

Considering the quality and volume of the incoming traffic to the microsite www.ustav44.cz during the monitoring period, Facebook appeared to be the best source as regards quality. This applies to all the links from Facebook, where most of the total traffic volume consisted of the following: redistribution, reshares, the Like button, and comments made by students of and graduates from the Department of Marketing Communications. In this way, also prospective applicants for admissions and some of the “Internet personalities” became aware of the existence of the microsite. Almost half of the total traffic (49.8%) came from Facebook. Apart from this, there was the direct approach, based on offline communication with secondary schools as part of our road show. Also, Twitter and organic search aimed at the phrase “ústav 44” or similar expressions were used. Last but not least, a significant portion of the traffic came from the banner placed on the homepage of the official website of the Faculty of Multimedia Communications.

If we evaluate the quality of traffic on the basis of the time spent on the site, regardless of the users’ interaction (as their access to the site was very limited), the traffic coming from this source may be identified as high-quality traffic. The same applies to the traffic coming from our organic search. As
regards the other traffic sources, their quality was significantly lower and their volumes considerably weaker.

Graph no. 5, Incoming traffic from social networks

XII. CONCLUSION

The official websites of both FMC and TBU provide only limited space, must follow certain rules, are “uniform” and provide very little space for creativity, for original graphic design as well as for the interactivity with their users. Therefore, the microsite www.ustav44.cz was created. Its primary goal was to eliminate the problems specified above.

Compared to the other degree courses of similar type, the degree course provided by DMC offers numerous benefits, particularly the following: a wide range of up-to-date subjects covering various areas of marketing communications; well-qualified and experienced teaching staff with expertise in their fields (research, development and the business sphere); individual approach to the students and opportunities for their individual self-fulfilment; linking theory and practice, and also student participation in real-life projects and tasks, which may help them prepare for their future careers. The Departmental students are well aware of all the advantages and strengths of the degree course provided by DMC. However, prospective applicants and the general public only know a little about these benefits. And this is the reason why it will be necessary to create a targeted communications campaign aiming to promote the above-mentioned qualities in a creative way, also using other marketing communication tools.

The microsite is only a basic tool of communication with the given target group. Therefore, the content as well as the tone of voice of the communications campaign used should also be reflected in the other tools to be used by DMC in the future. This is the manner in which it will be possible to create a unique and unmistakeable image of DMC as part of the process of integrated marketing communications.

List of abbreviations used
CR Czech Republic
FMC Faculty of Multimedia Communications
TBU Tomas Bata University in Zlín
DMC Department of Marketing Communications
WOM Word of Mouth

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In Pursuing Better Academic Result In University: A Case of Fuzzy Logic Analysis

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Abstract—A fuzzy logic approach is applied in this proposed system as a method to predict the performance student in pursuing better academic results in university. Fuzzy logic is used because the technique is suitable for statistical database as well as suitable to obtain general classification between excellence and moderate students. The main issue in this project is the difficulties to predict the student’s performance and to sustain their result. The fuzzy logic approach is suitable for data classification and the performance will be analyzed by using Matlab simulink. Besides that, several difference methods of membership were also been investigated in order to design and propose the most stable and reliable system. Based on the results obtained from simulation, it has provided meaningful characteristics that are significant and able to advice student getting better grades in academicals program (BEE & BEP). Moreover, the system will provide better study to student whose do not understand the university system during their early years in university.

Keywords—fuzzy logic; performance; classification; grades; university.

1. INTRODUCTION

Fuzzy logic is a theory concepts that offer a basis for thinking about vague concepts using a tool to model the knowledge, and also approach for kind of problem consider [13, 2]. There are many positive feedbacks about fuzzy from research paper that I found. They choose fuzzy logic because characteristic of fuzzy logic can be modeled as human thinking system and it can be better from traditional method [3]. Also, it can transform the experiences of man to mathematical expressions is a quite better manner [3].

Fuzzy logic is used because the technique is suitable for statistical database as well as suitable to obtain general classification between excellence and moderate students. Fuzzy logic is problem-solving control system methodology that leads itself to implementation in systems ranging [5]. The concept of fuzzy logic was conceived by Lotfi Zadeh, a professor at the University of California at Berkley, and presented not as a control methodology, but as a way of processing data by allowing partial set membership rather than crisp set membership or non-membership [5].

Nowadays, many students are busy for competing to get excellent academic result due to the competitive courses and facilities. Besides, it is undeniable that student performance can affect the university rank as well as for accreditation references. Unfortunately sometimes student did not find the proper and suitable way on how to make sure their performance can be maintain for every semesters. Normally the performance can be analyzed by measuring student cumulative grade point average (CGPA) upon their graduation. When the performance is good, then the same is expected on their overall courses. Eventually, we can use the first semester result student as a variable for the next semester references.

The academic performance is one of the factors to be referred when they thinking about job recruitment. The first thing will be judged from their resume is their academic results. After that companies will shortlist the nominees by evaluating their experience and other skills. If their CGPA is not competitive, then the possibility of recruitment can be decreased. To overcome this problem, student must be alert about their study plan and struggle for better results. To make sure the student always consider this, we propose the fuzzy logic based inference system. From here, they can always be aware about their result and also plan wisely for their future courses.

This project uses the fuzzy logic approach as a method to predict the performance student in pursuing better academic result in university. Fuzzy systems are built to replace the human expert with a machine using the logic as human would use to perform the task [1].

The main issue in this project is the difficulties to predict the student’s performance and to sustain their result especially from the day they entering university until graduated. The academic performance of students is very important which demonstrates what they have achieved in university especially when it comes to apply a job in any company. If the student has scored from the first semester, and they continue to maintain their performance especially considering the core courses in Electrical and Electronics Engineering, then it is expected that they will get an excellent result at every semester until the final year. But if the student just takes easy courses, they will get a low grade. Eventually, we can use the first semester result student as a variable for the next semester performance.

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The main issue in this project is the difficulties to predict the student’s performance and to sustain their result especially from the day they entering university until graduated. The academic performance of students is very important which demonstrates what they have achieved in university especially when it comes to apply a job in any company. If the student has scored from the first semester, and they continue to maintain their performance especially considering the core courses in Electrical and Electronics Engineering, then it is expected that they will get an excellent result at every semester until the final year. But if the student just takes easy courses, they will get a low grade. Eventually, we can use the first semester result student as a variable for the next semester performance.

Nowadays, many students are busy for competing to get excellent academic result due to the competitive courses and facilities. Besides, it is undeniable that student performance can affect the university rank as well as for accreditation references. Unfortunately sometimes student did not find the proper and suitable way on how to make sure their performance can be maintain for every semesters. Normally the performance can be analyzed by measuring student cumulative grade point average (CGPA) upon their graduation. When the performance is good, then the same is expected on their overall courses. Eventually, we can use the first semester result student as a variable for the next semester references.

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II. METHODOLOGY

In Mamdani-Style Inference, there are four step of process which is fuzzification, rule evaluation, rule aggregation and defuzzification. Fuzzification is to finds crisp from membership. Fuzzification process is based on producing fuzzy information provided and each concept analyzed into trapezoidal membership functions of fixed or variable widths. If it is assumed that the input data do not contain noise of vagueness, a fuzzy singleton can use. In this stage, first step is taking the inputs and determines the degree to which they belong to each of fuzzy sets via membership function. In this project, the interval for core subject is between 44 and 100 and rate for the output performance is between 0 and 4.0. This setting is fixed for this project.

Then it will continue with the next step which is rule evaluation. There are 4 input variables(courses offered) being identified such as Circuit Analysis, Digital Electronic, Computer Programming and Electromagnetic Field Theory in this fuzzy logic system. The rules are constructed by referring to the sample and the system. The total rules defined for this system is about 6561 rules. In rule evaluation, multiple antecedents was use, so fuzzy operator (AND or OR) are using to obtain a single number to represents the result of the antecedent evaluation. Now the result of the antecedent evaluation can be applied to the membership function of the consequent (THEN). Then process of unification of output of all rules is said as aggregation.

The last step in this process is defuzzification. This stage evaluates the rules but the final output of fuzzy system will be presented in crisp number. The implication result obtained for each rule should be aggregated and defuzzified to obtain a single crisp value. This implies the defuzzification strategy to convert output fuzzy variable into corresponding crisp value. The most popular method in this stage is known as the centre of gravity (COG).

As the system has been designed, now the first and second year student can predict their result especially for the final year, or in other words their CGPA upon graduation. Based on the four core subjects selected, student can infer how their performance in the future will be look like. Thus, an immediate action can be taken if they found that their performance is not up to what they have planned. Meanwhile, for the excellent students, they must keep up their efforts in maintaining their excellent result. Else, they could not sustain a good performance in later semester. Configured by this flow of processes, interestingly to found that this system is actually giving a motivation for the students especially for those who are in condition KG (Fails) and P1 (Need Attention) to double up their efforts in getting good results.

Without implementing this system in education, students can hardly predict their results in the next semester or overall performance from the semester taken. Thus, students will only studies to finish up their course without knowing that they can also get better results when they planned promptly and wisely in getting a good grade for the next semester.

Moreover, some of them could probably take actions such as repairing their courses that has lower grade. So, if they are in KG (Kedudukan Gagal-Fails) or P1 (Pemulihan-Need Attention) conditions, they might improve their grade to better position; KB (Kedudukan Baik-Satisfactory).

III. RESULT AND ANALYSIS

This proposed system comes with 6561 rules when four inputs and one output are considered. The system is build and compared with three different memberships which are Trapezoid, Triangular and Gaussian memberships. For each membership type, the results come out differently. However, there is time that they presented almost the same performance or prediction. As mentioned previously, the system uses four core subjects which are Circuit Analysis (CA), Digital Electronic (DE), Computer Programming (CP) and Electromagnetic Field Theory (EMT). This four core subjects act as inputs for the system and the output is performance student which Cumulative Grade Point Average (CGPA). For the membership function, there are nine fuzzy set in membership function which are designed by referring to the grade of the subject.

<table>
<thead>
<tr>
<th>No</th>
<th>Input</th>
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<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Circuit Analysis (CA)</td>
<td>D+</td>
<td>44-46</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C-</td>
<td>47-49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>50-54</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C+</td>
<td>55-59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B-</td>
<td>69-64</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>65-69</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B+</td>
<td>70-74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A-</td>
<td>75-79</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A</td>
<td>80-100</td>
</tr>
<tr>
<td>2</td>
<td>Digital Electronic (DE)</td>
<td>D+</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>C-</td>
<td>47-49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>50-54</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C+</td>
<td>55-59</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>A-</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>A</td>
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</tr>
<tr>
<td>3</td>
<td>Computer Programming (CP)</td>
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</tr>
<tr>
<td></td>
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<td>C</td>
<td>50-54</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>55-59</td>
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<td></td>
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<td>80-100</td>
</tr>
<tr>
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<td>Linguistic</td>
<td>Range</td>
</tr>
<tr>
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<td>--------------------------------</td>
<td>------------</td>
<td>----------------</td>
</tr>
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<td>1</td>
<td>Cumulative Grade Point Average (CGPA)</td>
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<td></td>
<td></td>
<td>PI</td>
<td>1.67-1.99</td>
</tr>
<tr>
<td></td>
<td></td>
<td>KB</td>
<td>2.00-3.66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>KC</td>
<td>3.67-4.00</td>
</tr>
</tbody>
</table>

### A. Trapezoid membership method case

For the output from Trapezoid methods, we can see that the result output of CGPA is near with the actual sample CGPA student. The range of membership is importance to get the actual result. It must tune and sees what the output that nears with the actual result. In fuzzy system, CGPA cannot get same with real result or maybe it just near only. It is because, for the input, we put minimum mark. So it can affect the output.

Figure 1 above describes that selection of four core subjects as inputs and CGPA as the output in pursuing better academic result. This system applies FIS to evaluate the performance of students. From figure, it shows that the system use Mamdani method with 6561 rules.

Figure 2 shows the fuzzy membership function for the input variable – core subject. This figure describes the type of membership that is chosen for this system which is Trapezoid. As illustrated on the figure, the range of membership in Trapezoid type is including nine linguistic variables. This membership function range is selected from 44 until 100. The selection is based on the grade classification presented in Table 1.

Figure 3 depicts the fuzzification stage for the output parameter performance with three membership function the range that designed to be in between 0 and 4 since there are four linguistic variables which refer to KC (Excellent), KB (Satisfactory), P1 (Need Attention) and KG (Fails). The design is also based on the grade ranges defined by university.
In FIS illustrated in figure 4, Rule editor is used to set rules based on the 4 inputs and one output. Rules have been calculated taking into account the number of student samples. This is also then compared to actual student results prior on designing the rules.

With references to the input values and using the above model, the inputs are fuzzified. Then by using simple if-else rules and other simple fuzzy set operation, the output of the FIS is obtained. In FIS, the output is calculated automatically by analyzing the four core subject.

FIS surface viewer is used to plot those two inputs and the output. This figure directly exposes the relationships between each input and the output. If one would like to analyze the other two inputs, then it can be done by simply defining the inputs as the axis in FIS.

Finally, if above settings have been conducted, then the results can be analyzed and viewed. Table 3 to Table 5 demonstrates the result between actual conditions and results with fuzzy inference method. As explained by these tables, the results are convincing and approximate the real situations. Most of the results being proposed by the system have lower CPA performance than the actual results. The system is designed in such a way that the student could predict the minimum achievement if these four courses are considered as their main references. It is worth to mention that, this consideration was also made due to there are only four courses being analyzed. There are also other courses that student must registered, and if these courses are registered, then the results could possibly change to be lower than actual. Therefore, the system attempts to provide the best minimum CPA that students can achieved in their study.

### Table 3: Result analysis fuzzy logic in Trapezoid membership method

<table>
<thead>
<tr>
<th>Student</th>
<th>CA</th>
<th>DE</th>
<th>CP</th>
<th>EMT</th>
<th>Actual result</th>
<th>Fuzzy result</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A-</td>
<td>A</td>
<td>3.78</td>
<td>KC 3.77</td>
</tr>
<tr>
<td>B</td>
<td>A-</td>
<td>A</td>
<td>A</td>
<td>C+</td>
<td>3.30</td>
<td>KB 2.85</td>
</tr>
<tr>
<td>C</td>
<td>A-</td>
<td>B+</td>
<td>B</td>
<td>B</td>
<td>3.44</td>
<td>KB 2.88</td>
</tr>
<tr>
<td>D</td>
<td>C-</td>
<td>C</td>
<td>B-</td>
<td>D+</td>
<td>2.20</td>
<td>KB 1.81</td>
</tr>
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</table>

### Table 4: Result analysis fuzzy logic in triangular membership method

<table>
<thead>
<tr>
<th>Student</th>
<th>CA</th>
<th>DE</th>
<th>CP</th>
<th>EMT</th>
<th>Actual result</th>
<th>Fuzzy result</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A-</td>
<td>A</td>
<td>3.78</td>
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</tr>
<tr>
<td>B</td>
<td>A-</td>
<td>A</td>
<td>A</td>
<td>C+</td>
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<td>C</td>
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<td>D+</td>
<td>2.20</td>
<td>KB 1.81</td>
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### Table 5: Result analysis fuzzy logic in Gaussian membership method

<table>
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<tr>
<th>Student</th>
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<th>EMT</th>
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<td>A</td>
<td>A</td>
<td>A</td>
<td>A-</td>
<td>A</td>
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<td>KC 3.46</td>
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<td>A-</td>
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<td>C+</td>
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<td>KB 3.46</td>
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<tr>
<td>C</td>
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<td>B</td>
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<td>KB 3.46</td>
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<tr>
<td>D</td>
<td>C-</td>
<td>C</td>
<td>B-</td>
<td>D+</td>
<td>2.20</td>
<td>KB 1.68</td>
</tr>
</tbody>
</table>

### D. Comparison between Memberships

From the table 3, 4 and 5, the results have shown different characteristics from different membership types. For the table 3 and 4, which illustrating inference from trapezoid and triangular; their fuzzy result is slightly similar. This is due to the tuning and similar membership. For this project, the best membership function is found to be the trapezoid membership. From a number of simulation analysis being carried in this research, it is found that trapezoid membership can adjusted to straight line. Nevertheless, other memberships could also be the best solution which is depend on the how the system tunes the membership function for the system and how the rules are constructed. Reason for the fuzzy result is not accurate or shows similar outcomes with sample is for this system it to predict the performance student by using minimum mark grade for the subject.
such as CGPA. The process also is used in artificial systems by using fuzzy logic tool, it can become easy system to find the best way to predict result in university. For this reason objective of this project now are achieved where the best number of rules and consider more variables. The aim and accuracy of the system can be improved by adding the toolbox of MATLAB is enables to create and to edit fuzzy inference systems.

The advantages of fuzzy logic expert systems compared to non-fuzzy expert systems are that they typically require fewer rules, need fewer variables, use a linguistic rather than a numerical description, and can relate output to input for any device without needing to understand the device's inner workings.

IV. DISCUSSION

After all the results have been analyzed, it proved that the accuracy of the system can be improved by adding the number of rules and consider more variables. The aim and objective of this project now are achieved where the best result is obtained after considering several factors in order to find the best way to predict result in university. For this system by using fuzzy logic tool, it can become easy system because it deal with linguistic and perceptions same with human language. Fuzzy logic also to the way our brains work. The aggregate data and number of partial truths which aggregate further into higher truths which in turn, when certain thresholds are exceeded, cause certain further results such as CGPA. The process also is used in artificial computer neural network and expert systems.

From the result of the simulation, it can be observed and concluded that Fuzzy Logic Toolbox as one of the MATLAB tools is very reliable software for predicts result in university and simulation that can provide and be helpful in term of research and development. The combination of the system with simulink makes the system able to simulate using many variables. Although that maybe some other existing software is available, MATLAB Fuzzy Logic Inference system is one of the competitive challenger that can give choice to the users. When the result comes to cost effective, this system is really recommended.

V. CONCLUSION

Actually, using Fuzzy Logic approach in education is generally something new in field education. But fuzzy logic now has reached wide range [8]. Student will improve their effort in study when seeing their performance analysis. It would lead to students being afraid to fail because the impression that failed subjects would drag the CGPA even further down. These systems also give motivation to student to get the excellent result. To those care about transcript it can give positive impact to their transcript average result.

This system is no actually for education in UMP, other university also can apply this system when grade for the core subject is same or way to classification is same. In industrial also can apply this system for classification performance worker in company.

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Power System Simulation Laboratory as a Modern Educational Tool

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Abstract—To ensure the success of the personnel of power systems are required not only deep theoretical knowledge’s but also practical skills, the acquisition of which in modern universities is associated with considerable difficulties. The paper provides an overview of opportunities to overcome part of these difficulties by creating automation and protective relaying testing educational and research laboratory. To generate testing signals power system emergency processes records and simulation software are used. For education purposes microprocessor-based, suitable for digital input testing signals terminal is created

Keywords—educational technologies, power engineering, simulator, testing, digital technologies

I. INTRODUCTION

A. An Overview of Power Engineering Issues

For hundreds of years, energy has been at the basis of the development of human society. From primitive campfires, stoves, windmills and horse power that were used for cooking, heating and transport, humanity has arrived at modern-day industry, transport systems and centralized district heating systems, which are unthinkable without modern, high-quality, reliable sources of energy. Electric energy, due to its characteristic features, has advantages in industrial, automatic production, transport and communication applications. The rising welfare level and life standard stimulates the need for energy services. Energy consumption is steadily growing; this tendency is expected to persist in foreseeable future and to promote further development of electric power systems.

The world’s growing population, the scarcity of energy resources and striving after the benefits offered by modern civilization have resulted in power systems of grandiose dimensions. Power systems are arguably among the most complicated artificial technical systems created as a result of human activities. They consist of thousands of generators, transformers, hundreds of thousands of kilometres of power transmission lines and millions of consumers. The maintenance and development of a power system in any country requires significant investments. The consumers, independently from the generators, change their energy demand in accordance with their wishes. All the elements of the power system function as a unified system. The operation of the power system is strongly influenced by a number of natural factors: temperature, wind velocity, illumination level, etc. Changes in the operating conditions also make it necessary to change the operating mode of power facilities.

The rise in energy consumption, the growing dimensions of power systems, their degree of complication and significance, the increase in the prices of energy carriers, the influence of occasional factors and uncertainty—all of the aforementioned has sharpened a number of serious energy-related problems [1].

• **Efficiency** and availability of power supply. Unfortunately, the standards of living for different layers of population differ even in developed countries that are well provided with energy. Still larger are the differences in living standards between industrially developed countries and developing countries. Provision with energy resources is very inhomogeneous at various places of the world. As a result of this, one fourth of the world’s population still have no access to electric energy sources and, consequently, to most of the benefits offered by modern civilisation. The main reason for this is the energy price, which is inaccessible to the poorer layers of population. The growth in the energy prices hampers the development of industrial production and consequently limits the opportunities to solve many social and environmental problems.

• **Reliability** of power supply. Humanity has gradually got accustomed to conditions that are unthinkable without guaranteed energy supply and has adapted its way of living accordingly. Even in case of short-term power cuts, modern-day cities, industrial enterprises and transportation systems suffer damage and large-scale economic loss, emergency and catastrophe threats arise, possibly even with large casualties.

• **Environmental impact.** Energy production is practically impossible without influencing climate, the air and water basin, the natural sceneries and, as a result, the human living environment.

• **Sustainability.** This concept is linked to the limited amount of basic resources available to modern society. Although the amount of energy produced from renewable sources has increased considerably over the last decade, yet it
is expected that almost 85% of the increase in the energy production amount will be related to an increase in the consumption of fossil fuel.

The acuity of the above problems has resulted in decisions on an international scale regarding the restructuring of power systems and the use of market conditions and mechanisms in the management of the development and operation of power systems. The power system is divided into a number of legally independent parts that compete with one another. Competition is the main factor that can ensure rational development of power systems.

Division of a system into a number of parts diminishes the dimensions of the objects to be managed. It seems that the models and algorithms for management and decision-making are simplified, yet at the same time, new problems emerge. To solve the problems described above are generally recognized two main ways:

1. Use of distributed generation.

2. Application of smart grid technologies, which uses information and communications technology to gather and act on information about the behaviours of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity.

B. Necessity of Skilled Engineers

In summary we can assert that the management and operation of modern power systems requires the use of a large number of well-trained engineers. It can be expected that the trend of growth of requirements for qualified personnel have to be continued in the future. Areas of personnel activity, management, operation and maintenance of energy supply process can be divided into the following groups:

1. Development of equipment and apparatus. Much of the effort in this group focused on the development of automation and control systems.

