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Preface

Nowadays, the emerging methodologies for digital, interactive and project-based professional education are central development direction in training and formal education. To achieve this, it will be important to engage a wider community of educators, trainers, technical experts from a wide range of disciplines to improve their educational methodology. This issue supports these aspirations with several aspects which appear in the papers.

Ilona Heldal and Carsten Helgesen showing the Digital HealthLab which supports interdisciplinary projects in Engineering and in Health Education. The paper illustrates a number of benefits, but also difficulties with starting up a required educational module in an area needed to be developed at a university in Norway.

Robert Pinter and Sanja Maravić Čisar present the implementation of a Project-Based Learning (PBL) at Subotica Tech - College of Applied Science and the method of measurement of individuals' performance in teamwork. They applied the Agile project management (Scrum) and PBL approach to achieve the management of students' project and identify suitable metrics for measuring performance in the group at the level of the individual.

László Bognar et al. introduce the development of calculus courses and showing a 3D virtual learning environment applied for the Mathematics course of the University of Dunaújváros. Based on their experience the 3D learning environment is suitable however the efficiency depends on the technological background the students have.

Igor Fürstner et al. deal with the problem of developing a telepresence system at Subotica Tech. Their results showed that the developed system could have worked properly with the given structure, i.e. that this teaching approach, a project-oriented work involving students from different technical fields.

Csilla Marianna Szabó shows a research dealing with the early school leaving in secondary vocational education. According to the results the following factors are considered basic in dropout: student, family, peers, and school. Teachers and schools have a very important role in reducing school dropout.

Imre Petkovics describes two new ICT technologies that are being increasingly implemented in the process of digital transformation in higher education.

Radojle Radetića and Nándor Burány analyze details of a precision electric circuit and recommend this as laboratory project to open new ideas, gain knowledge and skills in practice.

Many thanks to Robert Pinter for his support!

26 of November, 2018 Attila Kovari, editor of this issue

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The Digital HealthLab: Supporting Interdisciplinary Projects in Engineering and in Health Education

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Abstract

The importance of promoting interdisciplinary educations is recognized, however, initiating collaborative interdisciplinary educational projects is challenging. In this paper, we will present the Digital HealthLab (DHLab), an educational optional, yearly educational module developed to define systematic support for students who wished to work with interdisciplinary projects in their bachelor or master thesis. The students were from computing and from health and social care, and their projects influenced by issues regarding technology development and use. By presenting DHLab, we aim to contribute to a deeper understanding of challenges and benefits with initiating interdisciplinary education at universities. Data was collected during the initiation and evaluation of DHLab from observations and group interviews. Our experiences are important to highlight since there is limited knowledge on starting and running interdisciplinary educational modules in areas without already established collaboration traditions, even if actors from the areas are geographically close to each other. Our results showed that using processes for planning educational activities was essential to understand needs, requirements, and possibilities from the different types of educators. However, future research is needed to determine key activities systematically supporting the start of interdisciplinary student projects with a focus on the role of the different participating environments.

*Keywords:*Interdisciplinary education; technology development; technology use; engineering;health and social care; processes; collaboration.

1. Introduction

The need to foster interdisciplinary education aligned with societal changes (Colovic 2014), especially in the domain of health informatics (Brittain & Norris, 2000), is recognized earlier. Engineering solutions can ‘contribute significantly to improvements in healthcare delivery in the short, medium, and long terms’ and professionals need to ‘identify engineering tools and technologies that could help the health system overcome … crises and deliver care that is safe, effective, timely, patient-centered, efficient, and equitable’ (Reid, Compton, et al. 2005). However, interdisciplinary education is challenging to start, especially in environments where there is a lack of experience with such collaboration (Carlisle, Cooper, et al. 2004).

Here, it is important to note the differences between interdisciplinary, multidisciplinary and transdisciplinary education (Collin 2009). For transdisciplinary education, the aim is to define a common base, e.g., theories and methods affected by the involved domains, and for multidisciplinary educations, the members of the different domains work independently on different parts of an often larger project. In this project, we focused on interdisciplinary education, i.e., the intention is to strengthen the own discipline with lessons from and collaboration with another discipline. In computing, BSc or MSc theses focusing on developing technologies for healthcare can be strengthened by knowledge about needs from healthcare. Such knowledge can be achieved via discussions about concrete needs and possibilities with students and professionals from health and social science. Similarly, in health and social science, BSc and MSc theses can be strengthened by knowledge about existing and possible technologies for the respective studies. This knowledge can be achieved via discussions with students and professionals from the area of computing and informatics.

This paper is based on the experiences gained from the educational module Digital HealthLab (DHLab), which brings together students from computing (CE) and from health and social care (HE) educations interested in carrying out interdisciplinary work. The DHLab educational module was held in 2016 and 2017 and planned to run again in 2019. While in 2016 and 2017 the start-up was mainly externally financed, the university recognized the benefits of it, and it is planned to run in 2019. Its main goals were: 1) to increase the quality of engineering education by acquiring knowledge from needs and possibilities from health and social care environments, 2) to improve the quality of health and social care education area by increasing knowledge about technical possibilities, and 3) to provide information on interdisciplinary collaboration usable for bachelor (BSc) and master (MSc) theses. Communication with professionals was determined to contribute to these improvements. During the activities of DHLab, the students could discuss with researchers and practitioners in the involved areas. These expert and students discussions can support defining a plan with important issues beneficiary for BSc or MSc theses.

By presenting the initiation of the DHLab, and evaluations from students after the activities, together with observations from the involved teachers and researchers, the paper aims to contribute to a deeper understanding of problems and benefits with initiating interdisciplinary education at universities, especially for implementing interdisciplinary educational modules between nearly co-located environments without earlier collaboration experiences.

While there are several lessons for planning new educations *within* health informatics (see, e.g. (Dorsey, Clements, et al. 2015)), the goal of DHLab is not to define a new educational focus or to change the main focus of the participating engineering or health and social science environments.

2. Developing processes to overcome interdisciplinary barriers behind technology development for healthcare

Despite modern technologies populating operation and nursing rooms, medical offices, and the presence of similar technologies in education rooms developed specifically for professionals, many systems are not sufficiently user-friendly or trustable to use. The presence of technology in the classroom, as well as at a working place, does not guarantee valuable use. Missing information, or misinterpreting existing information, time pressure, not user-friendliness, or even unintended consequences of use can result in problems for seamless use at the working places, and in the working routines (see, e.g. (Ash et al., 2004; Hagiwara et al., 2013)). Although technologies can promise several benefits, they are not necessarily easy solutions to adopt. Several studies are investigating barriers to overcome to achieve a seamless introduction of new technologies. As an example of such barriers, Taniverdi and Iacono identified the values of considering technical, financial, behavioral, organizational, and knowledge barriers (Tanriverdi and Iacono 1999). Understanding of these barriers was further researched by Suneson and Heldal by illustrating the need for lowering the inter-organizational barriers. Organizations without earlier communication and collaboration experiences need to allocate resources for building common support for their new collaborative activities (Suneson and Heldal 2010). To lower or overcome these barriers can be difficult, and requires a deeper understanding from both technology developers and healthcare professionals. The interdisciplinary collaboration requires being able to communicate well (Hermans 2011) and that all participants have a common understanding of their shared problem. It is necessary to understand the practical issues around the solution - the workflow it shall support, the needed human-computer interaction, other systems and processes being involved, e.g., the value generation process with the technologies (Melville et al., 2004). Professionals involved need to understand each other's perspective; only one profession cannot solve the problems. Understanding and practicing interdisciplinary collaboration already at the universities may lower these knowledge barriers later, at the workplaces, so future nurses and social workers can plan better, with engineers, for future technologies supporting healthcare.

At the same time, the students with diverse background need to understand how they can handle the complex information from these different domains, and how they can generate values for themselves. They need to know how to process voluminous information, what they need to prioritize or to neglect. In general, using process steering instruments helps to keep the focus of attention in such complex activities, with recognizing core values, longitudinal activities, planning collaboration and defining multidisciplinary assessments for core competencies (Carlisle, Cooper, et al. 2004). The knowledge from one environment does not necessarily flow over seamlessly to another, without additional support. Not only domain knowledge, but also knowledge about tools and methods to work in the interdisciplinary arena is necessary, e.g., planning this type of teamwork and processes supporting these.

DHLab recognized this importance for defining processes, an approach supported by necessities and benefits to plan education in general (Biggs, 1996; Och and Ney, 2003), and in particular for this case. Being able to understand each other for CE and HE students, and enhancing activities focusing on the willingness to collaborate and develop new ideas together needs resources and plans (Chau and Hu 2002). DHLab tries to tackle this issue by illustrating concrete issues and real problems around working and problematic communication, cooperation, and idea initiation (Frenk, Chen, et al. 2010). Such training may strengthen the CE and HE students' competence for developing meaningful solutions, with increased social responsibility.

3. DHLab – environment supporting interdisciplinary projects

At the Western Norway University of Applied Sciences (HVL) several BSc projects at different computer and engineering educational programs focus on developing new technologies and applications for health. There are also a few BSc student projects from health educations (HE) considering modern digital technology use. These BSc projects are time and resource limited, and seldom include resources to investigate expertise from other domains than the own domain. The ultimate aim of a BSc project in engineering is to demonstrate knowledge, skills, and competencies within engineering. Therefore, CE students seldom discuss ideas or test their prototypes with professionals from other domains. Similarly, HE students seldom talk about other possible technical solutions with technical experts during their project work.

Many different universities have environments with teaching and research expertise in health informatics, a natural arena for issues regarding development and use of technologies supporting health and social care. Such an environment does not exist at HVL, while research and teaching within engineering and within health and social science, separately, have already established traditions. DHLab was motivated based on regional needs for student projects with interdisciplinary competence. Private and communal organizations showed interests in strengthening their collaboration with the university with such interdisciplinary projects, which may begin with student projects. Such organizations were Haukeland University Hospital, Avans, Bergen municipality, the simulator center at Haukeland University Hospital, etc.

4. Planning and starting DHLab

DHLab contains five half-day meetings with collaborative discussions and presentations from educators and researchers from the involved environments and practitioners from health informatics. Particular topics addressed are:

- learning to use digital tools,
- providing examples on current digital tools for healthcare,
- providing a basic understanding of technology development,
- discussing needs in health care,
- encouraging and supporting the development of new ideas for interdisciplinary cooperation.

The participants are expected to achieve knowledge about trends for what is new and interesting within health technology and to build up a common understanding of each other's academic language from the involved domains. Furthermore, they should gain skills needed for planning a joint project and using digital solutions to communicate within a project, and get experience with methodologies supporting the development of interdisciplinary projects. Students from different faculties are introduced to e-learning resources for different kinds of digital collaboration tools to practice professional communication.

DHLab was developed to support BSc projects, but student interests extended to MSc projects, already during the first year.

The different interdisciplinary project ideas for BSc or MSc thesis will be developed into descriptions for BSc and MSc theses with clear demarcation of involvement from both areas. Thus, a good BSc project in engineering should include a clear description of the motivation and need in the health care domain, as well as concrete ideas for user involvement, e.g., possible user tests. Similarly, a good BSc project in the health domain should discuss possible technologies and motivations for the chosen involved technologies.

At the present stage, it is not possible for CE and HE students to work together on a joint BSc project due to study regulations. Cooperation between a CE and an HE student would give rise to two separate BSc theses, with separate formal requirements. This makes close cooperation on a joint interdisciplinary project difficult.

DHLab was taught for the first time in autumn 2016, then it was improved and run for the second time in 2017. Both years the educational modules were run during autumn, beginning in early September and ending at the end of November.

In 2016, seven students participated, and in 2017, 14 students participated and followed all the DHLab activities. In addition, at several meetings, we had a few more students attending who chose not to follow the entire module due to several reasons. The students were recruited from several courses. After the first year, the BSc students from the first year acted as ambassadors for recruiting new students.