2. Designing of power system objects (development of new or reconstruction and modernization of existing power stations, substations and transmission lines).

3. Operational control of power plants, substations and network areas.

4. Operation of transmission and distribution grids, power plants and substations.

5. Management and operation of consumer’s energy demand.

Activity in any of the above-mentioned areas is related to the complex and dangerous equipment state changes. Errors in making or implementing decisions can cause serious consequences. In some cases there are enormous economic and social losses or even human victims [2]-[5]. The major blackouts in different parts of the world can serve as example of errors, which was made in different stages of process management or operation. The significant cost of possible errors determines the high demands on the staff, which ensures the development and operation of power systems. Much of the staff should have higher education and scientific degrees including doctoral level.

To ensure the success of the personnel are required not only deep theoretical knowledge but also practical skills, the acquisition of which in modern universities is associated with considerable difficulties. This statement may be explained by the variety of instruments and the conditions of their operation, by the high cost of equipment in the teaching and research laboratories. Encountered difficulties, the desire to reduce costs leads to the use of various simulators, allowing to obtain the necessary skills in conditions which are near to real.

Three types of simulators currently are used:

- Engineering software dedicated to the accurate simulation of the dynamics (including arc flash, load flow, short circuit, transient stability, relay coordination) of all electric power systems [13]-[15]. Even a complete virtual laboratory can be created, like for example, Virtual laboratory based on LabView software package [22]. Such simulators can’t be used for direct testing of real devices.

- The equipment, which can generate processes in real time and is specifically designed for basic testing of real protection and measurement devices [6], [16] (Fig. 1);

- Real-time large power systems process simulators (e.g.[7], [8]), which can generate processes in real time.

It should be noted that the last two groups of equipment are expensive, while the first group of simulators, are not appropriate for obtaining the sufficient practical skills.

This paper is devoted to the description of one of the possible approaches to create laboratory combining the best features of the mentioned simulators with purposes of its use in teaching and research on the development of automation and protection areas.

II. PROCESSES SIMULATION AND TESTING OF AUTOMATION

Recent advances in digital technology encourage utilization of microprocessors in automation devices, particularly in power system protection. Compared with conventional hardware, the embedded controllers are capable of providing the enriched functionality. Combined functions offer great advantages and on the other hand complicate the process of proving the design [9], [10]. The digital technologies and instruments provide new opportunities for error occurrences in software programs, algorithms, and hardware design [11], [12]. Higher level of confidence is obtained if the digital devices are tested for conformance to the specification and for withstand of the operation environment possible in field application. For this purpose, digital simulation systems have been used since the early 80s. The simplified test system configuration is shown in Fig. 1; computer runs the test procedure that obtains input currents and voltages waveforms and control settings, examines the test case and event identification procedure, and performs comparison of the results.
Here (Fig. 1), the currents and voltages are fed to the tested device by the Digital-Analog Converters (DAC) and power amplifiers [16].

![Fig. 1. Testing system configuration](image1)

The fundamental features of this scheme are:

- Computer is used both to simulate the power system and to control the conformance of test device response to the specification.

- The power amplifiers are involved being cause of high costs and large dimensions of the testing system. In fact, typically current signals range up to about 300A in peak, while the voltage signals up to 200V in peak. The energy required to generate the signals may range up to several kVA. Frequently, modern digital relays are connected to high number of current and voltage channels. For instance, transformer protection relay could control up to 9 voltages and 9 currents, while the relay of two-terminal-based line protection controls 8 voltages and 6 currents, as minimum.

This paper proposes new power system simulation method that, generally, utilizes simply digital signals.

### III. THE NEW POWER SYSTEM PROCESSES SIMULATION SYSTEM

The proposed power system processes simulation system scheme that takes the advantages of digital technology utilization is shown in Fig. 2.

Presented in Fig. 2 structure has the following features and properties:

- Laboratory server forms the library of processes in two ways:
  - applying special Programs (e.g. [13]-[15]) and user defined scenarios of accidents provides modelling and recording of emergency processes.
  - Collects records of real processes which was registered by power system automation devices.

- For automation and protection system algorithms and software testing purposes specialized micro-controller based terminals (see the description. below) was developed. These terminals allows to record multiple automation devices operating software and they may be tested using both analog and digital signals.

The fundamental feature of the structure (Fig. 3) is the possibility to communicate with the external computer, as well as the possibility to hold in internal memory waveform data of the input signals [16]. Thus, for real time software and device hardware testing it becomes necessary and sufficient: to write in memory and hold there waveform data of the input signals; to ignore input signals in testing mode, instead using the stored in memory data; to compare the responses of the ideal and the tested device, using computer simulation of device performance as ideal characteristic.

For the new technology application, the automation devices should be designed to accept the digital format of testing waveform data and to support the ability to ignore the analog-digital conversion results in testing mode. For this purpose special software has been developed and installed both to computer and to micro-controller of the tested device.

![Fig. 2. Power Systems Simulator structure](image2)

![Fig. 3. Microprocessor-based automation device structure](image3)
A. Testing Signals Generation

In order to analyze and evaluate the operation of automation and relay protection testing signals are needed. This signals may be generated by following tree methods:

1. Performing power system numerical simulation;
2. Registering and applying for testing procedure a real power system emergency processes;
3. Describing processes in the form of a mathematical equation.

1) Numerical Simulation of Processes in Power Systems

The modern software (e.g., such as mentioned in [13]-[15]) allows large power system dynamic simulation. Currents and voltages obtained during simulation can be saved in external file and can be used (after conversion into analog or digital form) for automation device testing. However, output signals of power system dynamic simulation software are represented with signal effective value and phase angle, but automation test system accept signals in COMTRADE format (instantaneous values) (COMTRADE is Common format for Transient Data Exchange for power systems), the converter program is required. Such conversion program has been made and it converts the EUROSTAG and ETAP output file into COMTRADE format. As soon as the COMTRADE data file is obtained it can be used by simulation system (Fig. 4) [18]-[20].

Fig. 4. Power system regime simulation and tested relay operation

At the first stage a model was constructed and fault was simulated and data illustrated graphically were collected. Current and voltage effective variable changes are shown at fault start moment. The power system model and various regimes (short circuits, line loss, load variations) are simulated with the EUROSTAG software.

After simulation it is necessary to analyse a reaction of a testing relay. For this purpose special software was created. This software allows to display analog and digital signals, construct vector diagram (in dynamical and static forms) (Fig.
4) enlarge signal waveforms to get more precise data on processes in time, find changes in digital signals as well as some other features.

2) Registration of Emergency Processes

Microprocessor-based protection devices are widely used in modern power systems. These devices, in most cases, write controlled processes in the memory and, at the request, forward the recording results through the communication channels to staff work station. Records of real processes are a great material that can be successfully used for educational and research purposes. Of course, the formation of the emergency process library requires the consent of power system managers. Fig. 5 shows a record of the real short-circuit process in high voltage transmission line.

3) Synthesis of Emergency Processes using Formulas

During some experiments, it is possible to define processes using mathematical formulas (for example the number of currents and voltages harmonics and theirs parameters). For parameters of signals definitions the results of numerical simulation of processes in power systems may be used. For this purpose the special program package has been developed. The program allows producing complicated testing sequences.

In the base of the synthesis is the partitioning of the produced sequence into segments Stages. For each segment the duration and the recurrence number should be defined. Thus, long duration signals could be described in compact form, saving the memory capacity of the device. For each segment the signal is defined in a separate dialog window Fig. 6.

Fig. 5. Process of short-circuit in high voltage transmission line
The user can establish changing in time phase, amplitude, frequency and harmonics of the signals. The defined sequences are added to the library, allowing easy adaptation to the new tests. Fig. 7 shows the example of the complex process synthesis.

The developed package was successfully applied in the process of the power system protection devices design. To implement the method of the unit parameter space, the PSS/E program package was used.

IV. EXAMPLE OF REALIZATION

The described methodology is implemented in the following developed complicated power system automation devices: asynchronous operation recovery automation; power transformers protection and automation; power line protection system, power line fault location [17]-[16].

Let us consider methods of implementation of the testing procedure by the example of shown in Fig. 8 power line protection system.

Two terminals are installed at substations M and N. The data is transferred by fibre-optic channels. The measurements synchronisation is done through the global positioning system GPS [16].

The system conducts functions of the differential protection (main protection), and functions of distance and overcurrent protection (backup protection). In addition, the system controls autoreclosing, fault location etc. operations. Each terminal receives phase currents (I\textsubscript{A}, I\textsubscript{B}, I\textsubscript{C}), zero sequence current (I\textsubscript{0}) and phase voltages (U\textsubscript{A}, U\textsubscript{B}, U\textsubscript{C}) as well as (U\textsubscript{0}) voltage in a separate input, plus, as required by autoreclosing function, an additional voltage of one of the line phases. Thus, for one terminal the space of parameters, that define analogous signals of the fundamental harmonic, is 18-dimensional (all the signals are complex). Taking into account that system consists of two terminals; we can declare the common space of the system analogous signals to be 36-dimensional.

In the case of the classical approach application the number of necessary testing trials becomes excessively high [20]. The only acceptable solution could be obtained then involving statistical testing [16].

Basically, two approaches are possible when statistical trials of the automation systems are arranged: testing in the signals parameters and settings space and in the space of parameters of the protected unit.

a) Testing in the signals parameters and settings space.

The procedure of the testing is shown in Fig. 9 [16]. In this case, the testing procedure comes to generation of the random values vector of the signals and settings, transferring and storing of these values in the tested device memory, monitoring of the device response and comparison of the response with the response of ideal device.

This approach has several shortcomings: appearance of the parameter combinations that are impossible in real power system, as an example, combination of the maximal current value and maximal voltage value of the faulted phase are possible. Consequently, the efficiency of the testing is decreasing. Complexity of definition of the ideal device characteristics complexity of assignment of the irregular shape signals (signals that besides the fundamental harmonic contain other harmonics or exponential components).
The efficiency of the method could be improved by transition from the signals space to parameters space of the protected unit.

b) Testing in the space of parameters of the protected unit.

Let us consider the network diagram in Fig. 10. The power line controlled by the tested device is short-circuited at distance $L_F$ through fault resistance $R_F$. The parameters $Z_s$ and $Z_r$ have the systems are varying, as well as the line parameters themselves. As the result, 12- or 16-dimensional space is formed. Furthermore, the most part of parameters has relatively narrow range of possible values and, as a rule, the distribution law is known for many of these [23].

The transition to the protected unit space allows to reduce the trials number, however the procedure itself becomes more complicated (Fig. 10 and Fig. 11).

In order to find the possible values at the inputs of the ideal and tested device, the model of the protected unit should be used. For this purpose one of the mentioned analytical software programs can be employed. The PSS/E program package includes also fault conditions modelling tools and Iplan - the built-in macro programming language that allows automating of the calculations. Thus, the implemented in the PSS/E program model can be accomplished by the external module that will form the data arrays containing virtual tests, and by the loader. That will lead to creation of the effective testing system (Fig. 11).

The growing complexity of the system is then compensated not only by the considerable reduction of the necessary number of trials, but also by the emerging possibility to check the devices operation in conditions that are similar to real ones at the future installation site.

V. CONCLUSIONS

1. Laboratory, that is able to ensure the testing and verification of automation and relay protection algorithms, software and hardware, can serve as the basis to get for students practical skills which is necessary for the development and operation of power automation systems.

2. Internet technologies and power system fault and emergency processes digital records enable the creation of educational and research laboratories, which use a real power system as input information source.

3. Specialized terminals that are able to use digital input signals, provide the opportunity for a wide class of experiments based on the use of a power systems simulation software.

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Combining academic education with soft skills development: some common aspects of educational preparation of IT professionals and schoolteachers

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Abstract—In the modern educational process aimed on preparing professionals in the applied areas, it’s crucial, along with purely professional training, to provide students both with solid theoretical background and help them to develop “soft skills” that will facilitate their smooth and efficient adaptation to the industry realities when they start their professional careers. In this paper we consider practical cases of acquiring soft skills through intensive field experience in two areas related to mathematical education.

Keywords—education; mathematics; IT

I. Introduction

In the modern educational process aimed on preparing professionals in the applied areas, it’s crucial, along with purely professional training, to provide students both with solid theoretical background and help them to develop "soft skills" that will facilitate their smooth and efficient adaptation to the industry realities when they start their professional careers. In this paper we consider practical cases of acquiring soft skills through intensive field experience in two areas related to mathematical education. The first area is preparation of qualified computer programmers and IT managers, and the other - preparation of schoolteachers specialized in teaching math. The paper continues research described in [1] that stems from a long-term cooperation between St. Petersburg State University, Russia, and State University of New York (SUNY), United States, through which several common aspects of educating mathematicians to work in an IT company as software developers or managers and prospective teachers to work for a technology-rich classroom were identified. The above-mentioned educational commonalities can be described in terms of the signature pedagogy construct - the “types of teaching that organize the fundamental ways in which future practitioners are educated for their professions” [1, p. 52]. In the modern world, when technology penetrates every aspect of human life, many basic principles used in educating highly qualified workforce of the future have to be revisited. One such revision concerns the need to bridge theory and practice. In the context of preparing computer programmers, it was observed that those students who have experience working as an apprentice for an IT company have come to possess a high level of appreciation of theoretical courses that deal with the issues of governance of IT projects and the quality of the development of programming products. By the same token, when the methodology of teaching courses are taught to teacher candidates who concurrently participate as interns in the life of K-12 schools, their grasp of current signature pedagogies of different content areas becomes much more meaningful and profound allowing for a true intellectual growth of all parties involved in the process of education.

II. Administrative Flexibility Principle in Connecting Theory to Practice

The St. Petersburg State University Mathematics and Mechanics Faculty Department of Applied Cybernetics is the major contributor to the cooperation in research between the two universities. The idea of considering tight cooperation between the University and world-class IT companies working in St. Petersburg as an immanent part of the process of preparation of young IT professionals, was initially formulated shortly before formation of the Department in 2007, and the original approach integrating theoretical courses and field experience of mathematics students was first implemented with a group of 3rd-year students of the Department. The initial experience of the implementation of such collaboration clearly demonstrated the critical importance of full administrative and organizational support of the innovative initiative from University side. Administrative support was strongly needed for solving such problems as coordination of schedule between practical field trainings and regular University...
lectures, making field practice mandatory for students and some others typical problems arising within collaboration between University and various industrial IT companies/

Note that in the area of IT education, there is a permanent gap between profile of graduate students and profile of industry companies’ requirements to junior IT professionals. This gap is fundamental and caused by two basic reasons. First, the innovations and modifications occur rapidly due to expeditious developments within the field. Second, the majority of students start their first job without possessing necessary soft skills - such as communication, presentation, teamwork skills etc. So, they are forced to acquire these skills just on their workplaces, in process of interaction with their colleagues and managers that causes additional difficulties and discomfort for both sides. These problems can be avoided by enabling students to master these soft skills even during the learning process, through intensive field practice.

Administrative flexibility principle, that this paper emphasizes, implies unconditional support from the administration in the development of new theoretical courses and materials for discussion groups, as well as the elimination or significant revision of outdated courses. Such change requires the need to use a workable blend of a small group of regular faculty members and a much larger pool of part-time faculty with diverse qualifications and expertise in key areas of computer science.

The SUNY Potsdam School of Education and Professional Studies (a school approaching the bicentennial of teacher preparation) is another major contributor to the joint research work of the two universities in the area of mathematics and computer education. The School provides prospective teachers with multiple opportunities in advancing their technological expertise, including active participation in research projects on the use of computers in a mathematics classroom [3, 4]. The rapid development and continuous upgrade of educational software including content-specific as well as generic applications makes it necessary to constantly revise methodology courses in order to reflect changes in technology and the revision of standards for teaching with technology. However, unlike the case of the Department of Applied Cybernetics located in the second largest city of Russia, Potsdam, like the many other school of education sites in the U.S., is located in a rural area. Nevertheless, the technological equipment of the School is as rich as in any other place in the country. Likewise, K–12 schools in the area have state-of-the-art computer laboratories and regular classrooms. In the context of educating prospective teachers, this raises the issue of not lagging behind the ever-changing technological environment available to schoolchildren. The role of the educational administration in facilitating and encouraging faculty-student collaboration in the context of professional development school is also critical.

III. Administrative Flexibility Principle and the Preparation of Software Engineers

Consider several examples of administrative flexibility in revising theoretical courses to address practical demands. One example concerns learning Java programming language by mathematics students. Now Java is one of the most commonly used programming platforms, especially in business applications development. Such situation is largely formed through an extensive ecosystem of Java-based industrial technologies grown during the last decade. Therefore, comprehensive knowledge of Java language as well as familiarity with appropriate industrial Java-based technologies is a must for the future software engineers. In the Department of Applied Cybernetics the process of studying Java and Java-based technologies was organized in two basic directions. Within the first direction, Java language basics are studying within both theoretical and practical courses. The theoretical course is taught by Prof. Safonov, Head of Java Technologies Laboratory of the Mathematics and Mechanics Faculty and renown scholar in this field [5, 6]. The relevant practical course that allows to master the techniques of practical Java programming, is offered by one of the authors of this paper, Prof. N. Kuznetsov. The second direction is a synthetic one-year course titled Introduction in Java/J2EE Business Programming that is delivered by the representatives of Exigen Services, one of the IT companies with which the department cooperates. The course is taught by company specialists and experts having extended industrial experience, on the site of the company and takes the whole day (6 academic hours) every week. All these courses (theoretical and practical basic Java course and course on Java business programming) are delivering simultaneously for the same students, so accurate coordination between them is extremely important. Obviously, such coordination would be impossible without strong support of faculty administration.

One of main goals of business programming course, along with studying new technologies, is to provide students with feelings of specifics of practical work on real industrial projects as well as development of necessary soft skills. Learning Java programming in industrial project-like mode using real infrastructure and actual managing techniques makes studies highly efficient because the learner can acquire both technical knowledge and necessary soft skills. In the words of one participant of the first run of Java courses held in 2007: “It was quite fascinating – because, first, we have learned lot of new technologies that are using by software engineers just now, and, second, we’ve got strong feeling of “how things are done” in modern global IT companies “.

Other examples concern the development and teaching of courses in the critical areas that lie at the border between IT and mathematics. Below is a brief description of such courses and references to the major publications by their instructors. So, Prof. Kiyayev-Deputy Director of St. Petersburg State University Research Institute for IT, has been teaching the course Management Aspects of Metrology, Standardization, and the Quality of Software Development. The course Theory
of Filtration of Random Processes is taught by Prof. Matveev, an expert in the theory of optimization [7, 8]. A course on financial management is taught by Prof. Vavilov who is an expert in portfolio investment control [9]. Most recently, Prof. Koznov, using collaborative learning techniques based on mind maps and Comapring tooolset [10], started teaching a course on special topics in software engineering. The flexibility of administration in making personnel decisions when creating such a highly qualified team of adjunct professors cannot be underestimated.

IV. Motivation and Internship

In the context of the collaboration model described above, there is a problem related to the time gap between studying courses combined with field practices (3rd year) and the moment when the students are able to join IT company as full-time junior developers (end of 5th year). During annual course at 3rd year, students have rather strong motivation supported by their acquisition of first "real-life" experience, and it is vitally important not to lose this motivation until the moment when the students come to their first jobs in IT companies. For this purpose, a model of internship is used by the companies – partners of the University. Students who have performed well during their studies and attracted attention of their curators from company side, are invited to become an interns – i.e. participate in real company projects within project developers’ teams. The students work for a company part-time so that they can combine their internship with regular University studies. After graduation from the University, those interns who proved their usefulness for the company, are promoted to full-time positions within the company. Students in the department know full well that unless they demonstrate advanced skills during their internship, their chances to continue with the company after the graduation are very slim.

A similar situation can be observed in the context of preparing teachers at SUNY Potsdam. During their field experience and student teaching, by trying to do their best, teacher candidates acquire deep understanding of intrinsic details of the teaching process and develop necessary soft skills. By result of field practice, they earn respect of their sponsor teachers, admiration of pupils and, as a result, a chance to be offered if not a tenure-track job but at least a stable part-time substituting position which, in many cases, may turn into a better professional opportunity. This is especially true when teacher candidates, utilizing skills gained through on-campus courses, support schoolteachers and their pupils in using computers either in a regular classroom or during small-group after-school projects. Here, however, an opposite effect than in an IT company can be observed. Practicing teachers, especially at the primary level, are not always experts in using modern software products and they welcome any help they can receive from the interns and student teachers whose, often superior, technological competence is due to their university preparation in this area. As a 2nd grade (veteran) teacher put it, "Most beneficial to me was the opportunity for a select group of students to be involved in a technology project/activity which I would not be able to offer. Technology is not strength of mine, so I welcome opportunities from others for enriching my students’ knowledge" [3, p. 250]. And these "others" also know full well that school administration, when making a hiring decision, always gives preference to a candidate with advanced skills in using various software tools in the classroom.

v. The Role of Theoretical Preparation

The modern IT industry can be characterized by high degree of specialization when the professionals working in one narrow field often don’t know about methods and approaches used in the other fields. Thus, a wide professional outlook becomes a major competitive advantage that allows IT professional to find non-trivial approaches and solutions that lie on the border between different areas. Even more important is the presence of strong mathematical background that can be useful not only for from point of improving young professionals’ abilities to solve ongoing problems, but also can be used by their hosts for improving quality and reliability of their products.

Here is an example. It has been since the post Second World War period, due to Wiener’s [11] seminal book on cybernetics, then a new concept, that the following paradigm gained widespread recognition and acceptance: any mathematical algorithm has an equivalent representation through the elements of electronics. It turned out, however, that in many cases of well-described algorithms underlying the cybernetic synthesis, an object controlled by a simple (or complex) algorithm exhibited an unreliable performance despite all seemingly accurate theoretical and practical predictions. It was then found that the reason for the ill behavior of controllable objects (which often simply go astray) was due to the instability phenomenon. This led to the need to study this phenomenon in rigorous mathematical terms.

Although mathematicians have been developing the theory of instability of control systems from the beginning of the last century, the importance of this theory in the practice of management and control was recognized only in the 1990s. In particular, as recent studies indicate [12, 13], the instability theory proved having the major impact on economics. Thus, in addition to the first backbone of cybernetics, the Principle of Synthesis and Design, the Stability of an Algorithm has become the second backbone of the modern cybernetics.

That is why it became the necessity to revisit educational programs in the Department of Applied Cybernetics towards the end of introducing students to the modern theory of dynamical systems emphasizing topics dealing with the problems of stability and instability of the algorithms of control. Consequently, a new theoretical construct called the dynamical management was developed by one of the authors of this paper [14]. Put another way, dynamical management can be defined as control with provision for instability. The dynamical management construct enables one to appreciate
the fact that the application of methods, results, and concepts of cybernetics that were developed primarily for engineering systems, can bear fruit in the study of many other systems (including social ones) where instability effects can be observed. Augmenting the modern theory of dynamical systems [15], the concept of control with provision for instability is now included as an important element of the theoretical preparation of future software engineers.

The need for a theory in the preparation of prospective teachers can also be supported by an example. An active participation of pupils in classroom discourse is one of the main characteristics of the modern signature pedagogy of school mathematics. In general, signature pedagogies being "pedagogies of uncertainty ... render classroom settings unpredictable and surprising, raising the stakes for both students and instructors" [1, p. 57]. Put another way, a phenomenon of instability of a kind may be observed in the classroom, especially when pupils are encouraged to ask questions about mathematical situations which may or may not have easy answers. So, a student teacher was observed attempting to answer a question asked by a primary grade pupil as to how many ways can five rings be put on five fingers. In fact, this question, connected to pupils' use of an electronic spreadsheet in exploring outdoor temperature changes [4], was asked after it was found experimentally that there are six ways to put five rings on two fingers. The teacher didn't suspect that the right answer, even if found, would be way too beyond young children's grasp and ability to verify through a hands-on activity. As a result, the question was left without a proper answer and a seemingly stable equilibrium of the pupil's interest towards mathematics was in danger of bifurcating into an unstable one. In order to provide teacher candidates with experience in distinguishing between questions that have and that do not have easy answers, something that can help them to avoid undesirable instability of the classroom discourse, a special mathematics content course for primary teachers was developed and has been offered each semester at SUNY Potsdam. The above two examples, borrowed from different educational settings, demonstrate how practice motivates the need for the theoretical preparation of both prospective managers of IT projects and companies and prospective schoolteachers of mathematics and perhaps other subjects.

VI. Educational Mobility in the Context of Field Practice

New tendencies in education associated with global mobility take the effect on the preparation of managers for IT companies as well as teacher candidates capable of navigating within the ever-changing market of modern technologies and tools. As a member of the global educational network, a student can take and get credits for a course (or courses) through either an official program or at his or her own initiative.

Regarding field practical activities, the educational mobility is quite useful for students because it allows them to experience a wide variety of possible types of either IT companies or schools - possible places of their future work. In particular, teacher candidates may select another US state or even a foreign country as a site for their semester-long student teaching experience. Far away from home, they can learn how to teach in an environment alien to them, how to use previously unknown software tools or recommend to their host school something they are familiar with through earlier field experiences or on-campus technology-rich courses. Obtaining learning experience from different universities or from far-off internship sites increases educational mobility of students.

In the case of preparing IT professional with intensive field training in IT companies, educational mobility is implemented through encouraging students to get familiar with various types of companies. In particular, it is done through short-term practices in such companies organizing on the project base. During such practices, students are united into one or more project teams that should develop some simple software product "from the scratch" to stable alpha version during 2-3 weeks working 4-6 hours per day. The intensive work inside project team lets students to quickly acquire soft skills specific for given company type.

VII. Collaboration between IT Companies and the University: Examples

As an illustration of useful and efficient collaboration between the University and industrial IT companies, let's consider two examples. The first example describes collaboration with St. Petersburg R&D Center of Informatica Corp - a US-based international company working in the area of data integration. Another example describes collaboration with Exigen Services - US-based company specialized in the area of business software development.

Informatica Corp is an international company, with headquarters in Redwood City, California. It is a recognized independent leader in data integration, with offices in more than 60 countries employing over 2500 people. The program of collaboration between the company and St. Petersburg State University started in 2011 as a result of the joint initiative of two authors of this paper, S. Kuznetzov-Head of Informatica R&D Center in Russia and G. Leonov-Dean of Mathematics and Mechanics Faculty.

Informatica Corp has been running university collaboration programs in the U.S., Russia, and India. The Russian program was localized at St. Petersburg State University, given an excellent theoretical background of its students in fundamental sciences such as pure and applied mathematics and computer science.
The main focus of the program is to prepare undergraduate, graduate and post-graduate students for the industrial software product development, and to give them more information about technologies involved, development methodologies, and industrial product lifecycle. Also, the program provides a prospective junior staff member with clear understanding of different professional positions and to product management supervisor, clientele representative, customer satisfaction personnel, etc.

The collaboration between St. Petersburg State University and Informatica Corp is beneficial for the students from multiple perspectives. They enhance their scientific and technical background with real-life examples of commercial business programming, learn to adapt to the culture of a large enterprise software company, augment their knowledge in big data governance – one of the most growing areas of IT. The University provides students with a flexible schedule of studies allowing them to spend a full day at the company site. This, in particular, helps one to become familiar with multiple routines and practices of the company that is crucially important for the development of the soft skills.

Exigen Services is a US-based global IT company with headquarters in San Francisco, California, that delivers services in the area of business software development for large US and European clients from different business verticals - banking, finance, insurance, telecom and others. Exigen Services has its offices and R&D centers in many countries worldwide - including US, CIS countries and China. The cooperation between Exigen Services and the Department of Applied Cybernetics has been started in 2007, soon after foundation of the Department. The collaboration program was a result of joint effort of company top management and one of the authors of this article, G.Leonov - Dean of the Faculty of Maths and Mechanics. The joint academic program includes two main directions: first, company experts deliver one-year mandatory course "Introduction to business programming in Java/J2EE" for 3rd year students. Second, regular practical trainings are performed for University students on company sites. The main goal of both kinds of activities is providing deep immersion of the students into real industrial atmosphere that allows them to master new cutting-edge technologies and acquire necessary soft skills. Such approach is closer to business school-like methodology rather than purely academic one.

Both companies offer internship opportunities for the students who demonstrated good results and high motivation during lectures and practical courses. Interns work on real customer projects conducted in the company on part-time basis; their working schedule is coordinated with University studies. After some time of internship, depending on their efficiency and overall economic situation in the company, interns may get offer for either permanent part-time or full-time positions within the company. As a rule, young people are moving at company employee positions during 5th year when the workload in the University is getting lower.

The figures demonstrating the dynamics of cooperation between the Department of Applied Cybernetics and two mentioned IT companies are shown in Table I (values in the cells mean number of students passed through the program):

### Table I

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### VIII. Analyzing Voices from the Field

The evaluations of the students' fieldwork by their hosts (some of which were shared above) are valuable means used in the process of deciding the improvement of academic programs. Equally important are students' reflections on the field experience component of their studies. Thus it is essential to solicit such reflections as appropriate. By analyzing voices of both parties, one can make an informed decision about various aspects of comprehensive curricula as far as the improvement and the revision of theory and practice are concerned. In the context of preparing mathematicians, the students' opinion of theoretical preparation as a vehicle for advancing practical aspects of software engineering has to be taken into account in at least two ways: either to make the appropriate revision of a theoretical course or try to develop a better appreciation of theory by students through the use of carefully chosen examples emphasizing the role of formal knowledge in applications.

The most common praise of the educational approach to the preparation of computer programmers highlighted in the paper is the opportunity to work on real projects as a team member. As one of the post-graduate students of the Department of Applied Cybernetics, underscoring both the value of theoretical and practical preparation through the University collaboration with Exigen Services company, put it: ” I had a year-long internship with Exigen Services. It allowed me to gain a valuable experience of participation in a real project and acquire skills of working as a team member. While at the company, I had a chance to utilize theory studied at the university as well as augment my theoretical background with new knowledge. I'm confident that my experience working at
one of the major IT companies would be appreciated by my potential employers in the future”.

Another doctoral student in the department was even more positive about her internships with Exigen Services, highlighting, in addition to the learning experience, the social aspects of fieldwork. In her words: “Practical skills are always important for a student to acquire towards the end of using them in the future professional work. However, not many companies offer internship opportunities to a student. At the same time, without experience it is difficult to be hired by a reputable company. Through my internship with Exigen Services I gained priceless experience of being involved in solving real problems. As a team, we worked on a project that required from me to study tons of new information. My supervisors always helped me to overcome difficulties and assisted with the clarification of any intricate matter. Last but not least, the internship with Exigen Services was not only work and study but also an opportunity to get to know interesting people”.

Reading the above two reflections allows one to conclude that the role of the Department of Applied Cybernetics was critical in establishing collaborative relationships with major IT companies. Obviously, the students would not have been able to develop such contacts by themselves. Also, one can see how the administrative flexibility principle, which works nicely in a university setting, can be extended beyond formal schooling to make students feel “confident” in their skills and abilities and see their field experience as “priceless”. Ultimately, having such a strong trust in the quality of their preparation allows the students to enter the ever-challenging modern job market of highly qualified workforce with a sense of self-competitiveness.

In the context of professional development school, one of the avenues in advancing teacher candidates' soft skills is to offer an opportunity to see a classroom as a site for inquiry and participate in the so called action research under the supervision of their professors. Consequently, teacher candidates who take advantage of this opportunity are encouraged to present their findings at professional conferences, in particular those, devoted to the use of computers in education. Teacher candidates who choose to respond positively to the call for doing action research, although feel little bit overwhelmed, eventually have high appreciation of their "extra" work. As mentioned by one of the teacher candidates who was sharing her experience of using spreadsheets with young children at a professional meeting: “The conference went well... people were interested in the spreadsheets the most, and how the students responded, of course. We were the only elementary age level research there - most of the conference [sessions] targeted college level research - and many situations were hypothetical, so we definitely added to the diversity of the conference. All in all I have been very happy with my decision to do research: it has given me a great experience and has really helped set me apart during job interviews” [3, p. 256]. Indeed, as was mentioned above, a teacher candidate with advanced soft skills (including computer skills) is always the preferred contender for a full-time teaching position.

ix. Conclusion

The analysis of teaching young professionals in two seemingly different directions, described in this paper - future software engineers and IT managers, on the one hand, and future math teachers, on the other hand - clearly shows all the importance of combining basic applied education with both solid theoretical knowledge and advanced soft skills. The most efficient way of proper soft skills development is intensive field experience. The paper describes authors' practical experience in conducting field activities for students of Saint-Petersburg State University and State University of New York. It is hoped that the ideas shared in this paper and the authors' unified pedagogical perspective on the development of students' soft skills can be used by diverse professionals - mathematicians, teacher educators, managers of IT companies - around the world.

Acknowledgment

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Life-Long Learning Know-How Transfer Centers for Flood Risk Assessment in Romania and Hungary

An EU-Cooperation-Project

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Abstract— The sector affected by surplus or scarcity of water requires proper understanding of river and landscape system behavior, what is possible to be done to prevent potential damages and losses need skilled professionals, who are familiar also with the newest IT based hydroinformatic tools and technological achievements to find the best possible solutions. An extensive programs of Water Authorities in Romania and in Hungary have been running to provide flood risk maps in all the main river basins including also those which across the both countries. The obtained results will be contribute to the better understanding and general prediction of flooding on the major river systems and assist the governments to act (in real time and space) in accordance with contingency planning based on flood risk management plans, moreover future development plans of regions and cities will get a proper guidance and platforms for future feasibility studies. However Flood Directive implementation has been ongoing in Romania and Hungary, ‘bridging and direct trainings’ for relevant sectors as it is planned in this project have not been provided and have not been planned for future in Romania and Hungary. Based on these needs in 2011 was initiated and organized an international cooperation project financed by the European Union with the theme: “Development of knowledge canters for life-long learning by involving of specialists and decision makers in flood risk management using advanced Hydroinformatic tools” [1]. In this paper we give a brief overview of the main objectives proposed, a description of the partners and some aspects of the activities developed in the project and some of the results obtained

Keywords— life-long learning, flood risk management, know-how transfer

I. INTRODUCTION

Why is this project necessary? Meanwhile in the recent past serious flood events occurred in Europe, European Union (EU) member countries have been working on the implementation of the Water Framework Directive & Flood Directive [2]. Huge infrastructural investments are and will be running. There is a need for i) proper understanding of river system and landscape behavior, possible prevention and measures, how to deal with potential damages and losses; ii) having engineers skilled in the field related to development of water management infrastructure as well as in system operation, who are familiar also with the newest technological achievements, capable to develop area-adjusted solutions by understanding the national/country specific environmental processes. Flood risk management plan is a communicator and disseminator tool of the knowledge gained during two previous stages across the horizontal structures of governmental and non-governmental bodies dealing with flood protection, flood mitigation and flood struggle in general. They mainly include proposals on how to reduce the losses of lives, property and environmental through flood prevention, protection of vulnerable areas and increased flood preparedness in each river basin. Future development plans of regions and cities will get a proper guidance and platforms for future feasibility studies. In Romania, each state institution wants to improve the skills of their employees. There is a lack of specialists who has enough knowledge about the hydroinformatics, thus in everyday work there is a very-very limited use of such tool, and meanwhile the work with complex problems has generated recently a need to use valuable tool and proper training series and consultation center. That is in the practice realizable only by means of Lifelong Learning Programs in accordance with the European Commission’s and UNESCO conceptions people at all stages of their lives to take part in stimulating learning experiences, as well as helping to develop the education and training. [2], [3].

II. AIMS AND OBJECTIVES OF THE PROJECT

a) Provide newest technical solutions and updated knowledge for the intensified water sector development via transfer of good ‘living’ technology which is already running in different part of the world and was not accessible for the aimed target group due to language barriers and financial capacities. It will be solved by the training activities of skillful trained national trainers;

b) Establish sustainable, reachable ‘seats’ of vocational life-long learning center for flood management where adjusted trainings will be available for professionals in all age. National trainings will be ensured by the trained trainers using not only technology but techniques learnt in the first year of project execution;
c) Introduce a communication tool for target groups and to integrate their needs into training programme by the help of surveys;

d) Improve knowledge for technical solution assessment methods in integrated water/flood management thus to create basis for quality standard measures, improvements;

d) Provide not only theory of hydro-informatics but its application evidences as well: experience of the real application of the presented IT technology and start real on-site discussion by participation of representative of different sectors;

e) Better availability to the European labor market, to contribute to the personal carrier of practicing engineers;

f) Set up a regional ‘Excellent Network’ for applied hydro-informatics for life-long learning, where high quality co-operation between institutions and enterprises providing learning opportunities was established [1].

III. GENERAL DESCRIPTION OF THE PARTICIPANT ORGANISATIONS IN THE PROJECT

“POLITEHNICA” University of Timisoara (UPT), Department of Hydrotechnical Engineering - lead partner, is one of the biggest and most well-known technical universities in Romania and in Central and Eastern Europe, as well founded in 1920. Department of Hydrotechnical Engineering, as part of “Politehnica” University of Timisoara, has a Research Center for Modeling, Designing and Behavior Monitoring of the Hydrotechnical Developments. The main research fields of the center are: managing research projects in water engineering, modern technologies and design in water engineering, numerical modeling of flow and pollutants transport processes, land reclamation and improvement, soil science studies and erosion controls, surveying, cadastre etc. UPT - consortium leader, responsible for smooth project management, coordinates partners’ activities and provides the necessary basic human and IT infrastructure of the training centre in Timisoara, Romania. The Department is responsible for national level training execution, dissemination of project results in national and international level and to reach national recognition of training courses and to ensure elaboration of project results into post-graduate course.

DHI a.s. Prague - core partner, is an independent, international consulting & research organization. DHI operates the software product MIKE 11 a top quality modeling software which remains one of the most widely used MIKE by DHI product. MIKE 11 is synonymous with top quality river modeling applicable in field of flooding, navigation, forecasting, water quality, sediment transport. Most of them involve real-time flow and flood forecasting and many of them include institutional and capacity building elements. During the past 25 years DHI has established numerous real-time forecast systems with the aim of supporting decision making for flood management and for operational support to reservoir management. DHI’s technologies are well proven and represent state-of-the-art through DHI’s dedicated and continuous Research and Development efforts.

Budapest University of Technology and Economics, Department of Hydraulics and Water Resource Engineering - core partner, was established 228 years ago. The activities of Department of Hydraulic and Water Resources Engineering cover the fields of education (gradual and post gradual), research and consulting, including up-to-date international technology transfer and cooperation with universities, research institutes abroad. In this field different aspects of design and upgrading of water infrastructures, operation and control of facilities, management and river basin planning, are considered. The department has a number of advanced tools of computer sciences and software. P2 has high reputation, its staff is skilful and well experienced in adult training and computer based information technology in national and international level (e.g. EUROAQUA Erasmus Mundus) as well.

Middle-Danube-valley Water Management Directorate - core partner, operates on 8384 km² territory of Hungary, what covers the areas of Budapest, Nograd county, 90% of Pest county and partly the areas of Heves-, Szolnok and Bacs-Kiskun counties. Main tasks: The determination of the water management technical of the establishments, the provision of expert opinions in case of administrative procedures, participating in supervisions, examination of water management complaints, flood and drainage control, preparation of the regional development plans, activities related to the water resource charge for use, participation in the environmental damage compensation and damage prevention procedures.

National Institute for Environment - core partner, operates on 8384 km² of Hungary, what covers the areas of Budapest, Nograd county, 90% of Pest county and partly the areas of Heves-, Szolnok and Bacs-Kiskun counties.

IV. KNOW-HOW TRANSFER APPROACH

The know-how transfer to be adapted is based on an interactive and linguistically approaches. The transfer and testing will be made on 2 levels:

i) First to develop the local knowledge basis (trainers and center with facilities) / this first target group will be the responsible for transferring and adapting the technology into local level. Fully understanding of the know-how and way to transfer further are essential therefore continuous quality assurance & mutual discussions must ensure the optimal effectivity. The training-series will be implemented into two steps: first 3 course events will ensure the hand over the basis of DHI technology, then it follows by the so called on-job trainings, the exercise based educational modules. Each event provides also opportunity to share and obtain DHI teaching experiences.

ii) 2nd level of testing (= localization) is based on the national adaptation (training materials will be developed in national languages which will incorporate actual local needs based on survey results), the training (and quality form feedbacks) will be for end-users (practicing engineering).

To see and understand better the learnt things, real time application trips are planned (the first for the future trainers...
when they do attend training course in Prague and the second for practicing professionals who followed already any of the national trainings in Romania or in Hungary in the second year of the project) [1].

V. DESCRIPTION OF MIKE 11

MIKE 11 is the software product, which made ‘MIKE’ the brand name for top quality modeling software from DHI and remains one of the most widely used MIKE by DHI product. MIKE 11 is synonymous with top quality river modeling covering more application areas than any other river modeling package available. MIKE 11 is applicable in field of flooding, navigation, forecasting, water quality, sediment transport, or a combination of these or other aspects of river engineering. Extending the range of applications, MIKE 11 also includes options for investigating riverbank overflow and catchment hydrology [4].

MIKE 11 is accepted by US Federal Emergency Management Agency (FEMA) for use in the National Flood Insurance Program (NFIP) [3].

Typical MIKE 11 applications:
- Flood analysis and flood alleviation design studies
- Real time flood forecasting
- Dam break analysis
- Optimization of reservoir and channel gate / structure operations
- Ecological and water quality assessments in rivers and wetlands
- Sediment transport and river morphology studies
- Salinity intrusion in rivers and estuaries
- Wetland restoration studies.

MIKE 11 offers the following hydraulic and hydrological simulation engines:

**HD – Hydrodynamics**

DHI’s classic 1D hydrodynamic engine for rivers and open channels, robustness and features, including:
- Fully dynamic solution to the complete nonlinear St. Venant equations for open-channel flow
- Muskingum and Muskingum-Cunge routing method options for simplified channel routing
- Automatic adaptation to subcritical and supercritical flow
- A large suite of standard hydraulic structures such as weirs, culverts, bridges, pumps, etc.
- Choice of fixed, tabulated/ adaptive simulation time step.

**RR - Rainfall-Runoff**

RR includes a variety of RR-models. Amongst these is a lumped, conceptual and continuous hydrological model as well as the standard unit hydrograph SCS method.

**SO - Structure Operation**

SO simulates operational structures such as sluices, overflow and radial gates as well as pumps and reservoir releases from user-defined operating strategies.

**DB - Dam Break**

DB provides facilities for definition of dam geometry, breach development in time and space as well as failure mode and includes DAMBRK / FLDWAV compatibility switch.

**AUTOCL- Automatic Calibration**

It is an automatic calibration process for a wide range of parameters, including RR parameters, Manning numbers, head loss coefficients, WQ parameters.

**FF - Flood Forecasting**

FF refers to the modeling of real time flood forecasting including state updating and data assimilation features.

**ST / GST - Noncohesive Sediment**

This refers to transport, erosion and deposition of uniform and graded noncohesive sediments, including morphological changes on river bed topography.

**AD - Advection-Dispersion**

AD include transport and spreading of conservative pollutants and constituents with linear decay (including heat).

**ACS - Cohesive Sediment**

This module allows the modeling of cohesive sediment with 3-layer bed description, including quasi-2D erosion.

**GIS- Extension**

This is a powerful extension for Arc-GIS providing features for catchment/river delineation, cross-section and Dem data, pollution load estimates, flood visualization/ animation as 2D maps and data/result presentation and analysis [4].

Note.

It is to mention that in urban area the 1D- M11 modeling not enough exactly and 2D models represents a better approach of the physical phenomena. They consider the topographical variations of the terrain and roughness while calculating the depths and velocities in two directions [5]. In the future editions of the training program the 2D modeling technique will be presented as well.

VI. RESULTS OBTAINED IN THE PROJECT

The most significant results obtained so far in the project can be summarized as follows:

(i) Establishment of training centers at “Politechnica” University of Timisoara (UPT) in Romania and at Budapest University of Technology and Economics (BME) Hungary with human and IT infrastructure for flood modeling and flooding forecast;

(ii) Training future Romanian and Hungarian trainers who will hand over the knowledge in national languages and develop educational materials;
(iii) Effective implementation of three national training courses in hydroinformatic theory and applications for specialists operating in various state units and companies involved in decisions against defence flooding including preparation of regional specific case-study projects (50 participants);

(iv) Establishment of a good framework to extend project results and generate further cooperation actions;

Participants in the training have developed application-specific projects for simulating flood wave propagation along a river in the region of the institution where they work Fig. 1.