After each year, a few months after the module, an evaluation was scheduled for all participants. The set up was as a semi-structured group interview, about general impression, main opinions, what was good and what was less good, what are the impressions about possible BSc/MSc project follow-ups, suggestions about structure. This was followed by an open discussion about general values related to such interdisciplinary modules, needs, and possibilities to follow it. Each meeting lasted approximately two hours. The results come from these evaluations, participant (teacher) observations, and summarizing reflections discussed together with the planning activities.

5. Activities in DHLab, and process support

To plan courses that are not compulsory for students is challenging. Therefore, to define and align activities and possible assessments process steering instruments was discussed (see, e.g., Briggs, 1996). Since the background of BSc and MSc theses is interdisciplinary and also should be used with interests from mainly regional organizations, several project support tools from the university and industrial organizations were considered. There are several models aimed to support projects in general, e.g., Lean is used in several parts of the health care (Brandao de Souza 2009), even together with other process support systems (Weber, Reichert, et al. 2008). There are process models developed to support communication activities (Hibbard and Peters 2003) or to measure progress (Purbey, Mukherjee, et al. 2007) during the length of an educational module (Kember 1989). Due to the focus on communication between two different stakeholders the Thesis Steering Model (TSM, see Heldal, 2016) was modified for DHLab 2016, but changed to a seemingly easier model.

5.1. About TSM

Thesis Steering Model (TSM) (Heldal 2016) is a process steering instrument which was earlier applied for supporting industrial doctoral projects. The familiarity with this instrument, and the fact that it incorporates two, often contradictory interests from industry stakeholders and academic stakeholders, motivated the use of the model. DHLab incorporated interdisciplinary collaboration between CE and HE students, and practical engineering and healthcare environments. Based on this model, the Digital Helselab process Model (see 5.2) was defined.

The TSM is an instrument for longitudinal support based on seven or so gates (see Fig. 1) with a special focus on the first gates until idea identification and generation. The four streamlines in TSM represent the constantly reoccurring interests in an industrial doctoral project, i.e., to obtain research values (1) and business or organizational values (2), and perform necessary activities in the Ph.D. process (3, the examination management) and a separate streamline for project control (4). This fourth integrate the three important areas with a focus on quality, time, cost and content of the project. The examination can also be defined through the gates representing activities in time, through the Licentiate (Lic) means a mid-term examination and later Ph.D. examination. These activities had to be evaluated in all parts of the milieu with different activities. One of the main benefits of this model is to allocate enough time to identify the common idea, interesting enough for the two environments, and sort out communication problems.

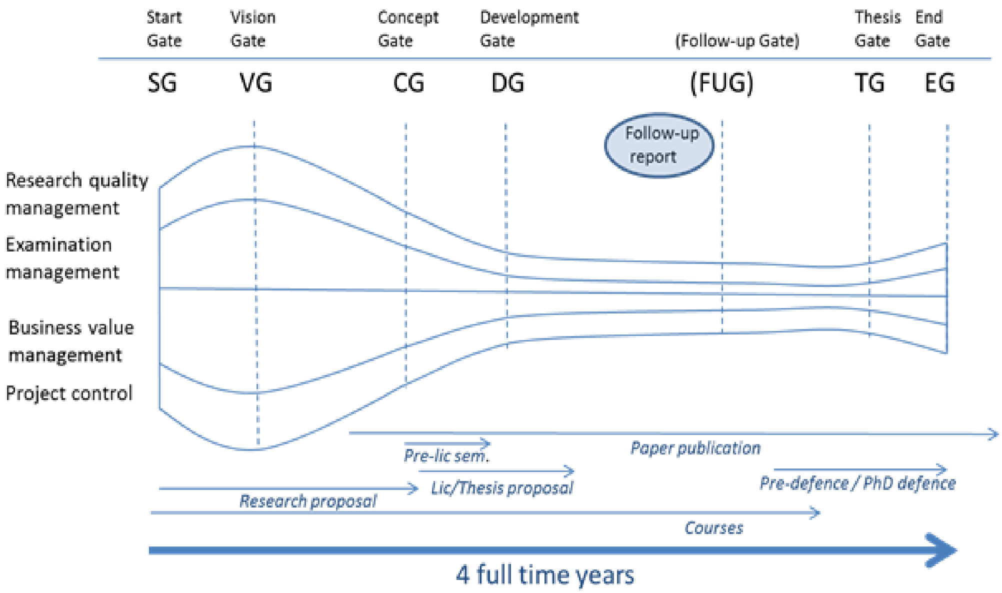

Fig. 1 A general overview of a doctoral project via the process model: TSM.

Each gate involves an associated gate meeting with systematic and thematic questions that are set out in templates. The answers to these questions require a great deal of teamwork on the part of the project group involving stakeholders from the different environments.

Thus, the TSM is not a quick fix guide to get past the gates, but more a process tool to get communication flowing in the project group and to harmonize the members' expectations. It is a method used to identify and discuss scientific requirements and find associated business values. Probably its most important benefit is the two first meetings, the start gate, and the vision gate. These meetings are planned to allow the members from the different interdisciplinary background not only to generate ideas, but also to communicate and sort out basic misconceptions due to their different domain knowledge (Martin, 2010). By using the model the participants can be supported to generate ideas carefully, anchor it, and plan activities, and *when* they should be done (by identifying important phases and elements as 'gates'), but leave the *how* question to the project group. This provides guidance and quality assurance for the research projects by going through a series of gates. By using TSM the communication between the different partners is systematically followed up and documented.

5.2. TSM adapted to DHLab

The starting point of the DHLab module corresponds with the start goals (until the gate idea definition) to TSM, albeit this project is much smaller in scale. Since the creation of new ideas is important and requires intensive negotiation of possible ideas and contributions from the involved parties, taking this step for granted does not necessarily result in good collaboration from all parties. Already in this initial part of the student projects, communication can be difficult as shown by, e.g., using the same terms for different meanings, different cultural or organizational background, priorities and regulations.

For structuring the facilitation of communication and development of ideas, four gates covering at least five meetings were defined (see Fig. 2 and Table 1). Between the last two gates, the students could book a meeting(s) with involved teachers from the different professions. The gates were planned seminars together with a group work between CE and HE students and teachers or the involved professions. DHLab is short, including only five meetings, and the four streamlines of TSM were reduced to two in DHLab: focus on valuing ideas for engineering and health and social care.

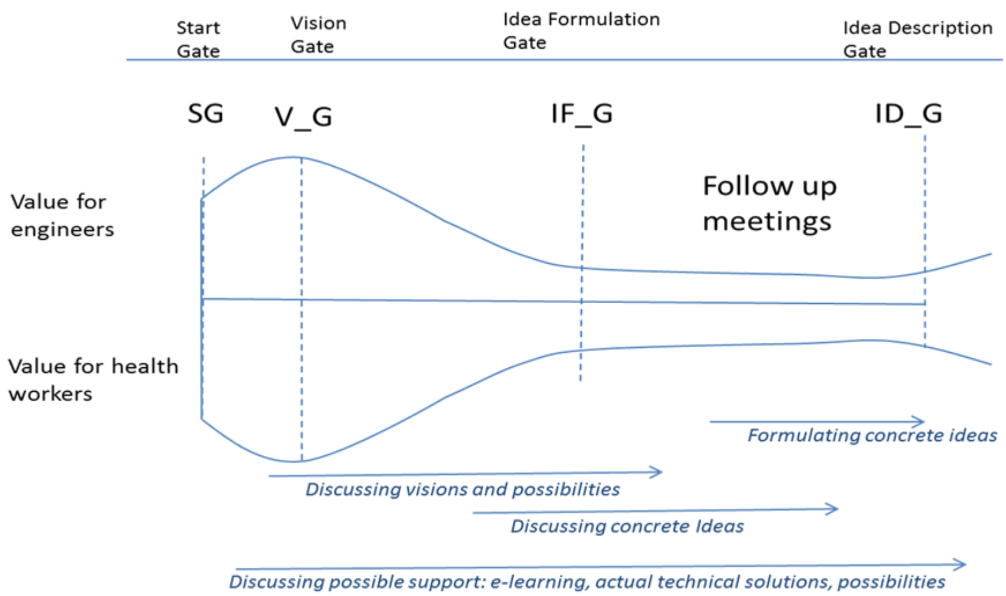

Fig. 2. A schematic picture illustrating the main elements of DHLab Process Model.

The projects within DHLab begin with a general overview (SG), followed by idea generations and discussion (V_G). At the start, it was important to have separate activities for forming the working groups with members from both CE and HE educations. To identify common ideas, interesting enough, for the two environments, and to allocate enough time was considered important. Therefore, a separate ‘gate’ was planned for discussions about possible and less possible ideas, associated to the own ideas of the students. These were performed in different possible group coalitions, involving different students, teachers and also representative people from organizations (IF_G). After a task with the idea descriptions (the suggestion for own BSc and extended to MSc theses), these had to be reformulated and discussed, again, by professionals from the different area, during follow up meetings planned by the students. These final ideas were described at the last seminar to both organizers and students. This description included clear involvements (from idea generation to communication and tests) with students or professionals from the other profession.

Table 1. Main activities starting DHLab and their correspondent gates.

Seminar	Activities	Gate
1	• Present participants • State-of-the-art overview, lectures • Initial ideas, brainstorming • Elaborate further follow-up ideas	**Start Gate:**Present the structure of the seminars including the process steering model.
2	• Discuss ideas and visions • Establish a common language and understanding for goals • Create interdisciplinary groups, to cooperate on a common idea.	**Vision Gate:**The project group is formed, and the project vision and expectations are formulated in general terms and are agreed to commence the preparing the project. Initial scanning of related work is carried out with a focus on novelty assessment.
3	• First elaborated version of idea • Focusing on clear vision • Identifying stakeholders • Describing novelty • Judging realism.	**Idea Formulation Gate:** Multiple project visions are generated. Several possible ideas are investigated, and possible goals and research problems are formulated. Related research and potential external cooperation environments are considered. The vision of the project has now become clearer.
4	• Second elaborated version of idea • Moving from idea to product • Security and ethical aspects • Selling points.	**Follow up meetings:** The main feasible research goals are discussed, and ways of reaching these are examined. The research background needed is discussed together with possible experts.
5	Final presentation of idea, sufficiently well described to be accepted as a BSc or MSc project.	**Idea Development Gate:** Here clear targets, plans, and methods to achieve the research aims are formulated. The resources needed to do so are planned and secured from all stakeholders, and therefore presentations were done at

‘While TSM meetings were for project groups including interdisciplinary members, here a meeting included several project group. In order to know if the students are on the right way towards generating manageable project ideas, we need to measure progress during the time. These measurements are collected before the second (number of ideas generated), third (number of presented complete ideas), fourth (number of meetings required by experts) and fifth (number of final presentation of a proposed BSc or MSc project) seminars. The DHLab Process Model describes partial goals for the five meetings, and it also gives a systematic method for measuring the progress of the students’ work (see Table 2).

Table 2Measuring progress through the seminar process

Seminar	The focus of activities	Progress measures (answers)
1	• Present participants • State-of-the-art overview • Initial ideas, brainstorming • Elaborate ideas for next seminar	After seminar: How many ideas have emerged? • from health students • from engineering
2	• Elaborate on ideas, categorize • Common language and understanding • Create interdisciplinary groups, to cooperate on one common idea each.	How many ideas after “homework”? • the groups´ “own” ideas • clarity of the idea at this point • interdisciplinary character (observation)
3	• Present first elaborated version of idea • Focusing on clear vision • Identifying stakeholders • Describing novelty	How clear is the idea at this point? • groups cooperation (observation) • groups communication (observation) • external help needed
4	• Present second elaborated vers. of idea • Moving from idea to product • Security and ethical aspects • Selling points.	How clear is the ideas at this point? • groups cooperation • groups communication • external help needed
5	Final presentation of idea, sufficiently well described to be accepted as a BSc or MSc project plan (good enough sketch).	How many well-described ideas were developed? • How many hours of work has been done during the cooperation? • How have the participants experienced the course?