![Example for a case study](image.png)

**Fig. 1 Example for a case study (the river Lac in the town Cornesti in Timis area, Romania):**

- a) Study area view in Google Earth
- b) Numerical model for the river zone (marked cross sections along the river)
- c) Longitudinal section along the river with simulated water level

**VII. CONCLUSIONS**

As has been mentioned an important concretely outcome of the cooperation project are 2 training centers equipped with computer facilities, educational software, training programme and professional trainers.

That was possible through an excellent project partnership which is formed by two higher educational institutions “Politehnica” University of Timisoara and Budapest University of Technology and Economics (BME), both of them carrying out gradual and post-gradual education, and the DHI a.s. which is the regional office of an independent, international consulting and research non-profit organization of DHI Water, Environment and Health seated in Denmark and a Water Management state bodies represented by Middle Danube-valley Water Directorate and National Institute for Environment, Hungary.

The series of training program of the centers will result a set of specialists countrywide who are able to apply the most updated water management methodologies and tools in their job. This knowledge will enhance their ability to get job not only in the national but also in the European labour market. The impact of the introduction of DHI know-how in the Romanian and Hungarian water management will improve the quality of analyzes and not only forecast of events but consequences of system planning and optimization.

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Abstract--The need to integrate multimedia in the process of teaching and learning at all levels of education is becoming more vital. Multimedia based on e-learning is seen as an effective alternative in teaching and learning process. This method is able to create a student-centered learning where students are encouraged of being independence; study at their own pace and at their own place. Nevertheless, the rapid development of information and communication technologies (ICT) in today's world has necessitate a new trend in the presentation of information in the form of Flash Video, which is more easy to understand and accessible instantly to users. The research is undertaken by introducing an e-based multimedia content by maintaining the concept of Gagne Learning Theory. An e-material entitled "Introduction to Computer Programming C++" has been developed containing learning activities that allow users to interact simultaneously with the material. The material is expected to be an effective teaching aid to entice students in the subject of programming.

Keyword: Gagne Learning Theory; e-learning; e-materials

I. INTRODUCTION

The National e-Learning Policy is introduced by the Ministry of Education (MOE) of Malaysia as an innovative effort towards improving human capital development. It is focus mainly in the Malaysian Higher Education Institutions (HEIs) towards a better developed nation, henceforth Malaysia being recognizable nationally and internationally. These efforts will lay a solid foundation for producing graduates who are smart, responsible, independent and self-reliant and could compete globally. In addition, it also can provide an equitable higher education system to all in accordance with the concept of lifelong learning.
Dato' Seri Mohamed Khaled Nordin the Minister of Higher Education of Malaysia, directed the National e-Learning Policy which is designed to provide a framework and direction for implementation of e-learning in the HEIs for a period of five (5) years starting from 2011 to 2015. Through this policy, HIEs will be able to progress into better aspects of e-Learning. This new movement must be fully utilized to the maximum in improving the quality of teaching and learning. The policy is executed in three (3) phases: Beginning Phase (2011-2012), the Filling Phase (2013-2014) and the Optimal Phase (2015). This policy has an e-learning framework which encompasses five main pillars; infrastructure, organizational structure, professional development, curriculum and e-content and cultivating culture. These pillars are a key driver to implement e-learning education for all by teaching and learning using online learning pedagogy or online and distance learning supported by information and communication technology to date.

II. PROBLEMS IN TEACHING AND LEARNING OF PROGRAMMING

Problem-solving technique is one of the techniques that must be mastered by students for them to be able to learn and understand the concept of certain topics. The students are expected to provide best solution on any problems in relation to the topic that could help further understanding the concept of a given problem. There are many strategies that can be used to encourage the problem solving technique. One of the strategies is using knowledge construct through self-explanation (Norasykin Zaid, Zaidatun Tasir (2011). Self-explanation is the capability of students to fully understand what they have learned during the learning process including problem solving (Norasykin Zaid, Zaidatun Tasir (2011). The statement or explanation to show the level of understanding can be expressed verbally, in writing, graphs or tables or as their tacit knowledge.

Based on the studies that have been done, it is found that, by giving a clear training to students of using self-explanation strategies, it will improve the students’ ability in problem-solving skill and lead to an effective learning process. The problem-solving skill is among the skills that are often applied by computer programmers. Thus, the novice programmers for example, are often associated with students of first year computer science courses where they are not exposed to any programming concepts. It is important to grasp the skills and knowledge to increase students’ abilities as a programmer and an effective problem solver.

Learning how to develop a program is generally regarded as a difficult task to students and often programming courses recorded high failure rates. Therefore, E-Learning Policy of Universiti Teknologi MARA Malaysia takes the initiatives to spearheads the establishments of courses in multimedia based materials as one of the approach to improve on students’ performance. Lecturers who have been appointed as content expert for certain courses will develop the course’s contents into interactive multimedia form; e-materials. Among the conditions that must be fulfilled is, the lecturers have involved in teaching and learning, as well as to conduct the courses that is developed into e-materials for at least two semesters. Hence, this research will also adopt this requirement for the e-material “Introduction to C++ Computer Programming” course.

Studies also found that novice programmers have experienced difficulties not in the area of understanding the programming language constructs, but to incorporate the results of each problem areas into one best solution, after the process of decomposition occurred. Most of the studies reported that a major disadvantage of novice programmer for having weak skills on planning and design (Robins, Rountree and Rountree, 2003).

A study conducted by Norasykin Zaid and Zaidatun Tasir (2011) stated that the programming language C++ is a language that is easy to learn as the basics of programming. This is proved by the analysis presented in the database of the i-Learn Centre of Academic & International Affairs Division of the Universiti Teknologi MARA. It is shown that based on the fourteen faculties under Science and Technology cluster, ten faculties offer Programming C++ as their basic programming course.

III. THE DEVELOPMENT e-MATERIALS USING GAGNE THEORY

The theory of Gagne Learning Model (1985) is used as the basis for the research phase where it is proven as a major contribution on the students’ learning process. This approach contains nine phases; gain attention, inform learners of objectives, stimulate recall of prior learning, present stimulus material, provide learner guidance, elicit performance, provide feedback, assess performance and, enhance retention and transfer (Siti Hajar Halili, 2011).

In continuation of learning theory research, a multimedia developer should be able to integrate the concept of teaching and learning with multimedia applications. It is important to have such knowledge in order to develop an effective e-materials to be conveyed to students. Teaching theory of Robert Gagne is considered as a major contributor to the design approach of teaching and training. One of his most important contributions is the theory of "events
of instruction” that can be applied to produce an effective teaching presentation (Robert Gagne in http://www.instructionaldesign.org/theories/conditions-learning.html).

A. Getting Attention

Before any teaching and learning can take place, instructors need to attract the attention of students, including:

• Attract attention by presenting something new, ask questions or present interesting facts. In Sardi Janudin studies (2004) showed that the adults’ focus of attention will decrease after the first ten minutes they were exposed to something that excites them.
• Use of stimulating substances such as changes in visual, audio and so on.

B. Inform Learner of the Objectives

The objective is very important in a learning process. Students need to know the objective for the information and knowledge dissemination. Therefore the process of learning runs smoothly.

• Please state the purpose of the presentation and why they should follow the objectives.
• Please indicate what they can do after the learning activities.

C. Recall Prior Learning

Before a learning is commence, stimulate student's memory by:

• Relate new information to information that has been learned.
• Recalling the concept, content and knowledge on what they have learned.

D. Presenting the Stimulus

Information in the normal form can be delivered more effectively and stimulate students by:

• Breaking information with important points.
• Present the contents through graphics, animation or sequence of the corresponding text.

E. Providing Learner Guidance

To facilitate the process of understanding, students need to be guided for them to have a smooth learning process.

• Describe the process of semantics or phrases, using symbols, signs or formulas to facilitate learning.
• Propose meaningful contents organization, such as giving examples, analogy or graphic representation.

F. Eliciting Performance

To measure the performance, students should be given appropriate trainings or tests that are according to their level of studies.

• Ask students to give respond.
• Ask students to do a lot of practices.

G. Providing Feedback

To improve performance, the instructor should emphasize:

• Testing and training during tutorials are not for formal scoring but as reinforcement activities.
• The importance of giving specific feedback on student achievement.

H. Assessing Performance

To complement the teaching modules, the following should be noted:

• Students must be given the opportunity to sit for the final evaluation.
• Assessment is prepared without any extra activities or feedback.
• Confirmation of skill level and certification given after achieving a certain level of score or percent

I. Retention and Transfer

To stimulate memory and facilitate the transfer of information, the following points should be considered.
• Training modules must have a focused performance, accompanied by a design and media that stimulate memory and transferring information.

• The concept of learning is repetition in an attempt to help the process of memory stimulation.

• Develop teaching aids in the form of electronic or online materials and reference materials. "Template" and "wizard" in the application are other methods that can improve performance. (Mohd Nor Hajar Hasrol & Mohd Nor Mamat, 2007).

IV. DATA ANALYSIS ON APPLICATION PRESENTATION

The results of the data analysis are based on a set of questions given to respondents. The researchers discussed all questions that have been analyzed in tables and charts for better understanding of each factor. This analysis only takes into account the terms of the application presentations that include the following questions.

A. Attractive Screen Designs

Based on Figure 4.1, the majority of respondents agreed that the screen design is interesting, which is at 52%, followed by the opinion strongly agree by 48% indicated that screen design is attractive.

B. Clear and Readable Text

The text is referred to the text used in the development of e-materials and in the content of e-materials. Figure 4.2 shows that the respondents strongly agree that the text is clear and readable with the highest percentage of 62%, followed by agree by 38%.

C. Effective use of Graphics

Graphics are included other than text in the contents such as icons, buttons and symbols. Based on Figure 4.3 below, 50% of respondents strongly agree that graphics are attractive, 50%, followed by the agreed opinion of 39%, and 11% was neutral about the graphics in software is attractive and effective.

D. Effective use of Colours

Colours play a role in the development of multimedia to attract users to use the e-material. Figure 4.4 shows that the respondents strongly agreed and agreed that the colors used are effective with the highest percentage of 41%, and then it is followed by neutral by 17%.

E. Effective use of Audio

Audio used includes sound effects, music and voice recordings. The majority of respondents agreed that the audio used is effective, that is 52% as shown in...
Figure 4.5. Percentage of strongly agreed stood at 45%, and 3% was neutral with the question.

**F. Interactivity**

The software provides interactivity elements such as mouse roll over and mouse click. The majority of respondents agreed that the elements are simple and adequate to be used by 52%, as shown in Table 4.6. Percentage who strongly agreed is 41%, and neutral by 7%.

**G. Effective use of Links**

Link is one of the techniques in hypertext and hypermedia. Majority of respondents strongly agreed that the link to each topic and the desired site is simple, ie by 48% as shown in Figure 4.7. It is followed by agreed percentage by 34%, and neutral by 17%.

**H. Effective used of Icons and Symbols**

Icons, buttons and symbols are the elements that are used to navigate the software. The majority of respondents agreed that the elements are clear and easy to understand, which 59% as shown in Figure 4.8 is. Percentage agreed respondents are 38%, and neutral only by 3%.

**I. Effective use of Application Guide**

User applications available to users are clear and easy to understand. Based on Figure 4.9, respondents agreed that the guide is easy to understand by 55%, followed by the strongly agree by 38%, and neutral recorded by 7%.

**J. Overall Application Performance**

The questions concluded the overall satisfaction on the performance of applications. Based on Figure 4.10, the respondents agreed that the overall performance of the applications with the highest percentage at 52%, followed by the strongly agreed by 45%, and neutral just posted a 3%.
V. CONCLUSIONS

It can be concluded that the results shown that the e-materials produced is at an acceptable level and meets the requirements of the targeted users. However, the findings of the analysis resulted from the existing results and do not mean the application is as a result of its best. Opinions expressed responded on the results of disagreement definitely shown dissatisfaction with the application developed. Therefore, continuous improvement is necessary in order to be reproduced better quality products and meet the requirements of all users.

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Abstract—This paper presents the process and impact of the application of a group decision support system (GDSS) in the reform of post-Bologna graduate and postgraduate study programmes in two higher education institutions in Slovenia. Four experiments with four groups including both students and staff were performed. We have used the GDSS tool TeamWorks to organize, moderate and document meetings intended to develop possible answers to the question "How can we improve the content and execution of the study programmes?" The obtained results are to be used in the design of new study courses. Analysis of the idea gathering process dynamics represents important information for researchers in the field of group decision-making process dynamics. In addition to the experimental work the structure of a group decision support process is described and guidelines for the further development of tools and methodologies are presented.

Keywords—Group Decision Support System; Education; Decision Process Dynamics; Expert System; Study programme

I. INTRODUCTION

Due to increased competition in higher education environments, universities adopted modern information and communication technologies (ICT) with the aim of completing high quality educational processes [1]. Group Decision Support Systems (GDSS) provide a useful tool for group collaboration and effective decision-making process. Sessions supported by GDSS can be more goal oriented, meeting agenda is easier to enforce and the members of the group provide the direction to each other [2]. GDSS support affects group interaction processes by increasing information influence (accepting information from other members as a reality) and decreasing normative influence (desiring to conform to the expectations of other group members) [3],[4].

The reform of study programs is a process where Group Decision Support Systems (GDSS) can be put to best use. In an academic environment the groups of teachers on the one hand and students on the other hand are directly addressed. Different study fields and departments in the organizational structure also need to be considered.

We have applied GDSS in the study programme reform process at two faculties: Faculty of Information Studies in Novo mesto, Slovenia (study programmes Informatics in Contemporary Society and Information Society) and School of Advanced Social Studies, Slovenia (study programmes Intercultural Management and Sociology), using the GDSS tool Teamworks [5]. Additional experiment was performed with the group of the students from the University of Maribor, Faculty of organizational sciences in order to compare gathered results. TeamWorks was developed to support group decision-making processes using the e-meeting paradigm. TeamWorks supports the execution of meetings by providing automated meeting minutes, agenda tools, idea gathering, categorisation and voting. It supports group collaboration, ensures anonymity of contributors and improves the efficiency of group decision-making process [6-11].

The purpose of the presented research covers three areas: a) to provide appropriate feedback from the students and staff regarding the reform of study programs, b) to analyse the dynamics of the creative process, c) to contribute to the further development of methodological and technical systems to support group decision making processes.

Four groups of students that were involved in the research came from the following faculties: a) Faculty of Information Studies in Novo mesto, b) School of Advanced Social Studies in Nova Gorica, c) Faculty of Organizational Sciences, University of Maribor. Staff members came from the following faculties: a) Faculty of Information Studies in Novo mesto, b) School of Advanced Social Studies in Nova Gorica. The diversity of the participating groups certainly contributes to the diversity of views on the reform of study programs.

II. METHODOLOGY

To support the decision making process we have used the GDSS TeamWorks [5] tool, which implements the e-meeting paradigm and acts as an intelligent agent. Russel and Norvig [12] noted since the 2nd edition of their seminal book in 2003 [12] we have seen a widespread application of several Artificial Intelligence methods in addition to advances in the AI theory and algorithms. Perhaps we are nearing the era when the “intelligent” behaviour of appliances and application will be the norm, and the intelligence will be seen as an aspect of good design, and such solutions recognized as merely “user-friendly”. Russel and Norvig [12] define AI as “define AI as the study of agents that receive percepts from the environment and perform actions.” In this sense, the GDSS system used in the research presented in this paper embodies an intelligent
agent, that implements simple decision methods for “Communicating, Perceiving and Acting” to take on several traditionally human roles present in a methodologically supported and structured meeting, i.e.:

- Meeting moderator: implements a meeting methodology to guide the participants through a series of meeting steps intended to bring them closer to a decision on the discussed problem.
- Meeting note-taker: documents the meeting steps and participant inputs in a structured document.
- Data analyst: applies quantitative methods to participant inputs to generate a statistical analysis of meeting events and results, giving insight to group dynamics in the meeting.

In this sense the GDSS is similar to the category of software popularly referred to as “wizards” (e.g. installation wizards, document creation wizards etc.), which implement AI methods usable for “simple decisions” as stated by Russel and Norvig [12], i.e. decision networks and multiattribute utility functions in order to automate a sequence of tasks.

Using the Teamworks GDSS, several activities were performed: collecting ideas (brainstorming), sorting ideas into categories, voting on priorities of categories and voting on the importance of ideas in each category. The TeamWorks GDSS system consists of a network of personal computers, where one of the computers acts as a TeamWorks server and others as clients.

The session participants are:

- decision group, in our case consisting of students and/or staff members,
- technical manager and
- content manager.

The technical manager of the session moderates the meeting using the TeamWorks server to ensure a smooth interaction of participants and progress according to the meeting agenda. The meeting should also include a content manager, familiar with the problem area and work methods, responsible for the session focus. Session management is simultaneously controlled and coordinated by the technical manager. All the participants should be able to monitor the session progress via the projection of the technical manager’s workstation, displaying the initial question, as well as current ideas, the voting results and other activities. Implementation of the session and the installation of the system are presented in Fig. 1. After the initial problem presentation the brainstorming part of session is started. This part of session in our case lasted for 30 minutes. Basic principles to be followed during the session are: a) the quantity of ideas can increase quality, b) any idea is welcome, negative criticism and ideas are to be avoided, c) unusual ideas can initiate a positive change of problem perspective and c) a combination of existing ideas can generate new ideas.

The mechanism of the collection of ideas is presented in Fig. 2. An adequate number of virtual sheets to record ideas on the topic/question about the reform of study program are generated for the participants. At the outset, one of the sheets is randomly sent to each participant. Participant writes/enters a new idea on the sheet. When an idea is entered, the sheet is forwarded to another randomly selected participant. Each participant can read the other participants’ ideas on the sheet. Using this mechanism, ideas are circulating among the participants. The insight into the ideas of other participants contributes to better understanding of the topic/question and intensifies the creation of new ideas. New ideas generated by the group can be seen on the projection screen. The content manager usually comments newly formed ideas and seeks to promote the collection of innovative, strategic ideas. At the end of the session, the participants are invited to answer a questionnaire, which is used to obtain feedback on the session experience and suggestions for improvements.

![Fig. 2. Mechanism of sheet exchange between participants in TeamWorks [5].](image)

III. RESULTS

In the first iteration of present research, three groups were involved in the experiment. Their sizes were $N_1 = 15$ (11 male, 4 female), $N_2 = 13$ (5 male, 8 female) and $N_3 = 9$ (5 male, 4 female). Postgraduate students of the Faculty of Information Studies in Novo mesto (FIS I) participated in the first group, first year students of the Faculty of Information Studies in Novo mesto and students of the School of Advanced Social Studies in Nova Gorica (FIS II) participated in the second group. The third group included students in the third year of undergraduate studies in the field of Information Systems, Faculty of Organizational Sciences University of Maribor. The problem/topic and a short introduction basic usage of the TeamWorks [5] tool were presented to each group of students. The initial question posed to participants was: “How can content and performance of the study be improved?” In all
three groups brainstorming was conducted anonymously as each participant randomly picked a username and password from a set of leaflets with printed login information. The number of generated ideas and the intensity of the group are presented in Table 1. The number of ideas per participant generated in the course of 30 min is defined in the table as group intensity. Based on gathered data, the number of ideas in one minute is calculated and presented in the table.

![Graph showing the dynamics of idea gathering in three groups, FIS I., FIS II., and FOV.](image)

Fig. 3. The dynamics of idea gathering in three groups, FIS I., FIS II., and FOV.

One-way ANOVA was used to compare means of gathered ideas in groups. The results of ANOVA showed that the null hypothesis on equal number of gathered ideas regarding the group can not be rejected at 5% significance level (Sig. 0.060>0.05). Therefore, there are no statistically significant differences between the average number of gathered ideas in discussed groups.

![Graph showing the dynamics of idea gathering in three groups, FIS I., FIS II., and FOV averaged for 5 minute periods.](image)

Fig. 4. The dynamics of idea gathering in three groups, FIS I., FIS II., and FOV averaged for 5 minute periods.

The differences in the process of idea generation can be seen in the analysis of the time between generated ideas. Fig. 5 and 6 show the distribution of time between generated ideas for group FIS I. and FIS II. A typical form of an exponential distribution is evident, but we cannot assume it is the Poisson process, since the input or acceptance capacity of ideas is unlimited.

<table>
<thead>
<tr>
<th>Group</th>
<th>FIS I.</th>
<th>FIS II.</th>
<th>FOV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of ideas</td>
<td>149</td>
<td>170</td>
<td>65</td>
</tr>
<tr>
<td>Number of participants</td>
<td>15</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>Time [min]</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Num. ideas/par./min</td>
<td>0.33</td>
<td>0.44</td>
<td>0.24</td>
</tr>
</tbody>
</table>

TABLE I. THE NUMBER OF GENERATED IDEAS AND GROUP INTENSITY

![Graph showing the distribution of time between ideas for FIS I. and FIS II.](image)

Fig. 5. The distribution of time between generated ideas for group FIS I. and FIS II.

![Graph showing the distribution of time between ideas for FOV.](image)

Fig. 6. The distribution of time between generated ideas for group FOV.
The distribution of time between generated ideas for group FOV is presented in Fig. 7. A difference in the form of distribution can be seen, which indicates the differences of the groups. The presented distribution has all the characteristics of the uniform distribution.

Considering the results of the groups the statistical test of differences in the work intensity in the group was performed. The nonparametric Kruskal-Wallis test was used. A comparison of the work intensity in the three groups was carried out. The number of gathered ideas per participant in the time interval of five minutes was considered. Table 2 shows the data for the Kruskal-Wallis test.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Average rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIS I.</td>
<td>6</td>
<td>11.25</td>
</tr>
<tr>
<td>FIS II.</td>
<td>6</td>
<td>12.50</td>
</tr>
<tr>
<td>FOV</td>
<td>6</td>
<td>4.75</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>

Hypothesis about the different dynamics of the three groups can be confirmed at risk level $p = 0.05$; $X^2 = 7.312$, $df = 2$, $p = 0.026$. Here the Kruskal-Wallis Test was applied in order to compare the dynamics of the groups with 2 degrees of freedom for three groups.

The ideas that were rated as the most important for the improvement of content and execution of the study programmes are presented in Tables 3-5. These ideas are selected from the gained categories, up to four from particular category.

<table>
<thead>
<tr>
<th>Id. No.</th>
<th>Idea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction of three different fields: 1) focus on computer science;</td>
</tr>
<tr>
<td></td>
<td>2) focus on social sciences; 3) focus on business - computer science</td>
</tr>
<tr>
<td>2</td>
<td>Increase the number of computer science courses while reducing the</td>
</tr>
<tr>
<td></td>
<td>number of social science courses</td>
</tr>
<tr>
<td>3</td>
<td>Better faculty support in job search of students</td>
</tr>
<tr>
<td>4</td>
<td>More practical work and less theory, more group work in classes</td>
</tr>
<tr>
<td>5</td>
<td>Computer forensics as a mandatory class</td>
</tr>
<tr>
<td>6</td>
<td>Block lectures</td>
</tr>
<tr>
<td>7</td>
<td>More interaction between students and professors during lectures and</td>
</tr>
<tr>
<td></td>
<td>less tedious lectures</td>
</tr>
<tr>
<td>8</td>
<td>The possibility of obtaining a professional certificate via courses</td>
</tr>
<tr>
<td></td>
<td>(e.g. Microsoft or Cisco)</td>
</tr>
<tr>
<td>9</td>
<td>More content on Moodle, supported by video recordings of lectures and</td>
</tr>
<tr>
<td></td>
<td>lab work</td>
</tr>
<tr>
<td>10</td>
<td>No seminar papers and more computer lab work</td>
</tr>
<tr>
<td>11</td>
<td>Inclusion of &quot;Living Labs&quot; in the study process. Students could</td>
</tr>
<tr>
<td></td>
<td>then pass their ideas in the study process</td>
</tr>
<tr>
<td>12</td>
<td>Open computer lab, as a sandbox for new ideas and learning about</td>
</tr>
<tr>
<td></td>
<td>computers and communication equipment</td>
</tr>
<tr>
<td>13</td>
<td>Just one location for lectures and exercises / relocation of</td>
</tr>
<tr>
<td></td>
<td>universities and higher education institutions into a science park or</td>
</tr>
<tr>
<td></td>
<td>incubator</td>
</tr>
<tr>
<td>14</td>
<td>Simpler faculty’s website / better information on the remaining</td>
</tr>
<tr>
<td></td>
<td>obligations of students / more transparent student’s web forms</td>
</tr>
<tr>
<td>15</td>
<td>Overly difficult schedule / schedule that is more relaxed, fewer</td>
</tr>
<tr>
<td></td>
<td>weekly lectures and exercises</td>
</tr>
</tbody>
</table>
TABLE IV. KEY PROPOSALS (FIS II GROUP).

<table>
<thead>
<tr>
<th>Id. No.</th>
<th>Idea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Less busy schedule, less weekly workload, lecture free days.</td>
</tr>
<tr>
<td>2</td>
<td>More lab work and fewer lectures</td>
</tr>
<tr>
<td>3</td>
<td>One course at a time instead of several courses in a week, fewer lectures</td>
</tr>
<tr>
<td>4</td>
<td>Better organization of work</td>
</tr>
<tr>
<td>5</td>
<td>Provision of compulsory materials (in physical form) for each class</td>
</tr>
<tr>
<td>6</td>
<td>Material published prior to lectures on &quot;Moodle&quot;</td>
</tr>
<tr>
<td>7</td>
<td>Seminar paper does not present best current practice (is outdated). Seminar papers are expected to be mostly practice oriented without theory.</td>
</tr>
<tr>
<td>8</td>
<td>Less extensive material, more in-depth treatment of courses</td>
</tr>
<tr>
<td>9</td>
<td>Too much theory, not enough cases</td>
</tr>
<tr>
<td>10</td>
<td>Start of lectures at 16:00 and no later (graduate studies)</td>
</tr>
<tr>
<td>11</td>
<td>Timely information concerning the changes in timetable</td>
</tr>
<tr>
<td>12</td>
<td>Career monitoring of the graduates and their employability</td>
</tr>
<tr>
<td>13</td>
<td>Provide more practical experiences, which are useful for further work</td>
</tr>
<tr>
<td>14</td>
<td>More practical examples and more integration of current life situations in lectures</td>
</tr>
<tr>
<td>15</td>
<td>Increasing the number of parking spaces, better location for lectures</td>
</tr>
<tr>
<td>16</td>
<td>Occasional foreign guest lecturers (world-class)</td>
</tr>
</tbody>
</table>

TABLE V. KEY PROPOSALS (FOV GROUP).

<table>
<thead>
<tr>
<th>Id. No.</th>
<th>Idea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Modernization of the curriculum</td>
</tr>
<tr>
<td>2</td>
<td>Less theory and more practical examples</td>
</tr>
<tr>
<td>3</td>
<td>Fewer courses not related to the chosen field of study</td>
</tr>
<tr>
<td>4</td>
<td>More emphasis on IT classes and not learning the basics of e.g. Word and Excel</td>
</tr>
<tr>
<td>5</td>
<td>Provision of free courses for students (programming, foreign languages,...)</td>
</tr>
<tr>
<td>6</td>
<td>Class Computing and informatics should keep pace with time and abandon the &quot;assembler&quot;, etc... considered to be social networks, etc...</td>
</tr>
<tr>
<td>7</td>
<td>Fewer classes, which should be more profound and not superficial</td>
</tr>
<tr>
<td>8</td>
<td>Possibility to follow the lectures and tutorials online</td>
</tr>
<tr>
<td>9</td>
<td>E-classrooms contain boring documents and presentations without innovative approaches, audio and video contributions, interactivity...</td>
</tr>
<tr>
<td>10</td>
<td>The possibility of implementing practices abroad</td>
</tr>
<tr>
<td>11</td>
<td>Improve the efficiency of the student affairs office, more friendly attitude towards students</td>
</tr>
<tr>
<td>12</td>
<td>Organise visits to successful companies</td>
</tr>
<tr>
<td>13</td>
<td>Faculty’s help with job hunt</td>
</tr>
<tr>
<td>14</td>
<td>Better connection of the studies with bigger and successful companies in Slovenia, given that the focus of the courses is IT for medium and large enterprises</td>
</tr>
<tr>
<td>15</td>
<td>Reducing the costs of part-time study, co-financing</td>
</tr>
<tr>
<td>16</td>
<td>Encourage businesses to employ students full-time and co-finance part-time study</td>
</tr>
<tr>
<td>17</td>
<td>Free literature (books)</td>
</tr>
<tr>
<td>18</td>
<td>More literature in the library (books used in lectures)</td>
</tr>
<tr>
<td>19</td>
<td>Books in electronic form, which could have been purchased in the iStore, etc...</td>
</tr>
</tbody>
</table>

Fig. 8 shows the structure of the session implementation with TeamWorks tool [5]. The complexity of the described decision-making process can be anticipated since only a part of the structure is presented in the picture. FreeMind [13] open-source software is used to present the process.

Fig. 8. Example of session structure export from TeamWorks [5] to FreeMind [13]. The representation of the structure is in the original language.

After the sessions, the participants answered a questionnaire that was used to obtain feedback and suggestions on the further development of the TeamWorks tool. The participants generally believe that the tool is effective for group decision-making and creative processes, but there is a lack of awareness that such tools and methodology actually exists.

IV. ADDITIONAL APPLICATION ON THE CASE OF DOCTORAL STUDY

As the additional research, we have performed the case study of reforming doctoral study at the School of Advanced Social Studies in Nova Gorica (we will name the group as FUDS). Here 10 participants collaborated. The group was a mixture of students and staff members (professors). In the Fig. 9 the dynamics of the idea generation for the FUDS group is shown. If one compares the dynamics to the previous three groups one could observe, that these group did not show fast rise and the decline in the process of idea generation. Here rather stable generation of the ideas was observed. This could be due to the fact, that the topic was addressed more seriously since the professors collaborated in the session and also provide the feedback on the generated ideas.
The results obtained by experiment groups represent important information for reforming the curricula of the study programmes. Because of the diversity of groups, with the participants from the three faculties, undergraduate as well as postgraduate studies, the results obtained are more diverse. Important indication is difference between the intensity of fourth, FUDS group work and other groups. This provides the starting point for the new research where the correlation between the group members profile and the efficiency of the group would be examined.

Diversity in this case is advantageous because it gives more extensive treatment of the problem and provides a wider range of ideas for improvement and reform of study programmes. In addition to the ideas gathered we have gained important information about the dynamics of the creative process, which is highly important for the development of contemporary information society. We believe that further in depth study of this type of process and usage of knowledge gained is necessary to develop better, more effective systems for group decision support. The feedback from the participants will serve to further develop and update the functionality of TeamWorks tool [5]. According to the opinion of decision group members this type of decision support tools should be regularly used in strategic decision making processes.

TABLE VI. KEY PROPOSALS (FUDS GROUP).

<table>
<thead>
<tr>
<th>Id. No.</th>
<th>Idea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>According to possibilities, to involve doctoral students in research projects carried out at FUDS.</td>
</tr>
<tr>
<td>2</td>
<td>More meetings where doctoral students could present their current research work</td>
</tr>
<tr>
<td>3</td>
<td>Make special courses for particular topics</td>
</tr>
<tr>
<td>4</td>
<td>Intensify cooperation on the relation student-&gt;professor and professor-&gt;student</td>
</tr>
<tr>
<td>5</td>
<td>To make &quot;brainstorm&quot; meetings among students, who discuss their topics and how to improve them</td>
</tr>
<tr>
<td>6</td>
<td>Concrete and more frequent discussion on the current state of the research work in the frame of doctoral study. This should provide a possibility to exchange ideas.</td>
</tr>
<tr>
<td>7</td>
<td>Free enrolment to NUK and other relevant databases.</td>
</tr>
<tr>
<td>8</td>
<td>Paid doctoral researches from the side of enterprises.</td>
</tr>
<tr>
<td>9</td>
<td>Cooperation with other faculties; subventions for the student exchange.</td>
</tr>
<tr>
<td>10</td>
<td>Lecture on the topic: how to write scientific paper.</td>
</tr>
<tr>
<td>11</td>
<td>Better connection regarding the research work in the case of first year of study (help at the involvement of the institution)</td>
</tr>
<tr>
<td>12</td>
<td>To provide an opportunity to involve students in the research projects.</td>
</tr>
<tr>
<td>13</td>
<td>Access to the newest scientific papers.</td>
</tr>
<tr>
<td>14</td>
<td>Remote access to as many as possible databases.</td>
</tr>
<tr>
<td>15</td>
<td>Doctoral students should be motivated to attend conferences.</td>
</tr>
</tbody>
</table>

The additional case study provides indication, that different group structure influences the intensity of work.

REFERENCES


študijskega programa informatike],“ v Dnevni slovenske informatike, Portorož, 2012.


Abstract—Studies on human engagement behavior whilst interacting with multimedia environment has now become very important due to the era of convergences of immersive technology in various digital platforms. This paper will describe a system to measure human engagement behavior in NORMA (Natural Observation and Reflection of Multimedia Application) experimental setting. The tool was developed as a Proof of Concept of The NEMD Model (Norma™ Engagement Multimedia Design Model) a renamed of An Engaging Multimedia Design Model that could explain the engagement phenomenon that has enticed the use of virtual spaces to complement its physical form. This paper is a description of The Measuring Engagement (ME™) Tool automated system in comparison to a system done manually. The system has proven to be a useful tool to enable us knows more about engagement and the phenomenon surrounding it. Findings could help us know more about engagement that may lead to excessive, immersive and addictive use of innovative technologies.

Keywords—multimedia; model; engagement; engaging; system; tool

I. INTRODUCTION

This invention is an automated system to measure human engagement behavior when interacting with a multimedia interface. The invention named The Measuring Engagement (ME™) tool is a NEMD version 2.0 system developed from a theoretical model NEMD MODEL (Norma™ Engangement Multimedia Design) Model [1, 2, 3]. This version is fully automated version which includes a database that collects exact facial expressions and interface in-real time during interaction. The data stored in the database will give a record of all events which include facial expression, interface and engagement levels at the time it occurs.

II. ENGAGEMENT

Engagement a psychological phenomenon is logically something that could not be measured but is an important psychological phenomenon that could determine the success or a failure of a design system.

According to research findings to prove the model, a system, be it a multimedia or a website application, is termed “successful” if the system could engage and sustained engagement. Engagement here can be defined as “Any form of representation of systems’ design that could make the user or audience ‘remain seated’, ‘be fully engrossed’, which is referred to as ‘fully engaged’ and has ‘the ability to sustain the engagement level, at a reasonable period of time of one to two hours or more’ is a vital factor to “ensure user engagement” and will be defined as ‘successful’ by the end-user or audience” [4]. Since most systems are gauge based on successfulness a system is a failure if it fails to engage the user. Therefore engagement is an important phenomenon in the evaluation of the design and development of multimedia application in various digital platforms.

III. BACKGROUND DEVELOPMENT OF TOOL

A form of system must be created to measure engagement. A manual system developed in 2004 is now named as NEMD version 1.0 (patent filled in 2009) was the first attempt in creating a system to measure engagement. The system was developed to assist the researcher in determining factors that cause users to be more engaged in one multimedia application to that of the other. The system was created and used in an experimental study towards the development of An Engaging Multimedia Design Model renamed The NEMD Model (Norma™ Engagement Multimedia Design) Model after an extended research to prove it[1, 2, 3].

A statistical data that has successfully been gathered by using this measuring system has proven that a tool could be created to measure engagement. The tool which was then a manual system has managed to measure engagement in various experimental conditions when the children were playing an engaging edutainment game The Sims – The People Simulator from the Creator of SimCity [CD-ROM] US, Electronic Arts (Maxis) (2000) to develop the engagement model. The data gathered from using the tool has helped the research knows more about engagement and the phenomena surrounding it. Some statistical data samples as seen in Fig 1, Fig. 2 and Fig. 3 below has given the researcher a basis to discover more about engagement and how engagement has
enticed the use of virtual spaces to complement its physical form.  

a. **Statistical Results of Study 3 - Testing the Engaging Multimedia Design Model using Kruskal-Wallis Tests**

b. **Statistical Results of Study 4 – A Study of Previous Experience SIMS WE Group (With Experience) versus SIMS WOE (Without Experience) Group**

Findings from the experiments have given a six component engagement model comprising of factors acronym as GIFCES (Goals, Immediacy, Feedback, Construct, Experience and Simulation). The experiments have shown that engagement is affected by levels having Construct and Simulation complimenting each other.

There is a need to know more about engagement in other experimental settings using other platforms and application. It is because of this the system was further developed into this presented version NEMD version 2.0. Feedbacks from here will be useful in the development of NEMD version 3.0

IV. **AN ENGAGEMENT SCALE SCORE**

NEMD version 1.0, a manual version, uses An Engagement Scale Score to measure engagement. Fig. 4 shows how the scale looks like. The scale score were given to users at the beginning of the experiment. In these sheets, a set of eight per sheet for a 40 minute interaction time, users are asked to tick at a scale of 0-10 of the degree of engagement level they were at as they went through interacting with a multimedia system at consistent intervals. The engagement scale is self-declared by users manually through given sheets. A timer is placed at a set of intervals and users were asked to place their feelings every time the bell rings.

Since the users were fully engrossed and immersive in the games or application given to them they often forget to place their indication. In this early experiment a person is employed as a reminder to make sure user ticked when the bell rings.

Even though the presence of the bell and the person does cause some distraction, regular and consistent interruptions at intervals does not distract users’ engagement stand. Research in [5] has also proven that users can be engaged, disengaged and reengaged again at any one time.

The self-declared data is not enough to measure engagement. Facial expressions and exclamations are some indicators of engagement. Therefore in this earlier study to develop the model users’ facial expressions were video.
recorded separately. Each facial expression was recorded using cameras at the ceiling, side and the back. The experimental study to test, redesign and retest the model was feasible because it was done in a usability lab in Loughborough University, United Kingdom in from 2002 to 2004 [6]. The building was equipped with cameras at the ceiling, side and the back. Everything is controlled in a room seen and observed by the researcher in another room with a one-way mirror. The interface and the facial expression of the user at the time of interaction were then superimposed to see what goes on at every 5 minutes during interaction. The data then was counter checked with the engagement scale sheets done manually to see which interface engages and disengage users.

As a result, the system is not portable. The screen captures of facial expressions even though occurring concurrently in-real time was separately analyzed by revisiting the superimposed recorded version of the engaging situation. Matters become worst when there is no usability lab in the present institution. Studies to prove the model becomes difficult and unpopular. Situations of setting up experiments to study online and offline activities become very cumbersome. A research team was gathered to develop this system into an all-in-one in-real time invention named as a measuring engagement tool The ME™ Tool. The system uses an open source operating platform in its’ NEMD version 2.0 version NEMD version 3.0 (still in its alpha stage) will be operating on its own platform and will be released soon.

V. THE INVENTION

This invention is a consolidation of a copyright and patent pending previous invention, “A Process for Determining Human Engagement Behavior in Multimedia Design System based on Designing Features which Exploit Psychological Needs made known as “The X-Factor in A Multimedia Engagement Behavior”. The invention has received a patent filing number as “A System to Measure Human Engagement Behavior” on 13 March 2009. This NEMD version 2.0 is a fully automated system.

VI. NEMD VERSION 2.0 VERSUS NEMD VERSION 1.0

NEMD version 2.0 system has made the whole scientific research process done on young teens 12-17 to develop an Engaging Multimedia Design Model [1,2,3,4] and [6] a much more comprehensive system to measure engagement. Since engagement in online activities have affected people from young teens to adults, all activities of engagement of users aged below, above and beyond 17, going through an engagement behavior whilst interacting with an interface design, could be measured much easily that the previous manually measured system.

VII. THE MEASURING ENGAGEMENT (ME™) TOOL (NEMD VERSION 2.0)

The Measuring Engagement (ME™) Tool uses a fully automated visualization method. NEMD version 2.0, is a measuring tool that can be used to measure user engagement level in-real time. The system could give us records of the compilation of screen capture; human face capture; and graphical representation of human engagement behavior as user interact with a multimedia application or an online website. The data are stored in a centralized database. The data collected could be used by developers of multimedia and online application to design, test and redesign a product.

VIII. USEFULNESS OF TOOL

A. Designers and Developers

This tool is useful to a number of stakeholders. The tool is especially useful to designers and developers of online multimedia applications include e-learning content developers. Designers and developers could use this tool to study the development of multimedia application before, during and after the production process. Such effort enables designers and developers cut down production cost in doing iterative methods. Errors and failures in design especially on disengaging factors could be detected in-real time. The compiled data will help designers and developers produce better quality products. High quality products when mass produced could give positively high monetary returns.

This automated system will enable designers and developers know the overall performance of the designed system as the user interact with them through data collected over a period of time. The record of findings will help designer design or redesign particular spots at a particular time. Designers of websites will be able to design validly engaging products. Therefore the data gathered from this system is especially useful for e-learning content designers to create applications for immersive technologies and futuristic life long learning materials.

B. Researchers

The development of this automated version can be extended its usefulness even more. The ME™ Tool of NEMD version 2.0 can cover a wider spectrum of users especially those researching on online activities. Researchers of online activities can determine levels of engagement of the application in-real time with data like screen captures of the user facial expression, screen capture of exact interface location, record of a particular point in time of engagement level, and an overall performance of engagement part. All the data are stored in .pdf form.

The .pdf data will be useful to academicians and researchers in learning institutions like schools, colleges and universities studying online activities. The data is useful to those research concerning engaging online activities. Researchers can use data to study on games, effects of social media, harmful addictive online activities of games and websites, cross cultural transfer studies, language discourse studies analysis, etc. Data gathered can help users create
models and theories in both the sciences and social sciences disciplines.

C. Research Agents and User Satisfaction Studies

This tool is also useful for research agents that are commission to measure user satisfaction in websites for commercialization purposes. Its automated system NEMD version 2.0 could accommodate real-time research of studying online activities for research agents doing research analysis for clients of commercial websites; for designers of learning programs e.g. testing smart learning materials for smart learning centers’ programs and the like.

The data collected will be kept in the designed database for easy retrievable. From the record research agents will be able to do an analytical study of the website designed by organizations like detecting and suggesting ways to improve customers’ design profile. The research agent will be able to tell clients what to do and not do if the application lacks the engagement factor from the data collected over the three forms of data: the facial expressions; the visual interface, and the engagement level. The measure of users’ psychological feelings would be made much quicker and easier to complete because each interaction could be measured through visualization as pop-ups on the screen. Whatever is presented could be seen and studied on the spot. In this NEMD version 2.0 automated versions the data can show the rise and fall of engagement pattern of users per interface per facial expressions at a set interval. The overall performance of data will be plotted as graphs and ready to be assigned for data analysis.

D. Data samples

The system has been tested in a number of experimental studies and has received good feedback. Students in the Language department have used the system to do many language study research of online activities. E.g. language discourse analysis of bloggers using online systems; identification of rhetoric components in online religious speeches; looking at engagement features in online snooker game; trace metacognitive strategies when engaging in online activities while playing games. A sample given below will give us an overview of the data obtained from the system. Fig.5 represents the logo of the patent filled Measuring Engagement (ME™) Tools.

Fig 6 and Fig. 7 shows part of the output got from using the system. Researcher or developer or designer could detect the facial expressions of users and gauge their engagement level as they go through the interaction with the multimedia application of online activities. In Fig. 6 the facial expression at the point of level of engagement for interval 1 is detected.

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Fig. 5: The Measuring Engagement (ME™) Tool Logo

IX. EXAMPLES OF AN ANALYSIS OF DATA SAMPLE

Fig. 8 is a sample of how the given data above in Fig. 7 could help a researcher in analyzing the metacognitive strategies used by the player in playing this Snooker Online Game. Before this let us first define what metacognitive strategies are. By definition metacognition refers to thinking about thinking or cognition about cognition [7] and [8]. Metacognition therefore is defined as “one’s knowledge concerning one’s own cognitive processes and …… that influences the execution of cognitive tasks.” Through metacognition, a person confronting a cognitive task can select a strategy and then monitor and regulate their progress on a task. The monitoring process allows a person to more effectively control his or her cognitive processes, thereby affording more efficient and active learning [9] in [10]
As far as gaming activities are concerned, metacognitive strategies involve strategic planning, monitoring, and regulating action. The steps taken are more specifically of planning that involves goal settings, generating questions, analyzing how to achieve the target goal, and selecting and organizing information for one’s decision. Through regulating action, a child modifies the actions or decisions in order to achieve the goal. [10]

When doing a metacognitive analysis of this case, a researcher will look closely at these engagement patterns and try to trace reasons why it occurs. In Fig. 8, the fall in engagement is known as ‘dips’. Dips are evidence of some form of ‘disengagement’. The data will enable a researcher to use an analytical and critical judgment as to ‘Why it happens’ and ‘when it happens’. Implementing the metacognitive strategies of planning, monitoring and evaluating into the patterns of engagement behavior collected will help the researcher justify the cause of this rise and fall phenomenon. Refer to [10] for a more comprehensive study of metacognitive strategies studies of gaming activity.