5.3. The Double-diamond model

After the evaluation of the educational module in 2016, the students did not understand the value of the DHLab Process Model process model clearly, and one of the involved teachers argued for the benefit and the easiness of using the double-diamond model (Howard, Culley, et al. 2008; Design Council 2018). Double-diamond is a model for a creative process which unifies the process used by many design disciplines, with two broader focuses. First, in the left diamond, on exploring and discovering the essence of a problem, in order to define the problem as correctly as possible, and secondly, in the right diamond, on exploring possible solutions to the defined problem(see Fig. 3).

The processes in the first area (or diamond) gives good guidelines of how to work in the cross-disciplinary teams with focus on “Discover” – getting as much insight as possible about the problem area and its context using divergent thinking - and subsequently focus on “Define”, - using convergent thinking to reach a problem definition. The second area of the diamond involves creating a solution to the defined problem, by exploring potential solutions and concluding with a solution that is implemented. The students’ work at DHLab clearly falls within the first diamond, while (possible) further work on the idea will happen if they adopt the idea for a BSc or MSc project.

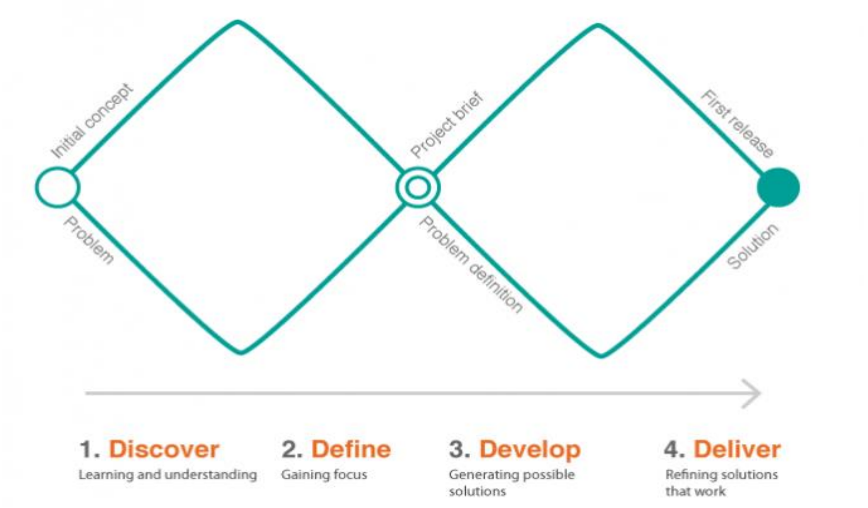

Fig. 3. Double diamond design process.

https://www.ebi.ac.uk/training/online/course/user-experience-design/phases-design

The double diamond model was used to support and motivate activities in 2017, and explain the processes leading from an idea or a need to a problem definition.

6. Reflections and results for organizing DHLab

6.1. Recruitment

Recruiting students turned out to be harder than we expected, particularly the first year (2016). Many students are reluctant to spending time on activities which do not "pay off" with ECTS, and many students have social activities in the afternoon and evening. Some of the students also have paid work, which is prioritized above extra-curricular activities. During each meeting there was 8-10 participants, but the number of constant followers was seven in 2016. These students followed all activities this year. This number increased to 14 participants during autumn 2017. This second year, some student groups from a compulsory course on innovation, chose to cooperate on projects involving digital solutions for health and social care innovation, and they also joined the DHLab.

6.2. Resulting projects

The following are finished suggestions for BSc projects which were later implemented:

- A dynamic digital form for collecting data from patients, about their pain registration
- A "Digital Pictogram" for communication between people without common verbal language
- A common calendar to improve communication between home nurses, patients and next of kin
- A method to discover risk of overdose with drug addicts

Two of these projects were continued as BSc thesis projects by the CE student themselves, and one was implemented by other students. Furthermore, two health care students used the overdose prevention idea for their joint BSc thesis in nursing.

The group that came up with the idea for creating the dynamic form for pain registration consisted of students both from CE and HE. However, the HE student had to drop out due to lack of support (due to formal problems) for working with the suggested BSc thesis. Additionally, discussing processes influenced an MSc student who developed an idea about process support via a mobile application for future parents (mParent App, Heldal et al 2018).

Here it should also be mentioned that two nursing students who participated in the first year, were not recommended to choose the project they wished initially, due to the regulations for the BSc project in healthcare.

6.3. Reflections from evaluating DHLab after the meetings in 2016

There were six students present at the final evaluation. Almost all students are appreciated the longer time allocated for and spent with idea creation. Here are some citations:

"I learned a lot, and I know that I can still innovate because I have ideas ... I also can play with the ideas and see it and examine it from different angles, both as ideas or as a suggested solution..." (Stated by an HE student, who appreciated the different role of an idea for a BSc work, but also for future users.)

"It is great to contribute to the technical solution. I did not have any idea that I [could do it] earlier." (Said another HE student.)

"I think it would be better to work with real practitioners. It was interesting to see what they believed to be usable… it was different from what I thought from the beginning." (The insight of a CE student, about the value and the difficulties of involving users in testing prototypes.)

Negative experiences were related to use of the chosen digital tools. Students did not appreciate tools, recently recommended by HVL, such as OneNote, SharePoint. Since the involved students were from the third year from their education, and already familiar with using digital tools for their work, they did not understand why they should choose another tool as they are used with. They used tools for sharing documents, e.g., Google docs, or communicated via Facebook instead. Neither did they appreciate the e-learning resources about how to use these tools. The added value of the new tools was too low.

"Why should we learn another tool when the existing ones are working?" were the opinions from both CE and HE students.

Most of the students appreciated the work within DHLab, and except from one HE student all wished to suggest it for their fellow students. This HE student was disappointed, due to not having the possibility to work with a CE student on the idea interesting for her. The general comments showed that HE students had higher difficulties to realize their ideas and combine the activities within DHLab with their activities for BSc or MSc work afterward. However, another HE student, who had a great idea realized by only CE students (with small modification) said that she is not disappointed since after all her idea was used and generated a good engineering work. Here, it has to be mentioned that the structure of DHLab's activities followed rather the BSc activities planned within the education for CE students with clear, separated time allocated for practical and theoretical issues.

While we had a structure for the meetings and planned for the presentation of the idea work as it progressed, the students did not remember the process steering instrument being used. This was a surprise, since it was used continuously, even if names (of gates, deliveries, etc) at the meetings were not used explicitly, except in the first two meetings. During these two meetings, the progress of the project was discussed more in detail. The students also said that they missed a much more "clear red line" through the seminars.

6.4. Evaluation from 2017

For this evaluation, again, all participating and partly participating students were invited, but only five participants met the organizers for a final evaluation of the module from 2017. The discussions were set up as a group interview about the general impressions: what was good or less good and needed to be improved for the students to be sufficiently satisfied with the time and the content of the meetings to prioritize the module.

The main opinions varied a lot 2017. The main obstacle to follow the module was the fact that it is time and activity related, and difficult to set in in their own plans. Several students agreed that it would be beneficial to have a similar type of educational module, mainly to train interdisciplinary collaboration in general, and not necessarily to prepare activities for the next coming thesis work. All students agreed that it would be great to have the possibility to work as an interdisciplinary team, and they wished to have obligatory education about tools and processes supporting interdisciplinary education. Most of them agreed that having the possibility to work on the same BSc thesis for students from different environments, would beneficiary. Even if the initial opinions about the 'type of the students' studying in the other domain was not without stereotypes, the general impression after the collaboration was good.

During 2017, more students worked with OneNote and SharePoint than the year before, when information about this tool was enhanced and discussed in the module. A reason for using these tools was formulated by one of the students: 'Yes, we use it since we are obligated to use it in another project.' Does this mean that students need motivations from several other projects for using a tool? - and, in general, there are too many tools, so they need to minimalize the usage of these to the most necessary?

Strangely enough, the students, still do not remember about process steering instruments, but appreciated the systematic planning and would require even more implicit systematic plans, including more feedback from the other area.

"I found a bit stressful to not have an idea until the third meeting, but it was OK. Now I understand that the earlier discussions led to something. Actually, I wished to have more feedback from all, from teachers, but most of all from practitioners", according to a CE student.

"I also found it difficult to connect to and wait for people… I have contacted other people, identified to be relevant stakeholders for my project, from physiotherapy but I do not obtain an answer, and I felt it was much time spent with waiting for answers. During this time I would need information about what I would need to work between meetings, or after the next step when I have or not have the help needed. I think more agile planning would be more beneficial." Said another CE student. This is a lesson, probably for the organizers, to focus on planning activities even for situations when students need to wait. Suggestions about handling these waiting-periods would also be appreciated. Several others agreed that not only the actual next step and activity,but an orientation between the steps and activities and other involved actors would be necessary.

7. Concluding remarks

This paper illustrated a number of benefits, but also difficulties with starting up a required educational module in an area needed to be developed at a university in Norway. It was shown that geographical closeness does not necessarily foster collaboration if other resources are not allocated for the module, and if the research and education areas do not have earlier collaboration traditions. Interests from students and some teachers can start up collaboration, but for longer-term planning, systematic resource allocation and harmonization to the different educations would be necessary.

While students overall appreciated DHLab to be helpful for thinking and planning their coming BSc or MSc projects, it was realized that some obstacles on the road towards full collaboration need to be handled. While several process steering instruments were applied, the connections between the activities and concrete support for activities have to be more accentuated. Many students are less interested in participating in voluntary activities which do not produce ECTS or other direct results. Also, many CE students can be uncertain about engaging in other areas, e.g., with a health professional, which is seen as unknown territory. The same situation is seen from the other side; the HE students have an almost none existing timeframe in their plans for extra-curricular activities. It is even more difficult to define a course module, such as DHLab as a formal part of their studies. While interests from some of the teachers and researchers were easier to obtain, their interests lessened during the time. There were also professionals who have been more reserved and do not see the usefulness and relevance of close cooperation from the beginning. Being situated in neighboring physical buildings and having common interests in developing teaching environments and research areas in focus was not sufficient to establish a longer-term collaboration. Recruiting students was also a challenge.

Many of the attitudes and thoughts from 2016 influenced the planning and the outcome of this educational module in 2017. However, it is dangerous to rely directly on some evaluations. After the outcome from the evaluation from 2016, seminars for using new digital tools from the activities were removed – but the students have begun to use these by themselves. The process steering model was changed from TSM to the Double Diamond model, but the students required, again, even more, the explicit connections between the different activities, requesting a clearer red line. Maybe process steering instruments should be explicitly included as a separate seminar during the educational module? Evidence on the benefits of steering instruments was not found, but the need for was accentuated. Which one, and how to find these forms, are questions for further research. For planning the next educational module for 2019, it would be important also to involve third expertise, the educators, people knowing more about pedagogical models and processes. There are clear descriptions for requirements for the quality and the content of a thesis report at the different levels, so maybe questions can be formulated more precisely for interdisciplinary BSc and MSc projects with help from the experts in pedagogy.

Certainly, the use of the chosen or the applied models could also be improved, based on the students' requirements, since it produced results and showed progress for the organizers. The main challenge, according to the organizers is to have the environment to prioritize time and resources to develop plans for collaboration. While meetings are considered to be necessary, they are hard to prioritize without explicit resources for them. Great modules cannot be created without great content, which needs time and meetings to plan. To support the common ground of the students, the educators and researchers need to establish basics for collaboration earlier. Hence, according to the experiences of the organizers, more focus on emphasizing the importance of strategies and processes need to be prioritized. However, how to handle these strategies and processes and exactly who should handle it in environments without collaboration traditions, need further discussion.

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References

Biggs, J. (1996). “Enhancing teaching through constructive alignment”. *Higher education*, 32(3), 347-364.