The emerging pattern of engagement could be classified into seven categories:

1) Low levels of engagement
2) The starting level range
3) Dips
4) Gradual increase and gradual decrease
5) Plateaus
6) Maximum
7) The ending level range

The description of these categories is based on three sources:

a. Comparing data
b. Scores of Engagement that fit the discussed category
c. Individual Cases Examples.

The above category was used in [10]. However, for this case only ‘dips’ at the starting and ending points will be discussed in analyzing the likely metacognitive thinking strategies that occurs during interaction. The first ‘dip’ is after the first starting interval and the second ‘dip’ after the highest engagement level.

X. METACOGNITIVE STRATEGIES ANALYSIS

Here is an example of how a metacognitive strategies data analysis could be done of the above case study of the girl in Fig. 8. The girl started by marking a 5/10 score when playing the game for the first time. After 10 minutes into the game the score went down to 3/10. (In metacognitive strategies this would mean the child starts to evaluate the outcome of the action after a first encounter excitement. The unknown factor or fear of the unknown has caused some form of disengagement).

Observing other patterns it could be seen that there was a gradual increase in engagement patterns from the second to the third and the fourth interval after 30 minutes of playing the game. (In metacognitive strategies this would mean that the girl has now feels ‘in control’ of the game. Thus, she could plan, monitor and evaluate every steps of the game easily using strategies she has learned and used before, therefore at this stage, her engagement was at its maximum level.

Maximum engagement therefore is at the time when the girl has reached her targeted goals.

However, as in most games, designers will change a challenge and the girl is faced with a new challenge and obstacles. This usually happens every time a player encounters a new challenge immediately after achieving a win. (In metacognitive strategies analysis this would mean that the child starts to reevaluate the outcome of an action to overcome this new challenge).

Identifying the likely metacognitive strategies could be one form of iterative method a designer could use to design engaging educational and entertaining multimedia applications and websites. Knowing metacognitive strategies’ characteristics and identifying it with an engaging interactive game-play experience could give us insights into features that could be included when designing engaging materials. This system could assist designers in doing just that. Here a researcher who is studying on metacognitive strategies could use this system to detect what movements the girl made when playing the game.

XI. OTHER SUGGESTIONS FOR ANALYSIS

From the data a designer or developer could use the data to detect usability issues on design products like games and websites, in this case, usability of the snooker game designed for online gaming. The system could be customized by the user of the system according to their need. Users of system could set the timing of intervals at any given time they like. They can customize it according to their own research demands. Thus in this way researcher, developer or designer could get to see all the interfaces set according to intervals in order to do a
A great appreciation to Universiti Putra Malaysia (UPM) for giving us the opportunity and support to continually pursue research on games under the Games and Gamification for Social Engineering Research Group, and from funding of the RUGS (Research University Grant Scheme), UPM. Special thanks is also conveyed to the PRGS (Prototype Research Grant Scheme) offered by the Ministry of Education under the Higher Education Division of the Government of Malaysia in continually supporting the development of this system to measure engagement and addictiveness into a much better system for the coming NEMD ver 3.0 version which will be released in the near future.

ACKNOWLEDGMENTS

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Intelligent Face Tracking for Collaborative Synchronous e-Learning using Pattern Recognition Model

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Abstract—Intelligent Face Tracking for Collaborative Synchronous e-Learning using Pattern Recognition Model can provide high levels of interaction for distance learning initiatives. With the rapid evolution of technology, face recognition login and tracking, continuous product evaluation is necessary to ensure optimal methods and resources for connecting students, instructors, and educational content in rich, online learning communities. This article presents the analysis of online, synchronous learning solutions. Focusing on their abilities to meet technical and pedagogical needs in higher education. To make a solid comparison, the systems were examined in online classrooms with instructors, guest speakers, and students. Relative to usability, instructional needs, technical aspects and compatibility are outlined for systems.

Keywords - e-learning; distance learning; collaborative learning; pattern recognition; face recognition tracking.

I. INTRODUCTION

In a relatively short amount of time, e-Learning has gained a permanent, highly visible place in the worldwide higher education community. A practice that a few years ago held only a niche role now is an indispensable element of many institutions’ curricula, success, and overall reputation. From working adult learners to full-time students living on and off campus to dedicated educators, individuals are increasingly taking advantage of synchronous e-Learning opportunities such as virtual lectures and mentoring, as well as asynchronous e-Learning offerings such as digital online courses, flexible content creation and distribution, and built-in assessment tools.

Collaborative synchronous e-learning is live, real-time and usually scheduled, facilitated instruction and learning-oriented interaction. This research emphasized “learning-oriented interaction” in order to differentiate synchronous learning from lecture, product demonstrations, and other “knowledge dispersal” activities. In opinion backed by plenty of research findings, the interaction is essential to learning. Collaborative synchronous e-Learning is synchronous learning that takes place through electronic means. Synchronous learning is distinguished from self-paced asynchronous learning, which students access intermittently on demand. Synchronous e-Learning has grown rapidly to become a significant component in most organizations and training environments. Collaborative synchronous e-Learning is live, real-time, interactive, electronically-enabled learning. Synchronous e-Learning sessions can usually be recorded and played back, but that’s not their primary strength or purpose. This research focus is on the live and the collaborative.

Although synchronous e-Learning is about utilizing tools to achieve effective training and education, identifying the main categories of synchronous e-Learning technologies is a good place to begin. Even though the rest of this research deals with what we will refer to as the “Web conferencing” category, it is important to differentiate these terms: Teleconferencing and its major sub-categories, audioconferencing and videoconferencing; Webcasting; Simulations; and Web conferencing.

II. KEY ADVANTAGES TO USING

Like most successful technology areas, synchronous e-Learning emerged to fill a need and then expanded to provide options previously unavailable to early adopters. The roots of synchronous e-Learning derive from three main influences: the classroom, the media, and the conference.
There are plenty of great reasons to adopt synchronous e-Learning approaches. Determining whether a learning need for synchronous e-Learning exists is rooted in its core definers. Synchronous e-Learning is real-time, interactive, collaborative and participatory, versatile, multi-modal (combining text, audio, video, graphics, etc.), and most importantly, fun and effective. Some of the key advantages to using Collaborative synchronous e-Learning include:

A. Connecting dispersed learners

Synchronous methods are especially well suited to organizations with geographically distributed learning populations. For instance, you may have a nationwide audience of regional representatives who need updating on product features and enhancements. Firms with telecommuters and remote learners will also realize tremendous advantages.

B. Real-time interaction and collaboration

Synchronous tools allow us to engage with other audience in real time, a very natural process that permits a spontaneous and flowing learning session. Answers to questions are immediate and clarification can be provided directly. Synchronous tools also lend themselves well to structured collaborative assignments. The social dimension of synchronous tools creates a learning synergy.

C. Sense of immediacy and co-presence

Synchronous tools are ideal for conveying late-breaking and time sensitive information. Since the human presence is so “front and center” when using these tools, the warm learner experience that is generated allays anxieties about the mechanical or depersonalized nature of technology-enabled learning.

D. Fostering a learning community

Learners benefit from sharing ideas and experiences with their colleagues. A major advantage to synchronous e-Learning tools is the development of a sense of connectedness and community among learners. Long term impacts can include better teamwork and collaboration skills, improved employee retention, stronger morale, and the formation of a collective identity.

E. Balancing learning dynamics

Synchronous e-Learning can reduce imbalances and create a more egalitarian learning experience. It can avoid the power dynamics of the face-to-face learning environment, where extroverts can dominate and where gender and other personal identifiers can impact group activities. Used effectively, synchronous e-Learning tools can overcome some of those barriers and level the field. The use of anonymous feedback tools can increase the comfort level of online participants by reducing the fears that adult learners often have around answering incorrectly in front of their peers. More generally, the variety of tools and communication choices available in synchronous e-Learning provides numerous options for connecting with diverse learners with different learning styles.

F. Unique functionality

Many synchronous e-Learning tools include features and functionality that offer unparalleled opportunities for fast and effective learning. Whiteboarding tools can permit class exercises that can be easily saved and recalled. Application sharing allows for rapid and easy group work. Web tours can guide learners to specific points of interest.

G. Extending application demonstrations

Provide software and desktop learning can benefit tremendously from the real-time application demonstration features of synchronous tools. Many tools also provide integrated virtual lab components, permitting supervised simultaneous practice sessions.

H. Synthesizing materials and concepts

Process-oriented tasks and information-heavy materials are best taught through asynchronous, on-demand training or reference materials. But the collaborative nature of synchronous tools makes them well suited to permitting learners to synthesize complex ideas. Synchronous e-Learning provides an online means for group learning techniques through discussions and dialogue, problem-solving exercises, and thoughtful reflection.

III. MAKING THE CONNECTION

Unlike basic audio conference calls, conferencing tools that support effective instructional methods to appeal to a wide variety of learning styles. The functions available and a few of their collaborative synchronous e-learning uses are:

- A slide or file display that allows the instructor to show students PowerPoint slides or other files.
- A whiteboard to brainstorm a list of ideas.
- Application sharing, so the instructor can do a software demonstration from one computer that can be seen by every attendee.
- Tool access, so the instructor can share the ability to use tools and functions of the online interface with students or other instructor.
- Peer-to-peer Chat, to get students to connect with other students.
- Instant feedback, to confirm the appropriateness of the pace and the content.
- Annotation, to focus students’ attention on a specific area of the screen.

A. Log-in with face recognition

Using only a browser, students and presenters can attend their Synchronous e-Learning on the Web by face recognition log-in and face tracking to access learns the content and multimedia.
B. Slide or display file

Instructor and Audience can use slides to help organize their content for presentation and to manage the flow of ideas. Bulleted lists, graphs, photographs, and screen captures help participants follow along. Often, by using this feature the instructor can also show sample documents created in Word, Flash, or HTML format. In fact, most products let you use the slides you already have, and they may support custom animations in PowerPoint. Another use of slides is similar to the advertising and trivia shown at movie theaters before the lights are turned down and the preview clips begin.

C. Whiteboard

With a whiteboard, instructors can encourage students to share ideas and comments through brainstorming, ask questions, and type their responses on the whiteboard. This promotes interaction, validates student input, and provides clarification for others who may not have heard the answers. The instructor can also use the whiteboard to sketch or annotate.

D. Tool access and sharing

The leader or leaders of the session control the images and tools that all online participants see. They can display files, annotate important points, and create quizzes slides. Students can contribute verbally, but cannot control the tools. You, or the training coordinator who sets up the session, can select the access level for each of the invitees so that two or more instructors can take turns delivering. There are also options that give all participants (almost) equal control.

E. Peer-to-peer Chat

Chat gives participants direct access to each other via text messaging, thus providing a forum for sidebar conversations and comments. Sessions where students work through a scenario and report their results to the group.

F. Student-to-Instructor Chat

Students are able to direct questions and ask for clarification without interrupting the flow of the class. Simply type their response back to the student.

G. Instant feedback

The comment I hear most from instructors about teaching online is that they miss being able to connect with students by observing behavior and asking Using instant feedback features, students can change an option on their screens to alert the instructor to slow down, speed up, or clarify.

H. Annotation

Create impact with annotation tools by drawing arrows to a particular object on the screen, circling or underlining words, or adding text on the fly. Participants can also use annotation tools in interactive exercises.

I. Multimedia content

Vary your instructional methods and engage student interest by showing AVI, Flash, or other action clips. Check your software product information for a list of supported file types. Users can use clips from Help files, materials, portions of asynchronous learning tools, or your own examples. Keep the clips short and highly relevant. Participants tend to surf away to something else if they lose interest.

J. Live demonstrations

This feature is useful in software training. Participants see how a software function as the instructor performs the actual clicks. When instructor design a live demonstration that may be lengthy, such as touring complex dialog boxes, include questions instructor can ask that will prompt students’ verbal participation.

K. Integrated telephony and VoIP

Users can handle the audio portion of the course that is the voices of the presenter and the participants with a simultaneous conference call. Voice over IP (VoIP) technology where voice is transferred over the Internet
making use of the microphone and speakers on each user’s PC. VoIP users may experience a choppy audio sound most frequently attributed to their Internet connection speed.

L. Video integration

Video integration allows participants and instructor to both see and hear each other on screen. If you want to see multiple participants, just change channels.

![Video Integration Diagram]

The research methodology of the e-Learning P3 Development and Delivery Model consisted of two sections: Content Development and Content Delivery.

![e-Learning P3 Development and Delivery Model Diagram]

IV. CHALLENGES AND LIMITATIONS TO CONSIDER

While there are numerous advantages to adopting synchronous e-Learning, there are also challenges and limitations to consider. These range from the logistical to the pedagogical to the technological.

A. Logistical

Time zone differences are significant for live training, especially for global events. If users have a largely mobile workforce, determine whether synchronous attendance is the most appropriate method for reaching them. Typically you won’t replace another training strategy completely; users may need to have resources capable of also providing face-to-face and asynchronous online methods.

B. Pedagogical

Synchronous e-Learning requires the resources and know-how for effective design. Existing face-to-face course designs will need to be repurposed for the more interactive requirements of the Collaborative synchronous e-learning. “Death by PowerPoint” will reduce learning effectiveness and create negative connotations among learners. Expect to invest in a program for training trainers on designing and developing use of these tools. Respect global cultural differences; identify and embrace how trainees respond variously to virtual synchronous approaches.

C. Technological

Bandwidth is crucial. Although some online synchronous tools can scale down for modern users, most require stable connections and high bandwidth. Consider also the firmwide impact on their network of multiple simultaneous users. Identify your audience. Will users need a Cross-platform, cross-browser solution? Coordinate any reconfiguration or restrictions on port, protocol, firewall, and file type policies with their IT representatives.

![Face Recognition and Tracking Diagram]

V. FACE RECOGNITION AND TRACKING

Face recognition log-in and face tracking to access learns the content and multimedia, collaborative synchronous e-learning is live conferencing. As with eigenspace projection, training images are projected into a subspace. The test images are projected into the same subspace and identified using a measure similarity. The difference of recognition method is how the subspace is calculated which used projection of training images into a subspace. The test images projected into
the same subspace and identified using a similarity measurement. The only difference is the method of calculating the subspace characterizing the face space. The face has the minimum distance with the test face image labeled with the identity of that image. The minimum distance can be Face Database of Testing Set Projection which used by Test Image Training Set Feature Vector (Feature Extraction) Feature Vectors Classifier (Euclidean Distance) Decision Making for Human Face Recognition calculated using the Euclidian distance method.

![Human face](image1)

![Face detection](image2)

![Grid Pattern](image3)

![T-Zone Pattern](image4)

**Figure 6.** Step of face recognition

![Person Images n+1](image5)

![Person Images n+2](image6)

![Person Images n+n](image7)

**Figure 7.** Point are transferred to a database as an algorithm of numbers

![Capture Face Person Image](image8)

![Left image](image9)

![Right image](image10)

**Figure 8.** Flowchart of the face tracking algorithm

![Face Database](image11)

![Testing Set](image12)

![Projection of Test Image](image13)

![Feature Vector](image14)

**Figure 9.** Approach for face recognition

![Training Set](image15)

![Classifier](image16)

![Decision Making](image17)

**Figure 10.** Training phase of face recognition

**VI. CONCLUSION**

Building and delivering online events takes a lot of preparation and a few pairs of hands, but with practice, instructor can create excellent and effective learning experiences. Collaborative exercises can help get over the problem of a heterogeneous audience by letting the experts within student teams shine. But in general, the Intelligent Face Tracking for Collaborative Synchronous e-Learning has a hard time on its own handling a diverse audience and complex tasks that require contemplation. This is why users may at times want to turn to what is done to distributing content across or through diverse media choosing the best medium for each topic or learning objective.

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Analysis of usability of the virtual reality technology for risk assessment in machinery design

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Abstract—The obligation to conduct risk assessment at the earliest possible stage of machinery design arises both from good engineering practices and legal requirements. The research conducted using Document Investigation and Expert Inspection method confirmed the usefulness of the VR technology for identification of mechanical hazards and for evaluating the possibility of access to particular elements of the machine. A model of anthropometric features of a human being have been very useful for both as well as for assessing obtaining the data necessary for evaluating the stress on the musculo-skeletal system. The final verification of the developed method will be performed by means of user testing (UT) method.

Keywords: risk assessment, virtual reality, safety of machinery

I. INTRODUCTION

The obligation to conduct risk assessment at the earliest possible stage of machinery design arises both from good engineering practices and legal requirements. According to the directive 2006/42/EC [1]:

“The manufacturer of machinery or his authorised representative must ensure that a risk assessment is carried out in order to determine the health and safety requirements which apply to the machinery. The machinery must then be designed and constructed taking into account the results of the risk assessment. By the iterative process of risk assessment and risk reduction referred to above, the manufacturer or his authorised representative shall:

- determine the limits of the machinery, which include the intended use and any reasonably foreseeable misuse thereof,
- identify the hazards that can be generated by the machinery and the associated hazardous situations,
- estimate the risks, taking into account the severity of the possible injury or damage to health and the probability of its occurrence,
- evaluate the risks, with a view to determining whether risk reduction is required, in accordance with the objective of this Directive,
- eliminate the hazards or reduce the risks associated with these hazards by application of protective measures”

This requirement imposes on the machinery manufacturer a direct obligation to carry out risk assessment.

General principles of risk assessment are set forth in the norm ISO 12100:2010 “Safety of machinery. General principles of design. Risk assessment and risk reduction” [2]. The procedures and principles of conduct described in that norm show the importance of carrying out a systematic risk assessment and of its proper documentation. The specific character of these activities indicates the use of computer solutions as tools supporting risk assessment. For that reason designing such tools is becoming more and more popular. E.g. methodologies of risk assessment at work stations (e.g. a computer tool called STER) have been developed in CIOP-PIB (Central Institute for Labour Protection - National Research Institute) and successfully used. Computer tools supporting risk analysis have been developed also for the purposes of machinery design [3].

Practical experience gained in the course of carrying out risk assessment on the stage of designing production systems presented in [4] showed that even not particularly detailed virtual models of automated production systems may considerably improve certain stages of risk assessment. This experience found its confirmation during development of a method of virtual modelling of hazard areas the purpose of which was to support the selection of protective equipment for machines [5]. The purpose of the research was to use the state-of-the-art computer technologies for streamlining the process of risk assessment conducted by machinery designers.

II. APPLICATION OF THE IRTUAL EALITY (VR) TECHNOLOGY IN THE FIELD OF SAFETY

A. Advantages of the VR technology

Virtual reality (VR) is an image of an artificial reality created with the use of IT technology. It consists in a multimedia creation of a computer representation of objects, space and events. It can present both the elements of the real world (computer simulations) as well as of a completely fictional one. There are two concepts of virtual reality:

- Immersion is the ability of a computer-generated environment to create an impression that the user is a part of that artificial environment and is “submerged” in it. The sensation of immersion is achieved through at least an impact on at least the sense of sight by means of a stereoscopic projection of two different images for the left
and for the right eye. The difference between these two images consists in a different point of observation. Both are generated in such a way that the point of observation of each one of them reflects the way in which human eyes naturally register images. Images may be displayed on two displays at the same time or alternately, or they may overlap on one and the same display. More advanced systems offering a better quality resulting from faster processing of information and a more precise rendering of image and sound, generate the environment which is easier for the user to assimilate. This is very important for the comfort, ergonomy and safety of work.

- **Interaction** is a term which defines the mode of operation of a computer system consisting in maintaining a continuous contact with the user (by exchanging the information about the position and the instructions). The information is exchanged continuously and has a direct impact on the performed tasks and on the displayed information. In the VR environment the interaction is broadened with the feedback from the system which may have various forms depending on the tasks performed on peripheral devices.

The most important attributes of virtual reality which determine the possibilities of application are the following [6]:

- the environment is computer-generated,
- the environment and user's sensations are three-dimensional,
- the user has a sense of presence in the virtual environment,
- the user can move in the virtual environment,
- the objects in the virtual environment behave in the same way as in reality,
- there is a real time interaction between the user and the virtual environment.

These features of the virtual reality technology allow such systems to carry out more effective analyses than those carried out by the commonly used CAD/CAM systems. The architecture of these systems allows better adaptation to the user's needs. At the same time VR presents real objects better than CAD/CAM systems. These features substantiate the assumption that VR may effectively support the risk assessment carried out by machinery designers.

B. **VR technology versus safety**

The methods of using virtual reality technologies (research using advanced computer simulation methods) have been developing extremely dynamically all around the world. The works devoted to application of this technique to analysis of safety of industrial systems are being carried out in many centres in the world. In the USA the most advanced works of this type are conducted e.g. by the Department of Health and Human Services, Centre of Disease Control and Prevention NIOSH. They apply to the use of virtual modelling for ergonomic analysis and risk assessment at work stations in mines. The application of these techniques in assessment of the risk related to natural disasters is presented in [7]. In [8] Kim and Gong presented the principles of using the VR simulation for assessment of the risk of collision in the sea transport. In the EU an Integrated Project called VIRTHUALIS (Virtual Reality And Human Factors Applications for Improving Safety [9]) has been conducted under 6PR. As part of this project the methods are being developed of using virtual modelling for taking into account human factor in designing the process installations, in particular in the chemical and petrochemical industry. In [10] the possibilities of application of the VR technology in research work concerning the effectiveness of warning signals are presented. The use of virtual reality technology for analysing safety at the construction site and for supporting trainings is presented in [11]. [12] presents a concept of application of VR simulators in safety trainings for lift truck operators, whilst in [13] the use of virtual simulations for selecting visual systems for machines is discussed. Research has also been conducted with respect to using enriched reality systems to increase safety in work stations. Examples of such applications are presented in [14]. General principles of using virtual reality techniques in the field of safety are discussed in [15] and [16]. Examples of application of VR in the area of safety and ergonomy are presented in [15]-[17]. The research in this area is conducted for example with respect to the needs of nuclear power stations were VR systems allow searching for personnel in emergency situations. The application of VR technologies seems to be particularly advantageous where training in real conditions carries with it a threat to human life and health. For this reason trainings in virtual environment are most usually conducted in such fields as medicine (e.g. virtual operations [18]) or atomic power industry (e.g. limitation of employee's exposure to ionizing radiation [19]). Research with the use of VR technologies is also conducted with respect to the operation of specialist machines, e.g. in mining applications [20]. VR technologies are used for the analysis of work ergonomy (e.g. in the case of operation of machines in mines [21]) and for identification of possible hazards (e.g. related to the work in a mine [21 and 22]). This research allowed to identify the possibilities of application of VR technologies in various aspects of analysing and increasing the safety.

The general concept of including the aspects of safety in the process of designing industrial equipment is presented in [23] and [24]. The first important step towards the application of computer technologies for safety analyses in the course of machinery design was the development of the Computer Aided Safety Standards Application for Design (CASSA) system [25]. This tool supports a machinery designer in analysing the possible scenarios of events taking into consideration safety aspects. For that purpose special, user-oriented interfaces were used, adapted to carrying out various types of analyses. The tool takes into account also various types of users such as machinery designers or standardisation group experts. These tools indicate that application of 3D modelling in risk assessment on early stages of machinery design is very effective.

All the previous research dealt with the issue of using computer technologies for risk assessment in detailed aspects, usually with respect to the ergonomy of work stations. In the available literature there is no information about any attempts to use the virtual reality technology for carrying out risk assessment in accordance with the machinery directive by taking into consideration all of its aspects. The process of risk assessment carried out by a machinery designer has different objectives and uses different methods of operation than e.g.
ergonomic analysis of work stations in the process industry described in [9]. The risk assessment method which will be analysed as part of the project will be oriented at streamlining the process of risk assessment required by the machinery directive, taking into consideration the specific character of machinery design. This will make it possible to systematise the operations related to risks assessment. Improving the risk assessment process and making it possible to carry out risk assessment already on early stages of machinery design will also reduce the costs connected with application of protective systems for reducing the hazards occurring at the machine. The project concerning the development of the methods of using VR systems for carrying out risk assessment in the course of machinery design is a natural continuation of the hands-on experience [4] as well as the research work conducted so far [3], [5], [13].

C. Risk assessment carried out by machinery designers

Risk assessment is a process which allows to obtain the most important information necessary for taking the decisions on safety assurance methods. It is an iterative process which should be performed on individual stages of the machinery life cycle. Its results depend, to a large extent, on the stage of life cycle on which the process is being conducted. Risk assessment carried out by a designer allows to gather detailed information about the construction of the machine and its functioning and identify the information which is important for the user.

The basic principles of risk assessment have been specified in the norm ISO 12100:2010 [2]. Fig. 1 presents a diagram of a general methodology of carrying out risk assessment methods specified in those documents. The operations conducted under the risk assessment procedure include:

- identification of the machine,
- establishment of the limitations related to the machine,
- identification of hazards,
- risk assessment,
- risk graph,
- numerical calculations,
- numerical scores,
- qualitative methods,
- control lists,
- measurements,
- combinations of the above-listed methods.

In the case of an unsatisfactory result of risk assessment the designer is obliged to apply proper measures to reduce the risk. Generally, risk reduction is not a part of the process of its assessment and therefore it is not covered by our analysis. The issues related to the use of the VR technology in the risk reduction process are presented in [5].

Risk assessment must be carried out independently for every identified hazard. In the case of various hazards, different risk assessment methods may be used. For assessing the level risk matrices,

- risk graph,
- numerical calculations,
- numerical scores,
- qualitative methods,
- control lists,
- measurements,
- combinations of the above-listed methods.

Usually, the specific character of hazard determines the method of risk assessment. For that reason risk assessment is carried out with respect to every hazard independently.

All the activities carried out in connection with risk assessment should be documented. The documents on risk assessment should contain the information on the applied procedure and the obtained results. This documentation, depending on the machine being examined, should contain:

- identification of the machine,
- assumptions with respect to the operation of the machine,
- description of identified hazards and hazardous situations,
- description of risk reduction measures applied on successive stages of design,
- information on residual risk,
- results of risk assessment.

III. METHODOLOGY OF RESEARCH

The purpose of the research conducted was to establish the usefulness of virtual reality technologies for a specific application, that is for carrying out risk assessment on the stage design of machinery. The available literature contains the information on a series of Usability Evaluation Methods (UEMs). The most popular ones include:

- document-based inspection (DI),
- expert inspection (EI) and
- user testing (UT).

Evaluation of effectiveness of these methods is presented in [26].

DI is a usability evaluation method which consists in analysing the documents on the requirements which must be met and the properties of the evaluated solutions (ISO / TS 16982 [27]). The DI method is used in many variants (cognitive analysis, compliance with norms and guidelines, compliance with the requirements of ergonomy [28], etc.). Effectiveness of this method depends on the organisation of the conducted analyses. A significant limitation to this method is the fact that it can be used only for evaluation of the already known solutions, in accordance with the current know-how. Skills of the experts applying this method are also important.
EI is a popular method of evaluation which finds application particularly in industry. It is an informal method consisting in evaluation based on the experience and knowledge of one or more experts. The experts diagnose potential problems based on the latest knowledge and their experience. This allows a relatively easy identification of potential limitations in the usability of the examined solutions. The limitation in the case of this method is the fact that it allows to predict only the problems known from previous experience.

The most well-known method is probably UT. It consists in practical testing of application of the developed solutions by their potential final users. The purpose of these tests is to gather spontaneous comments about the usability of the suggested solutions, as well as to conduct an evaluation on the basis of measurable indicators such as task performance time, accuracy of achieved results or the number of errors made.

The evaluation conducted in [26] indicated that individual methods differ both from the point of view of their effectiveness and the type of the detected problems. For this reason in this project all three methods will be used in turns.

On the 1st stage the DI method will be used to evaluate the potential usability of the VR technology in assisting risk assessment in the course of machinery design. Attempts will be made to carry out such evaluation with respect to the requirements of ISO 12100:2010 [2] on the basis of the documentation of 3 machines. The purpose of these attempts will be to establish on which stages of risk assessment the application of the VR technology might be useful. Various methods of assessment of the risk related to various hazards will be analysed. In order to get a greater certainty about the usability of VR, analyses will be conducted with the use of the PRO-M software [3] which guarantee regularity of tasks. The analyses will be performed by the experts who have wide experience in the risk assessment related to the use of machines as well as knowledge about the VR technology [4, 5, 12]. The results of the conducted analyses will form the basis for development of a draft method of using the VR technology for supporting the risk assessment procedure carried out by machinery designers.

On the 2nd stage, the analyses will be conducted by means of the EI method. For that purpose virtual models of three machines will be built. A team of experts will conduct tests of assessment of the risk related to their operation. The purpose of these tests will be to identify possible problems with the usability of the proposed methods as well as to suggest the ways in which these problems might be eliminated.

The final verification of the developed method will be conducted on the 3rd stage by means of the UT method. The developed method will be presented to the machinery designers who will try to apply this method to the currently designed machines. After that they will evaluate the usability of the proposed method.

In the process of analysing the methods of assessing the risk connected with various threats the PRO-M software has been used, developed in order to support machinery designers in carrying out such an assessment [3]. The basic features of this software are presented in [3]. The PRO-M software has been developed to simplify and formalise the operations of machinery manufacturers connected with carrying out and documenting risk assessment on the stage of machinery design.

All the activities have been conducted in close cooperation with the company specialising in machinery design.

IV. RESEARCH RESULTS

A. Assignment of VR technology to hazards

The research began with analysis of the risk assessment methods, used by machinery manufacturers, from the point of view of application of virtual reality technologies. The purpose of the analyses conducted by means of the document inspection (DI) method was to develop a matrix of assigning hazards to the functions realised by as simple as possible hardware and software configuration of the virtual reality technology, in the process of risk assessment conducted by machinery designers.

The research consisted in attempts to conduct risk assessment with respect to the requirements of ISO 12100:2010 [2] on the basis of documentation of 3 machines. Various methods of assessment of the risk related to various hazards were analysed. In order to get a greater certainty about the usability of VR, the analyses were conducted with the use of the PRO-M software [3] which guaranteed regularity of tasks. The analyses were performed by the experts who have wide experience in risk assessment related to the use of machines [3] as well as knowledge about the VR technology ([4] and [5]).

In order to select the machines whose documentation was analysed, over 150 various machines designed and built in the last few years had been examined. These included, first of all:
- multi-station assembly and production lines,
- automatic assembly lines,
- final product control testers,
- machines and equipment for production of foil packaging,
- automatic packaging lines,
- machines for automation of feeding, etc.

Initially, 12 machines were selected from among them for further analysis:
- glass lift assembly stand,
- trimmer for windowpane dividers,
- automatic bearing assembly press,
- stand with a rotational pane divider,
- assembly line for clamps,
- final control tester,
- connector auto cutting machine,
- automatic brush holder assembly machine,
- sleeve control device,
- automatic nipple assembly machine,
- leak testing stand,
- automatic spoke feeder.

These machines were analysed from the point of view of hazards and of their usefulness for risk assessment methods. In the end, the machines shown in the Drawing 1 were selected for the research:
- automatic nipple assembly machine,
- pump leak testing stand,
- automatic spoke feeder.

Przeprowadzone analizy dotyczyły użyteczności techniki VR przy prowadzeniu oceny ryzyka związanego z zagrożeniami:
- mechanical,
- electrical,
- thermal,
- noise,
- vibrations,
- radiation,
- hazardous substances and materials,
- explosion,
- ergonomic,
- related to the malfunctioning of the control system,
- related to ergonomics,
- related to the environment for which the machine is intended.

The following risk assessment methods were analysed:
- risk graph,
- control lists,
- risk factor calculations.
- hybrid,
- risk factor measurements.

On particular stages of risk assessment the experts analysed the features of the VR technology from the point of view of its usability in the conducted activities. As a result it was established that application of the VR technology can be very well grounded. The VR technology is particularly useful for determining the limitations related to the machine and identification of threats and hazard areas. This applies in particular to mechanical and ergonomic threats as well as threats related to malfunctioning of control systems. In this last case the VR technology can be useful for determining the functional requirements with respect to individual safety functions but it will rather not find application in the process of determining the requirements concerning the resistance to defects or in the evaluation of the achieved safety integrity level (SIL) and performance level (Pl).

The VR technology is slightly less useful in the process of risk assessment, however, in some cases the analyses indicated that it may assist the designer also in this area.

The analyses show, however, that the usefulness of the VR technology is insignificant if the risk is assessed by means of the method consisting in measuring the machine parameters and comparing the results with criterial values. This applies to such hazards as:
- noise,

<table>
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<tr>
<th>Hazard</th>
<th>Risk assessment method</th>
<th>Risk assessment and risk reduction stage</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>determination of the limits of the machinery</td>
<td>hazards identification</td>
</tr>
<tr>
<td>mechanical</td>
<td>hybrid</td>
<td>HU</td>
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<tr>
<td>electrical</td>
<td>check list</td>
<td>U</td>
</tr>
<tr>
<td>hazardous agents (noise, vibration, radiation, hazardous materials and substances etc.)</td>
<td>measurement</td>
<td>SU</td>
</tr>
<tr>
<td>explosion</td>
<td>applied materials analysis</td>
<td>SU</td>
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<tr>
<td>due to malfunction of control system</td>
<td>risk graph</td>
<td>HU</td>
</tr>
<tr>
<td>due to ergonomics</td>
<td>calculation of risk factors</td>
<td>HU</td>
</tr>
<tr>
<td>due to working environment</td>
<td>risk graph</td>
<td>SU</td>
</tr>
</tbody>
</table>

HU – highly useable, U – useable, SU – small useable
- vibration,
- dust,
- dangerous substances,
- radiation, etc.

Table 1 presents a matrix of assignment of the usability of the VR technology to hazards.

Analyses of the example of an unfinished machine show that the VR technology can be particularly useful for identifying the risk which could not have been reduced by its manufacturer, since it depends on the final construction of the machine.

Assessment of usability of the VR technology for supporting the risk assessment process, made by means of the documentation inspection (DI) method, was carried out independently by 2 experts specialising in machine safety and experienced in the use of virtual environments. The important thing here is the fact that conclusions of both experts coincided.

B. The use of the VR technology for risk assessment

The next step consisted in the development of a risk assessment method with the use of virtual reality technologies. The research was conducted by means of the expert inspection (EI) method. The analysis was performed with the use of the models of 3 machines made in the VR technology. The team of experts conducted tests of assessment of the risk related to their operation. The purpose of those tests was to identify possible problems with the usability of the proposed methods as well as to suggest the ways in which they might be eliminated.

For presentation of the virtual environment the OGRE3D (Object-Oriented Graphics Rendering Engine; www.ogre3d.org) library was used. Detection of collisions and simulation of physics was conducted by means of a popular Bullet motor. The analysis was performed mainly with the use of the projection technology. The tests were performed both by means of a laptop computer and a large screen projection with a 3D projector.

For carrying out the risk assessment in the projection method a model of anthropometric features of a human being was used, prepared by CIOP-PIB. The model, showed on fig. 2, was modified by introducing the functions which make it possible to simulate the work and collect the data necessary for assessing the load of the muscular and skeletal system.

Attempts to apply the immersion technology were also made, with the use of a video tracking system, wired gloves and HMD system.

Then, a method of creating VR models of machines on the basis of their CAD3D documentation was developed. This method uses generally-accessible FreeCAD, MeshLab, Blender3D and TrollViewer software, available on a license-free basis. This method was used to build VR models of 3 machines:

- tester of car glass lift (Drawing 3)
- bearing transport system (unfinished machine)
- automatic machine for cartridge regeneration.

The performed analysis revealed that the most convenient system for supporting the risk assessment conducted by machinery designers is the VR projection system, especially when a laptop computer is also used. The immersion system, on the other hand, turned out not to be very useful.

The developed method of using the projection system together with a modified model of a human being is particularly useful for determining the limitations related to the machine with respect to defining the access areas necessary for operation, maintenance and repair of the machine. This method is especially useful for analysing the fulfilment of ergonomics requirements with respect to:

- checking the access to operation areas, maintenance areas and control elements,
- obtaining the data necessary for evaluating the stress on the musculo-skeletal system.

It may also be used for verification of the effectiveness or reducing the risk connected with mechanical threats, but in this case the application of the method of modelling hazard areas and accessible areas, described in [5], is more suitable.

V. SUMMARY, CONCLUSIONS

Risk assessment should be carried out in accordance with ISO 12100:2010 [2] and the methods recommended in that norm. The purpose of using the VR technology is to facilitate the procedure of risk assessment as well as to make it possible to collect the data necessary for such assessment. As it follows from the conducted research, the model of anthropometric features of a human, together with a developed method of determining the parameters necessary for evaluating the stress on the muscular and skeletal system, provide particularly helpful support for risk assessment. Adaptation of the developed model to the norms standardised with respect to the Directive 2006/42/CE allows it to be used in the process of evaluating the compliance of machines which may be difficult in the case of using other available models oriented at evaluation of the work station to which the machine belongs.

The research also confirmed the conclusions drawn on the previous stage and indicating the usefulness of the VR technology for identification of mechanical hazards and for evaluating the possibility of access to particular elements of the machine.

The proposed method of creating a VR simulation was oriented at such a selection of IT tools which would not entail a
necessity to incur high costs of their purchase. Attention was also paid to license provisions. All the software used was analysed from the point of view of intellectual property and we selected only those whose licenses did not contain any provisions limiting the possibility of their professional application.

The problem of integration of various software environments was another issue. As it has been shown on the example of the three machines, transfer of the data from a CAD software does require a certain amount of work, but if the proposed software is used, such a transfer is relatively simple. Also the proposed model of anthropometric features of a human being can be read by the VR environment presentation software. Unfortunately, the PRO-M software does not have the interface which would make it possible to read text files generated by the VR software, however, introducing the read data directly into the PRO-M software is very easy. Furthermore, the PRO-M software has been used as an example. Every machinery designer can use other methods of risk analysis, e.g. filling out company forms developed precisely for that purpose.

The final verification of the developed method will be performed by means of user testing (UT). The developed method will be presented to the machinery designers who will try to apply this method to the currently designed machines. After that they will evaluate the usefulness of the proposed method, also from the point of view of its adaptation to the existing organisation of the engineering and construction office in the companies specialising in machinery production.

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A Linked Data approach to evaluate Open Education Resources

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Abstract— The social environments based on the Web 2.0 paradigm have modified the way people behave on the Web. One of the direct consequences of this change is that the amount of online resources produced and shared by users has increased considerably. Amongst them, it is possible to find materials that can be exploited for educational purposes. For example, YouTube, Flickr, Slideshare, more and more often collect resources that can be used in educational contexts. In this scenario, finding methods to support the evaluation of the educational relevance of online resources is becoming one of the greatest challenges faced by the educational technologists today. In this paper we propose an approach for the evaluation of the relevance of educational resources based on recent advancements of Linked Open Data.

Keywords— Linked Open Data, OER, Educational resource relevance

I. INTRODUCTION

The use of Open Educational Resources (OER) in learning settings, at different educational levels, has become more pervasive in the last years. This trend is mainly due to the availability of a really huge number of OER repositories as well as to the technological maturity reached by standards used to describe OER metadata.

However, in the last few years the flexibility yielded by Web 2.0 technologies has changed the way repositories are considered: from static collectors of resources to dynamic and social environments able to support exchange of knowledge [1]. The development of the Social Web has emphasized this condition [2] [3] [4], thus supporting social activities within OER repositories: mechanisms for commenting, voting, explicitly encouraging the sharing of resources are more and more often implemented in OER repositories. At the same time, the barriers between specialized OER repositories and generalist Web 2.0 repositories, such as YouTube, Flickr, Slideshare, are starting to fade away, so that the social environments have included specific areas to store educational resources, where academic institutions are publishing their OER (in addition to their official repositories).

Educational resources are therefore not only hosted by repositories specifically designed for promoting sharing of learning materials (usually supported by universities or research institutions), but even by general-purpose Web 2.0 sharing environments which represent a meaningful source of educational resources.

In this scenario, new needs have raised up. In fact, it is necessary to embrace an integrated methodology to provide a channel to access learning resources distributed in a plethora of digital sources on the Web. At the same time, it is necessary to develop automated ways to analyze and evaluate the huge amount of learning resources in order to support teachers activities in selecting the resources suitable for their course [5][6].

Concerning the first aspect, the technological advancements of the Web of Data, facilitated particularly by the Linked Data (LD) approach, provides the technological background to support reuse and sharing of knowledge across the Web.

Recent efforts on using Linked Data approaches for fostering educational data sharing have been widely documented in [7]. Furthermore, the huge amount of data released from the Linked Universities movement (e.g., from The Open University UK or Oxford University) demonstrates the increasing interest of the academic world towards the Linked Data paradigm. However, these approaches so far have mainly focuses on resources explicitly designed for educational purposes., while the exploitation of the vast body of knowledge not directly related to learning has not yet been considered widely.

The Social Web offers new opportunities to tackle the second issue raised before: social activities such as rating, liking and commenting, can activate mechanisms to infer relevant clues about the educational relevance of resources on the Web. This issue is more acute in emerging countries in which the digital divide between students and teachers especially in higher education is more evident. In fact, students have good English skills and are able to use social media environments not only for leisure but also for learning activities, while teachers are not so experienced with the use of these tools for learning [8]. In this scenario students’ social activities could be exploited to support teacher in selecting educational contents.
In the framework of the LinkedUp project\(^1\), several data curation activities have been carried out, aimed at assessing, cataloging, annotating and exposing all sorts of Web data of educational relevance. In this project a new RDF schema has been developed aiming at aligning disparate schemas used by different datasets. In addition, to enable an initial classification of different resource types, a vocabulary of educational resource types has been introduced to describe the properties of each dataset. Finally, a preliminary dataset catalog (named Linked Education catalog), adopting the VoID vocabulary for the description, cataloging and annotation of educationally relevant datasets, has been established.

The Linked Education catalog includes datasets of potential educational relevance. The existing dataset annotations often do not facilitate a comprehensive understanding of the underlying data, and the information provided by public registries or endpoints, such as the DataHub, are often insufficient to deduce the actual nature of the underlying distributed data. Additional knowledge is required about aspects such as:

- representation of resource types
- representation of topics in the datasets
- evaluation of educational relevance of learning resources
- assessment of the data quality

With respect to the first point, the representation of resource types, d’Aquin et al. in [9] analyzes and collects datasets explicitly referenced to education in which resources are exposed as linked data. The main aim of this work has been to analyze how the datasets are connected to each other, considering not only direct links between them but also the reuse of common vocabularies and types.

The representation of the topics covered by the datasets has been conducted by considering an approach which exploits the data enrichment capability of DBpedia spotlight tool, and the relations between concepts and categories in DBpedia. The evaluation of the educational relevance of the learning resources and the assessment of the data quality are in a preliminary stage.

In this paper, we discuss how the strategies to evaluate the educational relevance of OER are modified by the social web dynamics and by the linked data approach to the management of knowledge. In the next section, we introduce the potentials of social web and linked data to create the models that can be used to evaluate educational resources. Then, we illustrate an example of application of the enriched models. Finally, we conclude by pointing out the future work to be done in order to fully exploit the remarkable potentials of Social Semantic Web for OER.

II. EDUCATIONAL RESOURCE RELEVANCE

Since 2005, Duval [10] has highlighted that “quality is not a binary property of learning material but it is multi-faceted”;

\(^1\) http://linkedup-project.eu/
By changing the perspective and considering the social environments instead of the institutional repositories, the workload for the human review mechanism is not on a limited group of experts, but it is shared amongst all the members of the community. Despite a potential loss of quality in the evaluation process, the scalability and subjectivity issues are solved by this approach. Furthermore, the Wikipedia model has proved that if the community is large enough, also the quality can be improved [13].

Concerning the second mechanism used to evaluate educational resources, the text similarity, the repositories usually implement vector space representation for metadata of learning resources to perform an evaluation of the relevance of resources respect to the learning context in which the resource is used. This type of representation is traditionally adopted in information retrieval activities, and has been successfully used in the early web search engines. Nevertheless, the evolution of the semantic web has permitted the evolution of techniques based on concept similarity rather than text similarity.