Brittain, J. M., & Norris, A. (2000). “Delivery of health informatics education and training”. *Health libraries review, 17*(3), 117-128.

Carlisle, C., Cooper, H., & Watkins, C. (2004). “Do none of you talk to each other?”: The challenges facing the implementation of interprofessional education. *Medical Teacher*, 26(6), 545-552.

Chau, P. Y., & Hu, P. J. (2002). Investigating healthcare professionals’ decisions to accept telemedicine technology: An empirical test of competing theories. *Information & Management*, 39(4), 297-311.

Collin, A. (2009). Multidisciplinary, interdisciplinary, and transdisciplinary collaboration: Implications for vocational psychology. *International Journal for Educational and Vocational Guidance*, 9(2), 101-110.

Colovic, G. (2014). 3 - Ergonomic conditions of work. Ergonomics in the Garment Industry, Woodhead Publishing, India, 61-103.

Clements, K., Garrie, R., Houser, S., Berner, E., & Dorsey, A. (2015). Bridging the Gap: a collaborative approach to health information management and informatics education,*Applied Clinical Informatics*, 06(02), 211-223.

Design Council (2018, October12). Double Diamond. Retrieved from https://www.designcouncil.org.uk/news-opinion/design-process-what-double-diamond

Dykes, P. C., Samal, L., Donahue, M., Greenberg, J. O., Hurley, A. C., Hasan, O., T. O'Malley, A., Venkatesh, A. K. , Volk. L. A. and Bates, D. W. (2014). A patient-centered longitudinal care plan: Vision versus reality. *Journal of the American Medical Informatics Association*, 21(6), 1082-1090.

Frenk, J., Chen, L., Bhutta, Z. A., Cohen, J., Crisp, N., Evans, T., . . . Zurayk, H. (2010). Health professionals for a new century: Transforming education to strengthen health systems in an interdependent world. *The Lancet*, 376(9756), 1923-1958.

Heldal, I. (2016). Supporting Communication between Stakeholders Involved in Industrial Doctoral Projects by a Process Steering Instrument. *UASJournal of Finish Universities of Applied Sciences* (Spec Issue: Bridging professionalization and working life in context of responsiveness to change in society and the workplace), EAPRIL 2016.

Heldal, I., Efrem, I., Helgesen, C, Design and Development of a Mobile Application Supporting Planning for Future Parents, Studies in health technology and informatics, 251:71-74, 2018.

Hermans, J. (2011). Knowledge transfers in university-industry R&D projects: a situated approach, Doctoral Thesis, Universite De Namur.

Hibbard, J. H., & Peters, E. (2003). Supporting Informed Consumer Health Care Decisions: Data Presentation Approaches that Facilitate the Use of Information in Choice. *Annual Review of Public Health*, 24(1), 413-433.

Howard, T., Culley, S., & Dekoninck, E. (2008). Describing the creative design process by the integration of engineering design and cognitive psychology literature. *Design Studies*, 29(2), 160-180.

Kember, D. (1989). A Longitudinal-Process Model of Drop-Out from Distance Education. *The Journal of Higher Education*, 60(3), 278-301.

Porter, M. E. and E. O. Teisberg (2006). Redefining Health Care: Creating Value-Based Competition on Results. Boston, Harvard Business School Press.

Purbey, S., K. Mukherjee and C. Bhar (2007). Performance measurement system for processes. *International Journal of Productivity and Performance Management*, 56(3): 241-251.

Rathert, C., M. D. Wyrwich and S. A. Boren (2013). Patient-centered care and outcomes: a systematic review of the literature. *Medical Care Research and Review*, 70(4): 351-379.

Reid, P. P., W. D. Compton, J. H. Grossman and G. Fanjiang (2005). Building a better delivery system: a new engineering/health care partnership, National Academies Press Washington, DC.

Royston, G., C. Hagar, L.-A. Long, D. McMahon, N. Pakenham-Walsh and N. Wadhwani (2015). Mobile health-care information for all: a global challenge. *The Lancet Global Health*, 3(7): e356-e357.

Och, F. J., & Ney, H. (2003). “A systematic comparison of various statistical alignment models”. *Computational linguistics*, *29*(1), 19-51.

Suneson, K. and I. Heldal (2010). Knowledge Barriers in Launching New Telecommunications for Public Safety. International Conference of Intellectual Capital and Knowledge Management Hong-Kong, 429-439.

Souza, L. B. (2009). Trends and approaches in lean healthcare. Leadership in Health Services, 22(2), 121-139.

Tanriverdi, H. and C. S. Iacono (1999). Diffusion of telemedicine: a knowledge barrier perspective. *Telemed J*, 5(3), 223-244.

Taraldset, M. and M. S. Lien (2016). Eldre i arbeidslivet: hvordan vil økonomiske insentiver påvirke etterspørselen etter eldre arbeidskraft?

Weber, B., M. Reichert and S. Rinderle-Ma (2008). Change patterns and change support features–enhancing flexibility in process-aware information systems. Data & knowledge engineering, 66(3), 438-466.

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Measuring Team Member Performance in Project Based Learning

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Abstract

In this paper the authors present how they implemented Project-Based Learning (PBL) at Subotica Tech - College of Applied Science and how they measure the individuals' performance in team work. Given that PBL takes place in group work, the students' marks were formed on a group level depending on how well the project was realized. Experience has shown that the "one mark fits all" approach may not be adequate for the majority of the students, because they strive for feedback so as to help them grow and improve. This motivated the authors to study the functioning of the group and individuals, and identify suitable metrics for measuring performance in the group at the level of the individual. Data collection about the topic was conducted via questionnaire. By analyzing the feedback from students and the results of developing the applications, it can be stated that the PBL approach in teamwork is accepted by the students. Authors suggest metrics for measuring individuals performance, but also state that three years after the implementation of this approach there is still no ideal way to be objective towards every team member individually.

*Keywords:*project based learning; measuring team performance; agile development;

1. Introduction

Modern industrial societies generate a huge need for well-educated engineers. The need is especially great for those who completed their computer science studies. Key goals for higher education institutions include the need to educate, to teach, to transfer the up-to-date knowledge materials and techniques. Based on the requirements formulated by the industry (Privredna komora, 2017), Subotica Tech is also trying to adapt the curriculum and the students' competence to the needs of industry (Gőgh- Kővári, 2018).

The growing need, or seen from another aspect, the considerable lack of IT engineers can be explained by the following facts:

- Education is always one step behind in teaching or applying the new, current, or even the latest technologies. ICT is a very dynamic field which produces new technologies at a greater and faster rate than other fields. It often happens that while the curriculum is under development, the described technology changes to such an extent that by the end, when the curriculum is finished, it is not current any longer.

- Education produces different results in terms of competencies and acquired skills. There are numerous reasons for that, including the different teaching methods or equipment used in the learning process, or the difference in the students' level of motivation. Another problem must be mentioned, causing lower knowledge and skill transfer: the motivation of the educators. Their knowledge, skills and motivation are crucial for a successful teaching output.
- Students learn fundamental engineering knowledge, but they do not know how to implement it in real situations.
- Most of the curricula teach schemata for solving problems. The students' creativity is suppressed.
- Besides fundamental engineering skills, there is also a growing need for communication skills and the ability to work in groups.

2. Project vs. problem based learning

In this section the authors explain the main characteristics of project based learning. First, it must be described what the difference is between this approach and problem based learning. There are certain similarities between these two, though they are not the same. The main similarities are (Savery- Duffy, 1995; Loyens- Kirschner- Pass 2001):

- Focus is on an open-ended question or task.
- To provide authentic applications of content and skill. Emphasize student independence and inquiry.
- They are longer and more multifaceted than traditional lessons or assignments.
- Build skills for 21st century success

The main differences can be described as (Perrenet-Bouhuijs-Smits, 2000):

Table 1. Differences between PBLs

Project Based Learning	Problem Based Learning
Often multi-subject	More often single-subject, but can be multi-subject
May be lengthy (weeks or months)	Tend to be shorter, though can be lengthy
Follows general, variously-named steps	Classically follows specific, traditionally prescribed steps
Includes the creation of a product or performance	The "product" may be tangible or a proposed solution, expressed in writing or in a presentation
May use scenarios but often involves real-world, fully authentic tasks and settings	Often uses case studies or fictitious scenarios as "ill-structured problems"
It is easy to integrate it into the content of the course, while at a problem-solving course, the content is more difficult to define	Problem-solving is hard to integrate into curriculum
Working on a project means managing deadlines and resources	Managing resources is not so specific
The project mainly requires the use of already existing knowledge	Problem-solving emphasizes the acquisition of new knowledge.

Apart from the fact that the terms Project and Problem based learning are very often intertwined, the previously described differences highlight that these two approaches have different terms of implementation. Nonetheless, both learning approaches are methods which can supplement the classical teaching system.

On the web page of the "Problem Based Learning Initiative" (PBL Initiation, 2017) there are interesting cases of applying PBL in medicine. Those cases and from other researches (Werty-Ben-Delsarte, 2005; Mills- Treagust, 2004; Gagnon- Tsushima- Lehner, 2015) describe important characteristics of PBL. Some of the prerequisites of using PBL efficiently are:

- Students must feel responsibility for their education. Since this is the approach in which the student is in the centre, it is expected that the motivation for acquiring new knowledge increases if the student feels responsible for troubleshooting, project development and management of these processes.
- Tasks that can solve these approaches must be arranged to allow a variety of ways to reach a solution. What is called in everyday life a "problem", has complex character, otherwise it would not be called a problem. One of the most important skills that students can acquire through the PBL approach is the problem recognition and defining those parameters that could lead to solutions. If the task is not complex enough, and the way to the solution is relatively well defined, then the students are less motivated to create their own specific solution.
- In the process of solving the problem it is preferred to apply the knowledge from various disciplines, or scientific fields. Different perspectives lead to a deeper understanding of the problem and the creation of better solutions.

3. Motivation

Three years ago, the authors introduced Project Based Learning at Subotica Tech. The new approach was implemented in a course about development Android applications. The reasons for using PBL are:

- Mobile phone applications are solutions for real world problems.
- The applications are complex in nature.
- There are many solutions to the problem.
- Development requires knowledge from many fields of information and communication technologies.

While the previous list described advantages of using PBL from the students' point of view, here follows an account of how the teacher can also benefit from it.

From the teacher's perspective, presenting the capabilities of Android OS and the implementation of that knowledge in the app development requires far more time than is available in the semester.

Even if the teacher reduces the material about the Android operating system, the problem still remains, because it is possible to develop a wide range of different types of applications. For example, the teacher can focus on developing games, or geolocation apps, or some entertainment app (listening music, chat etc.) or even financial apps. Different types of applications use different features of Android operating system. One semester is sufficient for a deeper understanding and acquiring skills to develop one type of application. Since this is a complex area, the question arises as to whether a teacher has to decide what kind of applications the students need to learn to develop?

The opportunity for students to choose which type of app they want to develop, means additional engagement and learning for them. The motivation for these additional activities can be easily achieved because they will develop whichever type of app they prefer, the one that they prefer the most.

The teacher's role in the PBL approach is changed. The teacher takes on the role of a mentor or a coach. He teaches only those part of curricula which are needed to start the development. The rest of the required knowledge necessary for the project is then learnt by students.

Transfer of responsibility for learning is useful for students as well as also for the teacher. From the perspective of the teacher, this means that the pressure of constantly monitoring the changes in the IT technologies is reduced. Also it reduces the collision with the competencies that students can have in the given field.

Students' competence in specific IT area may be larger than the teacher's, because students can spend much more time studying the given technology which they are interested in. Less confidence due to the lack of competence, can lead to a lower quality of education.

4. Implementation of P(roject)BL

The students' work load in the college course in which the students learn the technologies related to the Android mobile applications is:

- Learning the theory needed to start developing mobile applications.
- Parallel to the previous theory, they learn agile project management methodology.
- After completing the theory, they start with the developing phase.

During the semester the application development is managed using the Scrum methodology (or framework). Scrum is an iterative and incremental agile software development framework for managing product development. It defines "a flexible, holistic product development strategy where a development team works as a unit to reach a common goal", challenges assumptions of the "traditional, sequential approach" to product development, and enables teams to self-organize by encouraging physical co-location or close online collaboration of all team members, as well as daily face-to-face communication among all team members and disciplines involved (Gagnon-Tsushima- Lehner, 2015).

Implementing Scrum in education needs to be done in a different way than in the industry, because the participants are students with little experience in developing software, and there is also a difference in rewards or penalty methods. The other aspects of Scrum were implemented as if it was a real software developing firm: students used all available tools and events provided by the framework. The only major difference between the suggested and the applied method was the number of student in the group. The suggested size is between 5 and 9 people, but in the college course the authors worked with smaller groups. Depending on the project's complexity, the number of students varied from 4 to 7.

The projects which were developed throughout the semester were client-server type applications. The client application was a mobile app, which does some task locally and communicates with the server. The server manages the communication with the client: it stores the received data, presents some statistics, or sends data from database upon client requests. All the applications have logging and integrated security options.

The entire huge theory of all the technologies required for the developing process cannot be presented in a single semester in one subject. This is why the students have to do additional work by themselves: they become responsible for the project's future, and in order to achieve success, they have to learn some of the material on their own. Additional learning thus entails additional motivation. The Scrum project management framework tries to help in this process with the following features:

Team work. Development is a group task. The group selects a project from the list of problems independently and without external pressure. As mentioned before, in this way, the group will be developing a project that matches the interests of the team members. Each member of the group has the equal rights within the team. Everyone has a responsibility towards the other members and is jointly responsible for the successful implementation of the project. The failure of the project is a failure of the team.

Transparency. During the semester the students are developing the selected project. They specify the project options and priorities in the development process with the teacher. The Scrum tools and events help to track the state of the development, how efficient the group or a given student is. In terms of motivation, it is very important for the group members to have a clear picture of each other's contribution in reaching the common goal. In Scrum, one should not speculate how much the others contribute to the project. There should not be an atmosphere in which an individual thinks he or she is doing more than the others, because it causes a lack of motivation and uncertainty in the project's realization

Motivation. The group is formed by the students. There is no external influence on the structure of the group. Students receive the description of the project in the form of short sentences. Those sentences describe the options that the customer wants to be implemented in the project. A brief description, called a 'story' in Scrum, contains only sparse information about the required option. By default, the customer knows only what he wants as an option in the application, but does not know which IC technology to use in order to develop that option. Due to the lack of specific orders, there can be several suitable solutions. This is convenient for the students, because they can design their own solution.

There are a number of aspects which have positive impact on students' motivation. For example, the group members determine the task distribution and the resources needed for accomplishing it unanimously. Thus, every member can be allotted a task which is exciting them. The pace of achieving the goal is also determined on a group level. By this, the task distribution and the load are equal in the group.

This approach takes into account the fact that in the group, there are students who have different areas of interest, as well as various skill sets. The heterogeneity of the group is desirable because all members bring their different perspectives to the task, making it therefore easier to understand the problem, and leading to better solutions.

As briefly summarized in the previously sections, the implementation of the PBL approach and Scrum methodology leads the authors to expect that students will be motivated to learn independently and apply what they have learned. This way, they will acquire the ability to identify problems and skills for designing one possible solution. It is worth mentioning that through teamwork, students also practice communication skills. Further, on Sprint Demo events, they have the opportunity to test their skills as presenters of the project. These are skills that are also among the fundamental engineering skills required in the real world.

5. Research results

The main goal of the research was to define the method for objectively marking the students' contribution through project developing. The task of tracking the team members' performance is vital both from the aspect of the teacher monitoring team work progress, as well as another team member, who is, in fact, a student, too. However, quantifying and measuring performance metrics is easier said than done, as the task poses difficulties for both mentioned parties.

This class enables the teacher to measure the performance at team level and at the individual's level. Individual level means how an individual contributes to the team qualitatively and quantitatively. The term 'contribution' covers not only how the individual completed a particular task, but it also relates to the individual's behavior. For example, it refers to how he/she works and communicates with others, to what extent the person participates in team meetings or how pleasant or easy other team members find it to work with the given individual.

Prior to this research, based on the Scrum suggestion, it was decided that only the group as a whole would be taken into account, therefore, the authors formed the students' marks on group level. This means that the project's elaboration at the end of the semester was the key parameter which defined the mark for the students. Due to this team level evaluation, a great number of students showed some dissatisfaction, as there was no differentiation between their own contribution in the group and those students, who they worked significantly less, yet received the same mark as the rest of the group. The talented team members demanded feedback from the teacher, so as to help them grow and improve. This motivated the authors to look into the functioning of the group and individuals, and to identify metrics for measuring performance in the group at individual level.

The study is based on data from questionnaires filled in by the students in the previous three academic years. The number of questions and types of questions in the questionnaire was changing because authors experimented with the applications of the Scrum framework in the learning process. In the current academic year, certain questions were added in order to gain a better insight into developments and the contribution of the individual to the success of the team.

The study involved third-year students of Subotica Tech. The questionnaire varied in length, the shortest questionnaire included 22 questions, while the last in the series was the longest with 39 items. There were MCQ type questions, those with the Likert scale of five degrees and those where students could write answers in textual form.

Many of the questions were related to the Scrum project management system and its options. The answers to these questions are not relevant for this study and therefore they will not be presented within the scope of this paper.

One of the question from the questionnaire was: *How noticeable was the positive contribution of the individual in the group?*

A large number of students answered that they noticed when "certain members" contributed more to the success of the project than others (Fig.1). The answers are probably the result that every individual believe that they were the ones who pushed the group the furthest. The answers also point to underlying problems within the group. These problems have to be solved, because in the long run, they reduce the motivation of team members.

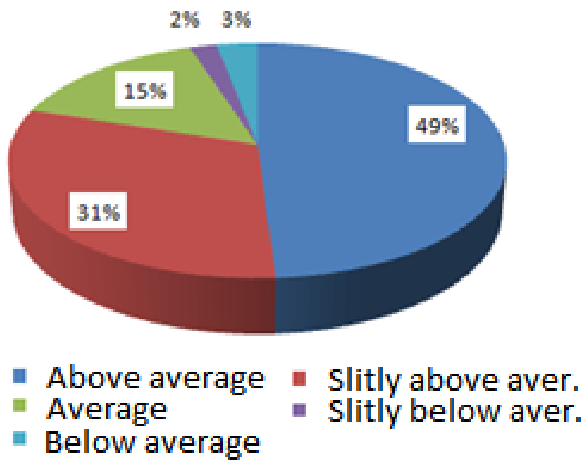

Fig. 1. Contribution of the individual

Another question was formulated with a similar content: How noticeable was the negative contribution of the individual in the group? Through the answers one can gain information about how satisfied the individual was with the quality and quantity of tasks done by other members. The answers, as for the previous question, showed that there was a problem in the system, because, despite the fact that the tasks were assigned under the coordination and with the agreement of all the members, most of the students think that a lot of the members were doing less than the student answering the question. The obtained answers highlight that 41% of the student agree a lot, that there is a member in the group who does not contribute enough. Another 20% of the students agree with the previous opinion, and 31% do not have an opinion. The rest of the students stated that everybody contributed the same.

The previous two questions highlight the problem that the implementation of the project management system in the learning needs some adjustments. The teacher cannot help in those situations, because he does not see the whole picture of all the happenings within the group. Usually the students solved any arising problems themselves. Because the whole team is responsible for the project, those solutions usually mean that somebody in the group takes the task over from the others. This is a typical students' solution, and it is not sustainable in the long run.

The next question relevant for analysis referred to the acceptance of the new methodology in learning: *Estimate how important it is to have someone in the group who will lead the project?*

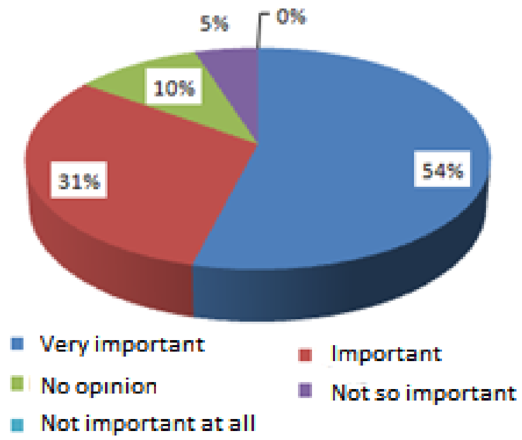

Fig. 2. Importance of having a ‘leader’ in the group

Although many students liked the idea of working in a group, where there was no hierarchy, the answer to this question shows that students still need someone, a classic ‘boss’, who will manage the project development (Fig.2)

This can be explained by the fact that the students do not know how to fully adapt to the method in which they themselves are responsible for their own learning. Their educational processes, in primary, secondary and higher education were mainly of the frontal type. The students always had a “person who manages everything”. Maybe this is a sign that the PBL approach should be implemented increasingly in primary and secondary schools.

Since this year, the questionnaires also included questions in which the group members could assess the work of their colleagues in the same team. Some of the questions on which each member of the team could grade the others with a score from 1 to 5 are:

- How reliable was he/she in the team meetings?
- Has he/she always accepted the job they were assigned to?
- If someone asked for help, did he/she offer assistance?
- On team meetings, did he/she have constructive suggestions?

Unfortunately, most of these questions did not provide specific information. Generally speaking, students fail to behave not in a manner as expected from future employees. Also the lack of student’s previous PBL experience affected their answers. If one of them in the team had greater prior knowledge in a technical field, the others accepted everything that the person proposed. However, this ‘easy acceptance of opinion’ also meant that knowledge from various disciplines or scientific fields was not applied, and there was a lack of different perspectives, which could perhaps lead to the deeper understanding of the given project problem at hand and the eventual creation of a better solution.

The lack of previous PBL experience and the experience of developing on one’s own had another side effect: the students were not able to accurately estimate how complicated their own task was and how much time it would take to complete it. A similar situation arose when a given team member had to estimate what the workload of another person in the team was. These incorrect estimations led to the previously presented answers, as well as to the lack of motivation and the uncertain future of the project.

To the question about assigned task acceptance, students gave the same grade to everybody in the group. Further research is needed to gain answers as to why someone gave, for example, the mark 2 (a very low mark) for everybody and also for himself. The same questions could be asked in the case when the answer contained the highest mark. Only 5 out of the 60 students' questionnaires contained answer in which the team members were graded with different grades.

The authors also found that there are contradictions between answers to different questions in the questionnaire. The examples include the following:

One the one hand, the answers showed that most of the students were satisfied with the communication within the group. Later, when asked how the group could be more effective, the answer was 'with better communication'. Also, those students, who stated that the communication was good, later when asked about the poor quality of the product (not all groups were successful in their development), answered that 'the communication was bad'. Further contradiction can be found in the questions when the students first gave a bad rating of the teammates' contributions, but afterwards, in another question, they stated that all of the options of the project have been maximally achieved.

There are also thought-provoking answers from students who have come from another study program, and they had obviously less knowledge of the required computer science techniques. They cut down their own scores realistically when asked about their contribution. However, at the same time, when asked what they would change for better efficiency, the answer was: nothing. Also, they stated that the project development process was well done, besides their poor contribution.

6. Conclusion

Agile project management (Scrum) and PBL approach was applied at Subotica Tech since the academic year of 2014/2015. For the past three years more than 170 students participated in the development of more than 50 ICT projects. Based on the answers to the questions from the surveys that the students filled in at the end of the semester, it follows that the Scrum agile management system is accepted by the students:

- 67% of them are satisfied with the possibilities of the Scrum.
- Approximately half of the students were satisfied with the structure of the group, with the work in the team and the way as the development was done.
- 47% of students were satisfied with the fact that they were allotted the task that best suited them.