Finally, the user profile strategy is traditionally developed by making users to select explicitly the topics of their interest from a taxonomy, which must be the same adopted to classify the resources. Recent work [14] has focused on the definition of the learner portfolio using semantic web approaches, in order to represent students’ learning objectives, learning outcomes, learning curriculum. The semantic representation can be used to connect students’ profile to the educational resources needed to reach the educational objectives.

III. EVALUATING EDUCATIONAL RELEVANCE: A LINKED DATA APPROACH

In the framework of the LinkedUp project both explicitly educational datasets (such as OpenLearn2 and the mEducator Educational Resources3) as well as implicitly educationally relevant datasets (such as BBC Programmes4 and Europeana5) have been selected in order to create the Linked Education catalog, as stated in the introduction. The selection took into consideration the heterogeneity of the data with the aim of creating an integrated dataset which combines a wide variety of educational as well as educationally related resources. Additionally, given the diversity of available resources, a classification of the available datasets, indicating their main purpose, nature and educational relevance was required. In order to address these issues, in [15] we presented an approach, composed by a set of data processing techniques to enable cross-dataset analytics. Our approach takes advantage of established datasets such as DBpedia and Freebase by exploiting the DBpedia Spotlight API6. Initially, our current implementation enriches resource titles and descriptions, as these are the most frequently used properties. This approach has been exploited to create associations between the unstructured title and description of each resource to DBpedia concepts, so that the unstructured text has been enriched through DBpedia entities. These generated enrichments have been used to create a weighted graph, in which resources are the nodes and the edges are weighted taking into consideration the shared enrichments between resources. Figure 1 shows a part of the resulting network including example resources from BBC, Linked Universities and Europeana datasets.

In the proposed approach the properties of the network (such as degree, centrality measures) can be evaluated to provide a relevance measure of the learning resources involved in the network. Moreover, votes, comments, number of visualizations, and other social activities related to each

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2 http://openlearn.open.ac.uk/
3 http://datahub.io/it/dataset/meducator
4 http://backstage.bbc.co.uk/
5 http://data.europeana.eu/
6 http://spotlight.dbpedia.org/
resource can also be used to weight the relationships between resources affording a relevance index that take into consideration both social and semantic aspects.

IV. CONCLUSIONS

The educational relevance of Open Educational Resources have been widely debated in the literature, and in the last few years the interest in educational data mining and learning analytics approaches has rapidly increased. Consequently, metrics to measure different aspects of educational processes, and in particular relevance ranking metrics for educational resources, have been proposed. The evolution of the Social Semantic Web has led to reconsider such metrics by introducing further dimensions to capture the new dynamics of education. In this paper we have proposed an approach based on the recent advancements of the Linked Open Data to highlight the “conceptual learning context” related to educational resources. This is a preliminary work, and we are going to test the concepts presented in this paper in the near future, in order to validate them.

ACKNOWLEDGMENT

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Abstract—In the last few years, many applications for mobile devices have been developed to support learning experiences both in formal and informal contexts. One of the main limits of these applications concerns the development of learning materials suitable for mobile learning contexts. In fact, learning content must be usually prepared in advance by teachers and maintained during the whole lifespan of the application. In this paper, we present MeLOD, a mobile learning environment, which exploits the huge amount of dataset in the Linked Open Data (LOD) cloud to overcome the previous issue, and provides contextualized and continuously updated information based on students’ location. The position of the student sent by the mobile device is used to interlink Geonames DBpedia and Europeana datasets to provide information about all the interesting cultural heritage sites close to the student. Moreover, students social activities like voting and commenting are used to enhance the knowledge base of the environment and to provide recommendations for next students’ visits.

Keywords—Mobile Learning, Linked Open Data, Semantic Web.

I. INTRODUCTION

More than 130 million Europeans routinely use their mobile phones to access the Internet. This information is contained in the 8th wave of the Mediascope Europe Study [1], one of the most comprehensive research studies on how people dedicate their time to the various media in Europe. Innovative and more powerful mobile information communication technologies continue to emerge and become widely available. According to the Educause Center for Applied Research (ECAR) survey on the use of mobile technologies in Higher Education [2], students want to access academic progress information and course material via their mobile devices (such as smartphones, and tablet computers), and 67% of surveyed students believe mobile devices are important to their academic success and use their devices for academic activities. Likewise, the widespread use of mobile technology, along with the availability of efficient mobile broadband connections, offers a unique opportunity to develop innovative methods of learning as well as to develop policies aimed at participation, given that the use of mobile devices transcends age, social status, economic level, gender and ethnic origins [3]. On the other hand, in the last decade numerous studies about the use of mobile and wireless communication technologies in education have been reported [4]. In addition to these studies we observe an important increase of mobile learning penetration rate in some country, like Taiwan, where there are national programs and strategies for e-learning to support the innovation in educational context [5]. In the same direction, we foresee a similar trend in other countries, like Italy, where there is a wide diffusion of mobile technologies, and national government is going to adopt, in the public education system, electronic books and tablet as primary tools for learning.

According to Horizon’ report [6] as well as to the roadmap of the National Science Foundation [7], Spector [8] analyzing recent research on emerging education technologies highlighted that mobile technologies will have a significant impact on future learning and instruction. Thus, while there is a great interest in mobile technologies for learning, it is important to investigate the effects of these technologies in educational context. In fact, although the effectiveness of new learning technologies is deeply explored by researchers and academics, and many studies have been carried out about the effectiveness of mobile learning, even today the evaluation of a mobile learning experience is demanded mainly on surveys and interviews. Very few studies have investigated validation methodologies based on blended approaches that include surveys, interviews and automatic and experimental analysis. According to Traxler [9], when we evaluate a mobile learning experience we have to consider a number of independent variables that influence the learning process. Actually, a mobile learning experience is a ‘noisy’ phenomenon where context is not clearly bounded, thus introducing a higher level of difficulty when we try to analyze it. A large amount of data must be taken into account, and the relationships amongst data must be identified. In MeLOD, a Mobile Environment for learning with Linked Open Data1 described in this paper, an evaluation dashboard has been implemented, in order to support teachers in analyzing mobile learning activities, improve the learning experience and personalize contents and teaching methodology.

II. THE MELOD ENVIRONMENT

The benefits and drawbacks of mobile learning in both formal and informal contexts have been explored through

1 http://melod.pa.itd.cnr.it/
many experiences developed during the last decade worldwide [10][11].

The MeLOD environment has been designed to support, through the use of mobile devices, the informal learning experiences that take place during the visit of a city. The MeLOD environment fosters a learning methodology based on educational models and technological advancements which characterize how people will learn in the next years. Firstly, there is a strong emphasis on the mobility of the learners and its consequences on the learning processes, which tend to become more and more contextual, informal and ubiquitous. Secondly, the social dimension of learning is encouraged through voting and commenting mechanisms that can be straightforwardly exploited in order to deliver recommendations and promote an online community of learners.

The MeLOD environment is composed by two main modules: a mobile application, with a friendly user interface, that shows the information to the students during their visit, and a set of web services that elaborate the requests coming from the mobile application to provide interlinked information from different open datasets. The main datasets used by the MeLOD environment are three: DBpedia, Geonames and Europeana. Moreover, in the last few years, many municipalities in the world are releasing their data as Open Data. For instance the municipality of Palermo (the city in which the environment will be tested next autumn) has already released the data about historical buildings in Open format. These data contain information related to opening hours, entrance costs, closing day, and other information under the responsibility of the municipality, thus this data can be really useful to enhance the description already available on the datasets of the LOD cloud (such as DBpedia and Europeana).

When a student is visiting an area of the city, the MeLOD mobile application sends his/her position to the server. The server uses the “Find nearby Wikipedia Entries” service of the GeoNames API to establish if there are Wikipedia pages concerning cultural heritage sites which are physically located near the student’s position (considering a pre-set radius). The list of nearby places will be used to access the corresponding resource on the DBpedia ontology. The rdfs:label of each resource is used to show this list to the mobile device of the students. In a more complex scenario, a student can select, before the visit, the main topics he/she is interested in. The list of topics is directly related to the DBpedia categories expressed by the dcterms:subject property. In this way the system can filter the results to be shown to the students according with his/her choice, as well as with the DBpedia category related to the cultural heritage sites.

The methods implemented by the RESTful API of the MeLOD environment can be divided into three categories:

- Authentication and configuration: manage users authentication and personalization features, in order to configure the environment for personal learning.
- Geo-located information: provides the mobile learners with contextual learning materials, by exploiting the Linked Open Data capabilities;
- Social activities: identify and make explicit the ties amongst the learners’ profile and her/his interaction with the context (other learners and learning materials);

These aspects have been implemented with the aim of supporting the development of specific mobile learning assessment tools on top of the MeLOD environment.

A. User Authentication and personalization

Mobile devices are more and more often used to support personalized learning experiences. In the MeLOD environment specific methods suitable at supporting this aim have been developed. In particular, students before starting their visit of the city have to indicate their preferences related to language, categories of interest and preferred media type. The language setting is used to identify the right DBpedia translation to be used for providing learning materials. Indeed, the translations of the DBpedia dataset are recently increasing, thus allowing the access to localized version of the contents. In this way internationalization issues are faced.

The MeLOD environment allows students to select the categories of interest for their visit. The list of categories are retrieved from the main topic classifications of the DBpedia category tree. These categories are queried from DBpedia using the following SPARQL query:

```
PREFIX skos:<http://www.w3.org/2004/02/skos/core#>
SELECT ?category WHERE {

?category skos:broader category:Main_topic_classifications
}
```

Example values from the previous query are: Education, Geography, History, Arts, Life and so on.

Finally, students can select their settings related to the preferred media type. In this way students can decide to receive contents in different formats (only text, text and images, multimedia formats and so on) depending on the technical capabilities of their device or on the reliability of the network (GPRS, 3G, Wi-fi) they are using for accessing the environment.

B. Providing geolocated Learning Material

Creating learning materials suitable for mobile learning context requires a notable effort. In fact, learning content must be usually prepared in advance by teachers and maintained during the whole lifespan of the application; in addition, teachers are required an extraordinary effort to organize the information for mobile devices, especially when they are not supported by a permanent technical group, as more and more often happens in public high schools. As a consequence, teachers can only develop a limited amount of learning.

2 http://dbpedia.org/sparql?default-graph-uri=http%3A%2F%2Fdbpedia.org&query=select+distinct+%3Fcategory+where+{++%3Fcategory+skos%3Abroader+catego+ry%3AMain_topic_classifications+}+&format=text%2Fhtml
materials, thus reducing the type and the number of learning activities they can plan.

The teachers’ effort can be simplified if the learning is already available somehow. For example, if they plan a visit to the town (which is a common activity at school), the most popular mobile stores (Apple and Android) already include, in their catalogs, several applications providing specific information about hundreds of cities in the world. This information can be used to support successful the visit of a city, also during a visit related to learning activities. nevertheless, the information provided by these applications is usually extracted from proprietary data source, and cannot be easily customized to be really suitable for learning settings. MeLOD exploits the huge amount of dataset in the Linked Open Data (LOD) cloud to overcome the previous issues, by providing contextualized updated information based on students’ location that are continuously updated. In particular, the MeLOD environment interlinks the DBpedia, Europeana and GeoNames datasets with contextual information of the students’ learning experience. Moreover, MeLOD is capable to provide users with localized information by using the DBpedia internationalization features. In fact, DBpedia has its contents translated in several languages, thus providing localized contents.

C. Social Learners activities

Learner’s profile has a significant role in carrying out personalized learning experiences. This aspect is more relevant in mobile learning than in traditional settings since personalization aspects concern not only the learner’s preferences (e.g. subject, type of learning resource, editorial features, and so on) but also the technical capabilities of the devices, which influence the kind of resources accessible through the device. In the MeLOD environment students can choose the type of content to receive. As mentioned before, students can prefer to receive text and images but not video contents. The preferences of the students are properly stored in the MeLOD environment, using specific entities of the MeLOD ontology (described in section IV). Moreover, specific simple rules expressed using the RIF (RIF Rule Interchange Format) language are defined, in order to identify the layout to be used to display the information on the mobile device depending on the preferences of the students and also considering the information available for the resource. Indeed, the datasets used to retrieve information about learning resources (DBpedia, Europeana) can contain different type of media for the resources.

One of the most important and innovative features of the MeLOD environment is the possibility to enrich the learner’s profile not only with the places s/he has visited, but also with information about her/his learning interests, information which is inferred by analyzing the cultural heritage sites s/he has visited. In fact, the use of the Semantic web technologies enables inferring mechanisms which exploit the potential of the Linked Open data cloud, and makes it possible to connect the specific cultural heritage visited by the learner to a upper level concept, thus moving from particular instances to general concepts. Both the DBpedia and GeoNames datasets can be queried in order to connect concepts, considered that all the learners’ activities are related to the location in which the activities take place.

The social activities of voting and commenting performed by students during a visit of the city are central to the pedagogical models behind the mobile learning experience presented in this paper. These activities are also used to feed new knowledge into the student profile.

Data regarding the cultural heritage visited by each learner, the educational materials accessed by him/her, the learning interests inferred by the system, the votes and comments published by the learners, in relation to the time when and location in which every single activity takes places, provide a unique data source that can be exploited in order to improve the analysis of the learning experience, for example through Learning Analytics mechanisms, provide feedback to the learners and teachers, and activate a redefinition and adjustment of the mobile learning activities.

For example, following Ferguson and Buckingham Shum [12], most of these data can be exploited to identify social behaviors and patterns which prove particularly effective to achieve learning objectives.

III. MeLOD in Use

In this section a use case scenario of the MeLOD environment is presented3.

1. The first step is the Login. Users have to insert their username and password to access the MeLOD environment. After the Login, the home page shows a welcome message with a short description of the application, and a menu to access the main functionalities.

2. The second step is the setting of the students preferences (see Figure 1). In particular, the user can select language, preferred media format and categories. These preferences will be used to feed the user’s profile. In the preferred media format menu students can select the media to be used for visualizing information. For example, the users can select the media format most suitable to the bandwidth of the available mobile network (3G, EDGE, GPRS). The preferred categories menu allows the users to select the macro categories that better fit their interest. The content will be filtered according to these preferences. As stated in the previous section the categories are directly retrieved from DBpedia through the Sparql endpoint.

3. Once the user has selected his/her preferences, the system is ready for use. By clicking on the “Map Menu” in the Home page, the point of interests (POI) near the position of the user will be shown. Only the points of interest belonging to the categories preferred by the user will appear. This view is created by integrating the information coming from the GeoNames API (for the geographic positions) with the information coming from DBpedia.

3 A detailed description of the MeLOD in use can be found at: http://melod.pa.itd.cnr.it/melod-in-use.html
4. By clicking on each POI in the map students access a specific page related to the POI to get further information retrieved from DBpedia. The layout of the page is chosen accordingly with the students’ preferred media format and the type of information available for the selected POI (photo, video, text). Finally, by clicking on the Vote button, the user can vote and comment the POI (see Figure 2).

IV. ONTOLOGY DEVELOPED OF THE MELOD ENVIRONMENT

The MeLOD environment is based on semantic web technologies, all the information are stored in a OWL.im triple store, and an ontology has been defined in order to represent all this information. In our approach several commonly used ontology to represent people such as FOAF, or GeoNames to represent longitude and latitude of points in a map have been combined with an upper-level ontology related to learners’ profile and activities. The main classes of this ontology are:

- User: this class is used to identify users within the MeLOD environment. In particular, information related to name, surname, email are stored.

- Configuration: this class represents the configuration parameters for each user in the system. In particular, this class stores information related to users preferences such as: preferred language for the learning resources, or preferred media type depending on the hardware capabilities of the mobile device of the Users.

- Session: this class represents the learning session associated to the Users. For each User there will be more sessions.

- SocialActivity: This class represents the social activities performed by the Users. In this version of the MeLOD environment, the two social activities of voting and commenting have been represented.

- Track: This class is used to store the information connected with all the activities carried out by the Users.

Several properties have been defined to express the relationships between classes, such as hasSession to represent relationships between users and their learning sessions, or hasTrack to identify the tracks occurring within a learning session. It is important to highlight that the MeLOD environment tracks the activities of the students exploiting the expressiveness of the RDF language. In particular, the designed ontology has been used to represent specific actions supported by the MeLOD environment. In the prototypal stage in which the system is at the time of writing, the attention has been focalized to students’ actions related to the request of contents during their visit, and the social activities of commenting and voting performed during the visit. Thus, each student is connected to his sessions through the m:hasSession property. Then sessions are connected to the Tracks through an RDF triple, with the m:hasTrack property. Each track is identified by its type and its location. The type is used to identify if the action is a social action or a request for contents, while the location is used to identify the place in which the action occurred.

![Figure 3: RDF graph of students actions](image-url)
Figure 3 shows a naïve example of three tracks for a student, two of them are related to voting and commenting, while the third one regards the request of contents during her/his visit. The activities of the student produce facts that can be added to the knowledge domain.

Tracking students’ activities by means of an RDF model supports the implementation of data mining processes that can potentially take advantage of the meaning expressed by semantics contained in the relationships between concepts. The semantic approach enables further inferences on the analysis of the data. Statistical data mining can be still accomplished, since the RDF graph can be queried in order to extract information expressed by numeric values. Moreover, the RDF model expresses direct connection with entities in popular ontologies, thus activating analysis based on semantic relationships.

To make an example, most of the municipalities provide data on the cultural heritage compliant with the LOD principles [13] thus providing interlinks with data provided by other datasets in the LOD cloud, such as DBpedia. Municipalities’ data include general information on the opening hours, number of visitors, and do on.

In our environment, the students’ actions that occur near a cultural heritage are connected with the corresponding concept in the DBpedia ontology. In this way, all data related to that cultural heritage contained in the municipality datasets are automatically linked with the students’ data logged by MeLOD, and can be compared with available data regarding the most visited cultural heritages. In such a way, the environment can recommend popular places that have not been already visited by the students.

V. ANALYSING LEARNING EXPERIENCE

In the MeLOD environment the assessment of mobile learning experience is carried out using a dashboard. The dashboard is developed following a plug-in based approach in which the core of the system can be gradually expanded with new plug-ins. The developed dashboard has been designed with the aim of providing visualization tools for helping teachers in monitoring the activities of the learners. In this initial stage we addressed our attention to the analysis of social activities and how to extract interesting clues that can be used to enhance learners experiences.

The following charts are available to the teachers:

- a bar charts representing the number of actions performed by each student. Teachers can also configure the dashboard to take into account different type of actions such as: voting, commenting, searching cultural heritage on the map, send message to nearby students, and so on.
- A pie chart representing the percentage of actions performed by each student
- A pie chart providing hints about the participation of the students to the activities under investigation by the teacher.

These charts can be used by teachers to respond to the following questions:
- How students participate to each activity?
- Which activities are more preferred by each student?
- What are the most used activities by the whole class?

The following SPARQL query has been used to extract the action performed by each student in their learning sessions, through the tracks related to each session.

```
PREFIX melod:<http://melod.pa.itd.cnr.it/ontology/>
SELECT ?student ?action (count(?action) as ?actionCount)
WHERE {
  ?student melod:hasSession ?session .
  ?session melod:hasTrack ?track .
  ?track melod:hasAction ?action
}
GROUP BY ?student ?action
ORDER BY DESC (?actionCount)
```

Moreover a specific section of the dashboard shows the analysis of the activities for a selected student.

This page can be accessed by the teacher selecting one of the students from the list of student, and it contains:

- the map with the cultural heritages visited by the student,
- a gauge chart for each activity under examination selected by the teacher (a maximum of eight gauge charts can be displayed). Each gauge chart indicates the participation of the student compared with the mean of the whole classroom.
- the list of activities performed by the student, ordered by date (most recent at the top).

The analysis of learners activities on the map can also be relevant to identify qualitative clues on the learning experience. For instance the following scenario can be useful to reveal cultural heritages that were not considered during the planning phase of the learning experience: the teacher defines a learning task consisting in the visit of a limited area of the city with the objective of finding and commenting several cultural heritages belonging to a specific architectural style or period (for example: Baroque churches). Teacher can select the subjects by choosing amongst the topics of the DBpedia categories (in the example Baroque Churches are represented by the correspondent DBpedia concept4). During their visit, students comment the churches that – according to their knowledge - are related to the topic chosen by the teacher. When a student comments the church, his position can be used by the environment to identify the cultural heritage he has

4 http://dbpedia.org/resource/Category:Baroque_churches
commented\(^5\). The DBpedia dataset provides relationship between the cultural heritage and its corresponding categories, thus it is possible to provide indications whether the student has achieved the objective of commenting the Baroque churches or not.

Furthermore, if many students report the same place as related to the target topic, and there is no link in DBpedia with that topic, the teacher can verify if the cultural heritage (that is in that place) belongs to the target topic and add it to the environment. In this way new knowledge coming from the real experience of students and produced on-site is fed into the knowledge base of the environment, thus providing the substrate to activate social knowledge building processes. The pedagogical framework behind this approach is under investigation and will be implemented in future version of the environment.

Two new plugins are under developing and will be added to the dashboard in the near future. In particular, a plugin to provide suggestion of similar pathways followed by students is under development. This plugin exploits Association Rules technique to provide recommendation related to the cultural heritages to visit during the learning experience, based on the sequence of cultural heritage visited by students in previous learning experiences. Moreover, a new plugin to aggregate students that have performed similar social activities of voting and commenting, in the same location by using clustering technique is also under development.

VI. Conclusion

In this paper we have presented MeLOD, an application based on mobile devices to support learning with Linked Open Data. Defining MeLOD precisely is not easy: actually, it combines the results from many research fields: firstly, it can be defined as a Mobile Learning application, since it is based on mobile devices, allowing users to study everytime and everywhere, provides formal and informal learning contexts and students’ activities depend on their physical location. Secondly, as most of the mobile learning systems developed during the last few years, it is a social learning environment, by providing specific mechanisms to support social activities by the students. Then, MeLOD is a semantic web application, by including function mechanisms which are typical of the new vision of the Web. Finally, MeLOD is an example of application of the Linked Open Data paradigm.

The combination of these different facets of MeLOD makes it a unique learning environment, and its potentials need further investigations in order to demonstrate that they can be transformed into real and practical benefits for students and teachers. For this reason, a trial period with some secondary schools in Italy will be run next autumn, and the analysis of the data produced during that period will provide useful insights on the potentials of this new kind of learning environments.

\(^5\) Examples of the API provided by MeLOD can be found at: http://194.119.209.93:8080/GeoFinder/

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