In addition to the positive experiences, there are also some shortcomings that can be deducted from the questionnaire but also observed through conversation with the students. Differences in motivation for creating application, quality of developed solutions, working habits, level of teamwork skill, learning approach and ultimately individual goals lead to different levels of contribution in project realization.

The project management system contains options for solving these problems, but these solutions also work well in industry where team members have a different status, and there are better methods for influencing someone’s motivation.

Applying project management in an educational environment needs specific implementation. The data from the questionnaires was used to gain more specific information about Scrum implementation and happenings within the group.

The problem of the objective evaluation of a student, based on the questionnaire data, has not yet been resolved. The grades that present the acquired knowledge and skills are still formed based on the student’s achievement during an oral exam. A paradoxical question arises: should an individual be measured in a team work? Many project management experts unanimously say there is no need for that.

The Scrum spirit means that everyone jumps in to help; ideally, all team members work together on all of the stories. Different skill levels or types contribute to the best of their abilities. To create metrics for individuals, besides being inaccurate, would probably cause competition and division within the team. Individuals should work as a unit, be tracked as a unit, and succeed or fail as a unit (Scrumalliance, 2017).

Many will agree with the previous statements, that there is no need for any metric to track individual performance. But, if there is no measurement of individual performance, therefore it may work negatively for a person who is a high performer. People need to be rewarded by their contribution in the team, otherwise, they will stop working more than what is expected from them.

Another important question arises from applying the Scrum spirit: How can an agile company promote employees? There will be no promotion and career development if nobody pays attention to each team member individually. In order to promote employees one must use any metric or technique that is not only "working time at the company" (Rise, 2017).

There is a suggestion to use in education the following five metrics for measuring team member performance (Scrumalliance, 2017).

Attendance. First and foremost, it is important to look at whether a team member shows up to work or not.

Helpfulness. Helpfulness is important for fostering a culture of teamwork, allowing your team to perform better when tackling difficult tasks together.

Efficiency. Team members need to be able to complete their work on time - Look for missed deadlines, or work that suffers as a result of cramming for deadlines, for clues as to how efficiently a team member is working.

Initiative. It is nice when those you work with ask what is needed and where they can help. It is even nicer when they see a need and take steps to meet it on their own. Initiative is definitely a sign of team satisfaction and engagement.

Quality. Members who care about what they do and are engaged in work will likely perform better, and it is a good idea to recognize the resulting achievements.

Having in mind all the described difficulties of evaluation and performance measuring, the authors are planning to implement a new type of questionnaire next academic year. The aim is for the authors to design the tasks in the project in such a way, that every student is to have a so-called "critical element". This "critical element" is a work assignment or responsibility of such weight and importance that unacceptable performance on the given element would result in a failed overall mark for the project development. In fact, it can be called a 'pass/fail system' based on which the team member can be evaluated. This system, however, is difficult to adjust because each participant must be aware of what is important, what his/her specific task is, at what level "good" performance starts and "bad" performance ends, etc.

Another approach is to form two groups of students: one who does and one who doesn't prefer to work (develop, learn) in the team. This solution is not considered yet for the implementation, because it raises many new questions.

After defining these metrics to measure one's performance, there is still a doubt about implementation, because:

- team members are people and not just resources to be consumed, and
- how can we quantify the performance of the 'rock star' member of the team?

References

Greg Gagnon, Walter Tsushima, Albert Lehner, Just Do It! A Reflection of Motivation in Project-Based Learning, Third 21st CAF Conference at Harvard, in Boston, USA. September 2015, Vol. 6, No. 1 ISSN: 2330-1236

Gőgh, E., & Kővári, A. (2018). Examining the relationship between lifelong learning and language learning in a vocational training institution. Journal of Applied Technical and Educational Sciences, 8(1), 52-69. https://doi.org/https://doi.org/10.24368/jates.v8i1.27

Henrik Kniberg: "Scrum and XP from the Trenches", Enterprise Software development Series, free online edition, http://infoq.com/minibooks/ scrum-xp-fromthe-trenches

John R Savery and Thomas M Duffy. „Problem-Based Learning: An instructional model and its constructivist framework“ Educational Technology Vol. 35 Iss. 5 (1995) Available at: http://works.bepress.com/john_savery/4/

Julie E. Mills, David Treagust, Engineering Education, Is Problem-Based or Project-Based Learning the Answer, Australasian Journal of Engineering Education 3, January 2003.

Loyens, S. M. M., Kirschner, P. & Paas, F. (2011). Problem-based Learning. In K. R. Harris, S. Graham & T. Urdan (Eds.), APA Educational Psychology Handbook: Vol 2 (p. a). Washington: American Psychological Association

Privredna komora Srbije, 2015 (http://www.pks.rs/PrivredaSrbije.aspx)

Perrenet, J.C., Bouhuijs, P.A. and Smits, J. G. M., 2000, The suitability of Problem-based Learning for Engineering Education: Theory and Practice, Teaching in Higher Education, 5, 345–358.

Problem-Based Learning Initiation, http://www.pbli.org/shopping.

Wertz, V., Ben-Naoum, K., Delsarte, P., 2005, PBL in Mathematics: What is a "Good" Problem? Proceedings of the International Conference on Problem-Based Learning, University of Tampere, Faculty of Education and Lahti Polytechnic, Finland.

https://www.scrumalliance.org/community/articles/2012/january/tracking-individual-performances-in-scrum

http://rise.xyz/blog/5-metrics-team-member-performance

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Improved learning environment for calculus courses

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Abstract

The Department of Mathematics of the University of Dunaújváros is devoted to the success of their students. It results in a deep understanding of the students' needs. Appropriate course material including video lectures, notes, handbook, practice tests, detailed study guide, consultations personally and via email, chat using social networks make this approach fruitful. Modern learning methods are also introduced. Several studies show that changing the learning environment (LE) of higher education courses increases student success. In this work the improvement of the LE applied for the Mathematics course of the University of Dunaújváros is introduced. Using this LE the education is much more effective than in the traditional ways.

*Keywords:*teaching mathematics; education; learning environment;

1. Introduction

In 2000, College of Dunaújváros (later University of Applied Sciences of Dunaújváros, DUE) was the newest undergraduate institution in Hungary with about 4000 students. Mathematics courses were given in a traditional lecture format and direct teaching was applied. Students come to class, listen to lectures and then they were expected to do tasks to demonstrate their knowledge.

Educational methods usually applied in the higher education are presentation, explanation, discussion, debate, demonstration, learning by doing method, project method, cooperative educational method, simulation, roleplay and game, study trips, home assignment. (Howeversimulation, roleplay and game, study trips frequently cease to exist on maths courses.) Other methodologies and other formalism of calculus were available worldwide, that is opposed to the standard approach of Weierstrass, teaching calculus with infinitesimals were introduced. (Hernández, L. M., Fernández, J. M. L. 2018). Furthermore, some universities implemented computer labs using a Computer Algebra System (CAS) evaluating hybrid teaching to foster interactivity and facilitate a more personalized work with the students. The appropriate CAS was hard to identify. Often Mathematica, Matlab, Maple or even Derive was the chosen software. Nowadays GeoGebra or Octave seems to be good candidates also. (León de la Barra et al. 1999).

2. Developing the course

It is increasingly difficult to maintain student interest for a long period of time. Multimedia technology is considered as a useful tool that can capture the attention of today's students. Teaching with the hybrid-format (Young, 2002) or blended learning combines the typical traditional course components (lectures and in-class activities) with some online course component providing flexibility. Students complete learning activities online and in the class synchronously (Kerres, M., DeWitt, C. 2003).

Several articles compared the hybrid method and face to face method in teaching Mathematics and other subjects. It is found that "students taught by the hybrid method were able to participate actively in the duration of the course" and they achieved better grades. (Lacatan, 2013)

It is also shown that mathematics courses strengthen the soft skills of students. A multivariable calculus course covering functions of several variables, partial derivatives, multiple integrals, vector functions, and vector calculus were taught over a period of 14 weeks with 2 hours face-to-face and a 1-hour laboratory session by blended learning methods. Students activities consists of working in a small group, critical thinking and problem solving, doing assignments, reading and writing. "Results indicated that the blended learning multivariable calculus course has positive effects on students' communication skills." (Kashefi et al., 2012)

Later open source and free online courses were also developed to provide high-quality calculus.

This open source material can be modified to meet the needs of other instructors. (Korey, 2007).

In 2000 Calculus lectures and practice lessons were available for the students at DUE. In the lecture session, the mathematical concepts were introduced to the whole class. After the students had established a general idea of the concept, they then proceeded to the practice session. In the practice session, students were directed to perform mathematics tasks.

The first course in the scope of this work is Precalculus. On DUE this course is not an obligatory course, but available for volunteer students if it is needed. The aim of the Precalculus course is developing and deepening problem-solving ability as well as mathematical background needed prior to higher level mathematics courses. The prerequisites of the course are secondary school mathematics. The applied method is direct teaching in small groups, solving computational and applied exercises using projector, blackboard, calculators, and computers. Finishing this semester, the students know the mathematical background required to perform higher level mathematics courses and they are ready to understand and solve mathematical exercises and problems emerging in their field of science. Students should take responsibility for their own work. There is a considerable amount of material to be covered because the content of the course includes algebra concepts, integral exponents, radicals and rational exponents, operations with rational exponents, factoring, algebraic fractions, the solution of linear equations and inequalities of one variable, systems of equations, linear functions and their applications, quadratic functions, logarithmic functions, logarithmic equations and inequalities and plane trigonometry.

Usual activities are learning of the theory and solving mathematical exercises with direction and without direction using pattern and examples. They use traditional books, e-books, hyperlinked documents and other sources from the internet. During the semester there are three compulsory tests: one (maximum 30 points) on the 3rd week, the second (maximum 40 points) on the 7th week, and the third (maximum 30 points) on the 12th week. The tests consist of questions on applied problems. The students may make up the three tests on the 13th week.

The obligatory course in Calculus is Engineering mathematics 1 and 3 (Two semesters are given for basic Calculus).

In these courses, mathematical theory is introduced to solve quantitative problems in technical and other fields. On the lectures notions and methods are introduced in a lecture hall, using blackboard. Practice lessons or seminars and computer labs are taught in small groups, solving computational and applied exercises. The course requirements include knowing basics mathematical background and theoretical concepts and knowledge and understanding of the concepts needed in further studies. Basics in applying a computer algebra system is also a must.

The contents of the first course are the following: Set-theoretical background. Functions of one variable. Basic properties of functions of one variable. Limits of functions and sequences. Differential calculus of functions of one variable. Differentiation rules. Mean value theorems. Applications of derivatives. Integral calculus of functions of one variable. The definite integral. The indefinite integral and its properties. Basic properties of functions of several variables. Differential calculus of functions of several variables. The Mathematics 3 course is the last Calculus course on DUE. It consists of the following topics: Special differentiation rules. Geometric application of derivatives. Area. Volumes and surfaces of revolution. Length of a curve. Centre of gravity. Multiple integration. Numerical integration. Solving nonlinear equations. Separable differential equations. Variable transformation: ax+by+c. Variable transformation: y/x. First order linear differential equations. Second order linear differential equations. Missing variable in second order differential equations.

In 2012 DUE developed maths and other courses as well. Calculus was developed and implemented in the Moodle as a course management system to increase student success.

The courses are built from video-driven mini-topics. Each mini topic has an introductory video and one to three questions after the video, as can be seen onthe icons of Fig. 1. The content of the course can be found onthe left side of the screen. On Fig 1. from the chapter “Special differentiation rules”the subsection “Logarithmic differentiation” is chosen. In this section four media content is available. The content can be chosen from the icons visible on the top of the screen: A short video introducing the method itself, notes for this section in pdf form and the appropriate chapter of the handbook. At the end of this mini-topic a multiple-choice test is to be solved. This problem is similarto the one solved in the video. In this chapter section 1.2, 1.3 and 1.4 is also can be studied. Section 1.5 consist of a test including selected problems from this chapter. A homework also can be found in this section.

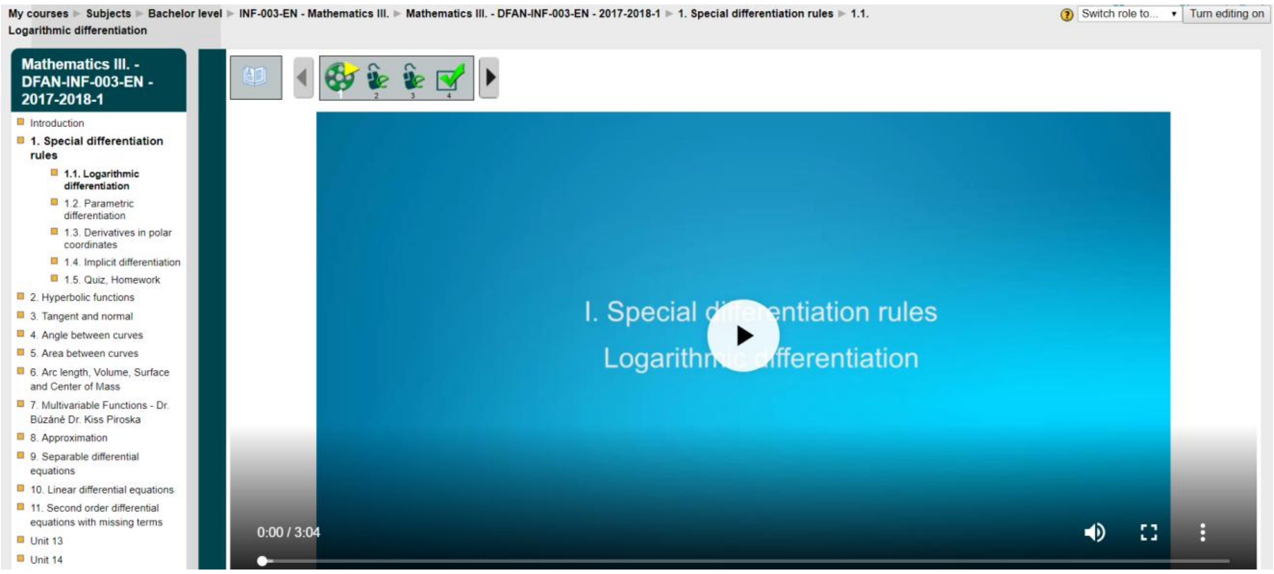

Fig. 1. The Mathematics course in the Moodle system.

Students should answer these multiple-choice tests correctly. A sample can be seen on Fig. 2. Automatic feedback for students is given. These courses are applied in distance learning, although the course material is available for the full-time students as well.

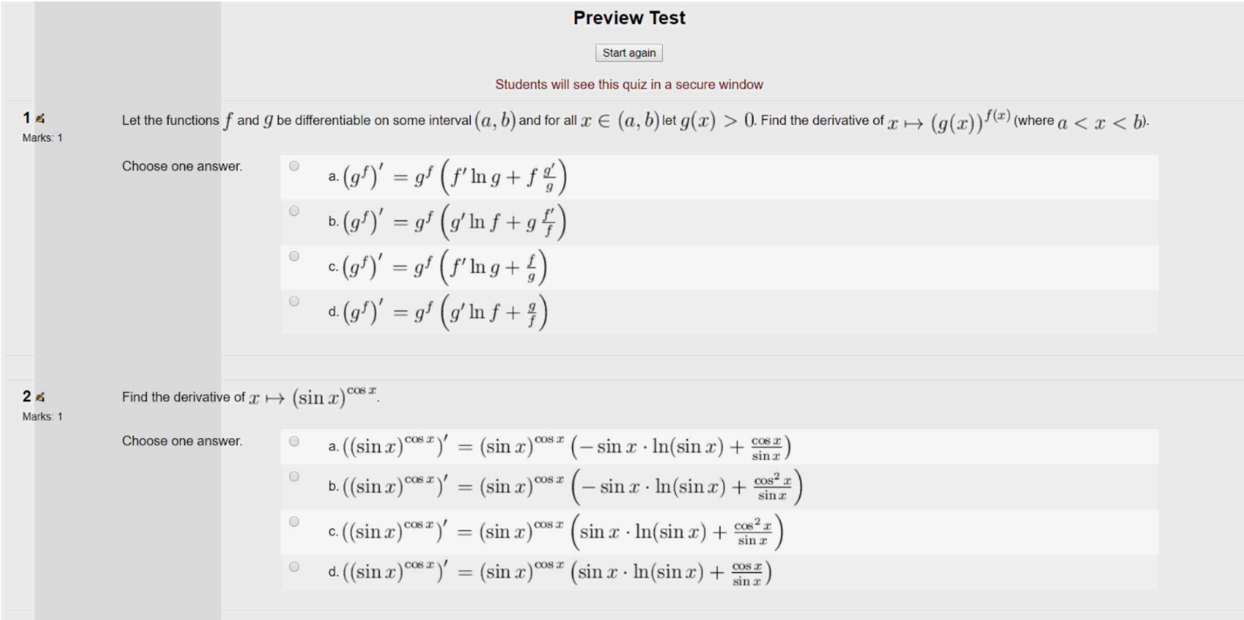

Fig. 2. Sample multiple-choice test for the Mathematics III course in the Moodle system.

Student attrition has been a continual topic of concern in distance education research. There have been some research explicitly studying the preferences for (asynchronous) online courses versus traditional classroom courses.

Drop rates for distance classes have been consistently higher than those of traditional classes (Cookson 1990). In fact, many educators have implied that the high drop rates—and the resulting lower success rates—of such courses should disqualify online education as a high-quality option to traditional education (Perspective 2001). However large studies have been conducted to compare the effectiveness of the different forms of course delivery and to establish key factors to build up successful online courses with relatively low drop rates (The NMC Horizon Report: 2012).

The reasons for students' attrition have been intensively investigated.

Four categories of factors have emerged to explain and predict attrition in distance education (Garland 1993; Gibson 1998):

Student situation: events that arise from life circumstances such as changes in family and employer support, employment or financial status, educational status, health, and academic self-concept.

Student disposition: personal characteristics including learning style, motivation, and perception-of-obligation (i.e., feelings of being obligated to a specific instructor or classmates to remain enrolled in the class) as well as other demographic variables such as academic preparation, GPA, ethnicity, gender, Web and e-mail competency, family size, number of dependents, and socio-economic status.

Institutional system: factors relating to the quality of the course such as the instructor's planning, preparation and delivery, and the quality of student support provided by the instructor, another faculty, staff, administrators, and the institution.

Course content: the difficulty, or perceived difficulty, of the subject matter.

Diaz (Diaz 2002) noted that given the differences in populations, online students may drop for different reasons than traditional students and that those reasons may have little or no relationship to students' academic abilities.

Although there have been few research explicitly studying the preferences for online courses versus traditional classroom courses, there have been several investigations of students' preferences for important components of these formats, namely face-to-face interactions and asynchronous discussions. Support for the idea that students would prefer, and learn more from, face-to-face communications comes from a variety of theoretical perspectives including social presence (Short, Williams, & Christie, 1976), media naturalness (Kock, Verville, & Garza, 2007), and especially, media richness (Daft & Lengel, 1986). Media richness theory suggests several advantages of face-to-face communications including body language, auditory cues, other non-verbal cues, and immediacy of feedback.

There has been a lack of research studying the factors – known or unknown to the students – which affect their preferences in choosing the different course formats. Statistical methods have been applied to establish those features of the students which might influence their choices between the different versions of teaching and learning.

As can be expected the ages, ICT skills of students influence their choice. Their attitude to learning (based on their self-evaluations) severely affect their choice too. The "lazier" they regard themselves the larger the chance to choose the online video lessons instead of the classroom work.

3. Introducing virtual learning environments

In 2017 improving the learning spaces in Moodle was decided on DUE.Virtual reality is widely used in medicine (Riener R, Harders M., 2012), education (Horváth 2016) and many other fields (Galambos et al. 2010; Baranyi et al., 2015; Gilányi et al., 2017.; Ujbanyi et al. 2016; Varaljai, 2016). Considering that the 3D visualization applied in the virtual reality (VR) learning environment better suits the cognitive processes of the human brain, MaxWhere, a 3D environment engine available is applied.

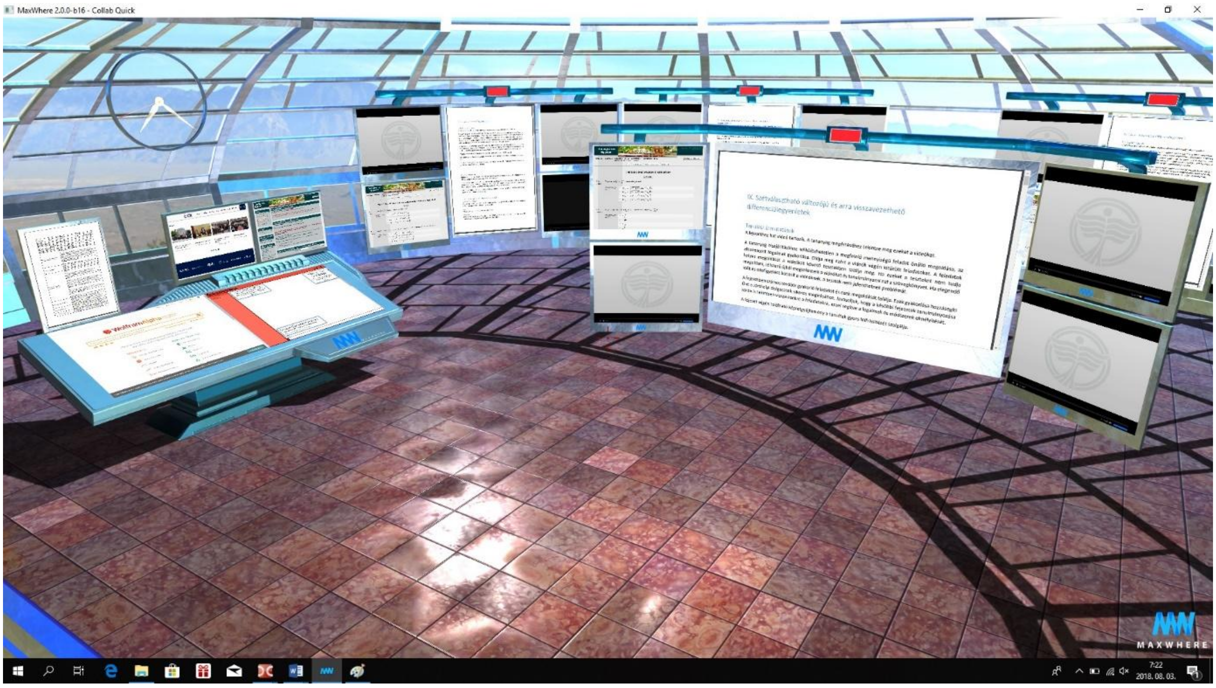

Fig. 3. Learning contents in MaxWhere

The contents of the course are very similar to the Moodle version, but it is found, that the 3D environment is much more effective than traditional techniques (Horvath, I.,Sudar, A.2018).

The course content is implemented in the CollabQucik space. There are 4 midterms in a semester and a space with the learning material of each midterm is available for the students, see Fig. 3.

In what follows the learning environment for the first midterm in details is considered, because the other spaces are very similar to this. The content of this midterm is special differentiation rules and application of calculus. In the middle of the space, a smartboard with five windows can be seen. The web page of the DUE, the Moodle, the course content, WolframAlpha and online Octave is available here. There are six other group of smartboards in this space. These include a variety of learning contents. In the first group, one smartboard in the middle and four other smartboards around this can be seen. The content of this group is special differentiation rules. On the middle board, a book chapter on logarithmic differentiation method is introduced using an example. This example can be found as a 3 min video on the smartboard in the upper right corner. In the upper left corner, a Moodle page is available with the appropriate multiple-choice tests. Students should first study the book chapter and the video lectures. After getting some insight into the method itself they should solve the problems in the video and answer the questions in the Moodle window. Solving the problems, they can have an automatic feedback on their understanding.

4. Conclusions

A survey was conducted to investigate the attitude of students towards electronic learning materials of University of Dunaújváros. It is concluded that the students have a positive attitude towards the virtual LE although the detailed analysis of the survey is to be published in another article. It appears that 3D learning environment is suitable for many students, however the efficiency of this method depends on the technological background the students have. The MaxWhere 3D learning environment was found to be a useful tool for mathematics education.

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References

Baranyi P. and Csapo A. and Sallai G. (2015): CognitiveInfocommunications (CogInfoCom), Springer International PublishingSwitzerland, p.191. (978-3-319-19607-7, 978-3-319-19608-4 eBook,doi:10.1007/978-3-319-19608-4,
http://www.springer.com/us/book/9783319196077#aboutBook

Cookson, P. (1990) Persistence in distance education. In *Contemporary issues in American distance education*, ed. M. G. Moore, 192-203. Elmsford, New York: Pergamon Press.

Daft, R. L., & Lengel, R. L. (1986): Organizational information requirements, media richness and structural design. *Management Science, 32*(5), 554-571.

Diaz, D. P. (2002): Online drop rates revisited. *The Technology Source*, May/June.
http://technologysource.org/article/online_drop_rates_revisited

Horváth, I. (2016), Innovative engineering education in the cooperativeVR environment, 7th IEEE Conference on CognitiveInfocommunications (CogInfoCom 2016), 16-18 October, Wroclaw,Poland, pp. 000359 - 000364, doi: 10.1109/CogInfoCom.2016.7804576

Galambos, P.,Reskó, B. and Baranyi, P. (2010): "Introduction of VirtualCollaboration Arena (VirCA)," in The 7th International Conference onUbiquitous Robots and Ambient Intelligence (URAI 2010), November24-27, Bexco, Busan, Korea, pp. 575-576

Garland, M. R. (1993): Student perceptions of the situational, institutional, dispositional, and epistemological barriers to persistence. *Distance Education* 14 (2): 181-198.

Gibson, C. C. (1998): The distance learner's academic self-concept. In *Distance learners in higher education: Institutional responses for quality outcomes*, ed. C. Gibson, 65-76. Madison, WI: Atwood.

Gilányi A., BujdosóGy., Bálint, M. (2017): Virtual reconstruction of a medieval church,8th IEEE Int. Conf. on Cognitive Infocommunications(CogInfoCom), 283–287.

Hernández, L. M., Fernández, J. M. L. (2018): TeachingCalculuswithInfinitesimals: New Perspectives; *The MathematicsEnthusiast*,Vol 15 No. 3. 371-390.

Horvath, I. Sudar, A. (2018): Factors Contributing to the Enhanced Performance of the MaxWhere 3D VR Platform in the Distribution of Digital Information; *Acta PolytechnicaHungarica* Vol. 15, No. 3, 149-173.

Kashefi, H., Ismail, Z., Yusof, Y. M. (2012)The Impact of Blended Learning on Communication Skills andTeamwork of Engineering Students in Multivariable Calculus, *Procedia - Social and Behavioral Sciences* 56. 341-347.

Kerres, M., & DeWitt, C. (2003). A didactical framework for the design of blended learning arrangements. *Journal of Educational Media*, 28, 101-114.
Kock, N., Verville, J., & Gaza, V. (2007): Media naturalness and online learning: Findings supporting both the significant- and no-significant-difference perspectives. *Decision Sciences Journal of Innovative Education, 5*(2), 333-355.
Korey, J., Rheinlander, K., Wallace, D. (2007): Open Calculus: A Free Online Learning Environment, *Journal of College Teaching & Learning* – December 2007 Volume 4, Number 12. 71-80 p.
Lacatan, L. L.: Hybrid Method and Face to Face Method in Teaching Mathematics: Effects on Students' Performance *International Journal of Information and Education Technology, Vol. 3, No. 2, April 2013 p. 143-146.*
León de la Barra, G., León de la Barra, M. and Urbina A.M., (1999): OnSpecial "Hybrid" Courses in Mathematics, *Proceedings of Frontierin Education Conference*, San Juan, Puerto Rico, November 1999.
Perspective. (2001): Distance education: The latest not-so-big thing. September 5.
Riener R, Harders M. (2012): Virtual Reality in Medicine. Springer London.
The NMC Horizon Report: 2012 Higher Education Edition
Young, J. R. (2002, March 22). Hybrid teaching seeks to end the divide between traditional andonline instruction. *The Chronicle of Higher Education*, p. A33.
T. Ujbanyi, J. Katona, G. Sziladi, A. Kovari: "Eye-Tracking Analysis of Computer Networks Exam Question Besides Different Skilled Groups", 7th IEEE International Conference on Cognitive Infocommunications (CogInfoCom), Wroclaw 2016
Varaljai, M. (2016): "Establish innovative learning environment by virtual lab concept", 7th IEEE International Conference on Cognitive Infocommunications (CogInfoCom), Wroclaw.

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Development of telepresence technology during the teaching process at Subotica Tech

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Abstract

Nowadays industrial solutions in the field of mechatronics often integrate the actuators with sensors and control units. This integration creates complex mechatronic devices. The complexity of these devices is evident, because this integration asks for communication between sensors, actuators and their control units, and communication with external control units and sensors, as well as other actuators, and often humans. To be able to prepare the students to the professional challenges they will face after finishing their studies, the teaching process at Universities and Colleges must adapt to this shift in the concept of what the industry is today, i.e. tomorrow. This research deals with the problem of developing a telepresence system at Subotica Tech as part of the project-oriented teaching process, which introduces the main aspects of modern industry, which are known as Industry 4.0. The problem is discussed by presenting a case study.

*Keywords:*telepresence system; industry 4.0; product development; mechatronics;

1. Introduction

Today's industry is changing, both in conception and organization. Previously, the third industrial revolution introduced advanced electronics and information technology, which resulted in further automation of existing production processes. Nowadays, the development and establishment of global networks incorporate the machinery, warehousing systems and production facilities in the shape of Cyber-Physical-Systems. In the manufacturing environment, these Cyber-Physical Systems comprise smart machines, storage systems and production facilities capable of autonomously exchanging information, triggering actions and controlling each other independently. This facilitates fundamental improvements to the industrial processes involved in manufacturing, engineering, material usage, supply chain and life cycle management. The Smart Factories that are already beginning to appear, employ a completely new approach to production. Smart products are uniquely identifiable, may always be located and know their own history, current status and alternative routes to achieving their target state (Kagermann, Wahlster, and Helbig, 2013). This business approach is named Industry 4.0, which is a term publicly known from 2011, and includes six design principles (Hermann, Pentek, and Otto, 2015):

- Interoperability,
- Virtualization,
- Decentralization,
- Real-Time Capability,
- Service Orientation,
- Modularity.

Interoperability means that all Cyber-Physical-Systems can communicate with each other and are connected over to Internet of Things and Internet of Services in the context of SmartFactory (2016). Virtualization means that a virtual copy of the physical world allows the monitoring of the processes (Gorecky, Schmitt, and Loskyll,2014). Decentralization as a demand, which arises due to increasing difficulties to control systems centrally, makes it necessary to keep track of the whole system at any time. To be able to keep track of the whole system at any time, real-time capability is required. To be able to answer to specific customer requirements, service orientation is needed as well (Schlick, Stephan,Loskyll, and Lappe, 2014). Finally, modularity as an approach enables flexibility regarding to the adaptation of changing requirements by providing functional independency of individual modules (Pine, 1993).

Modern mechatronic devices are gaining more ground in most diverse areas. Large number of devices contain more and more mechatronic elements (Fürstner, and Gogolak, 2015). These devices also have multiple sensors and actuators.Therefore, the teaching process at Universities and Colleges has to adapt to this shift in the concept of what the industry is today, i.e. tomorrow, and to prepare the students to the professional challenges they will face after finishing their studies (Solis, Nakadate, Yoshimura,Hama, and Takanishi, 2009). Mechatronic systems are playing an increasingly important role nowadays. Therefore, the understanding of the design and control of such systems is a necessity for the future engineers. The teaching process faces a problem, which arises from the fact that this process requires multidisciplinary approach. Nevertheless, students are willing to do research work for solving practical problems when these are related to an interesting competitive contest (Odry, Harmati, Kiraly, and Odry, 2015).Winning one or two awards in a contest gives students a sense of accomplishment and gives to the institution a sense of pride and visibility. This is an important factor for technology-oriented university students, who often have low learning achievements in traditional theory-based lecture courses (Su, Cai, Lee, and Chen, 2016).

Educational mechatronics is an innovative way for increasing the attractiveness of science education and scientific areas in the view of young people. As a multidisciplinary field, it promotes the development of systems thinking and problem solving. Also, teamwork, creativity and entrepreneurial skills are required for the design, programming and innovative exploitation of mechatronics. Consequently, it is regarded as very beneficial if engineering schools and university program studies include the teaching of both theoretical and practical knowledge on mechatronics.

At Subotica Tech, this new business approach is taken into consideration by introducing multidisciplinary projects, often in cooperation with companies, into the curricula, i.e. into specific courses, namely into the course of Design of Mechatronic Devices and Project. By doing this, students from Mechanical Engineering, Electrical Engineering, Informatics, and Mechatronics can work in teams on a rather complex problems, producing results, which would be difficult to achieve if working alone.

One form of a modern mechatronic device is a telepresence system. These systems are an emerging topic, mostly in the fields of unmanned vehicle systems, particularly in remote communication, and/or field inspection. Telepresence, as a mechatronic device, covers a great variety of technologies and human studies. Therefore, it is difficult to systemize, implement, and examine it and is usually analyzed in different perspectives, such as tele-operated construction systems, telepresence systems of unmanned vehicle systems, human-machine interfaces, visual aid and perception, and user operation (Wen, Yang, Tsai, and Kang, 2018).

Regarding the construction of the system, the research focuses mainly on the structure of the system, which incorporates a series of sensors, actuators and control mechanisms (Higgins, and Slaughter, 1993). The research of the unmanned vehicle systems has brought much attention in the recent years, because of their high mobility and low cost (Dadhich, Bodin, & Andersson, 2016; Ellenberg, Kontsos, Moon, &Bartoli, 2016; Zakeri, Nejad, & Fahimifar, 2016).

The research regarding human-machine interfacesfound that theloss of situational awareness, inaccurate attitude judgment, and failureto detect obstacles are common occurrences. The operator is an integralpart of the control loop and because he/she depends on video for perception,direct interfaces typically demand low-delay, and therefore high-bandwidthcommunications (McGovern, 1991).

In the case of remote systems, visual feedback can often be limited by onboard camera restrictions. Also, most of the existing systems currently rely on 2D images or videos as a visual aid or supervisory control. However, operating unmanned vehicle systems by watching 2D images may cause unwanted collisions. This is because using 2D displays in remote environments may lead to misjudgments of the size and shape of objects in the environment, and of the distance between the controlled system and the environment or objects (Livatino, & Muscato, 2012, Yaguchi et. al, 2014).

When a telepresence system operates in a complex or dynamic situation, it may be difficult for the operator to accurately perceive the remote environment and to make timely control decisions. Therefore multimodal and multisensory interfaces can and should be used to cope with these problems by providing efficient tools for command generation and feedback (Fong,& Thorpe, 2001).

The presented research deals with the problem of real-time control of a telepresence system, which is driven by two motors. The basic goal of control is to achieve the desired motion of the developed system in real-time.

The reminder of the paper is structured as follows: In the 2nd paragraph the developed mechatronic device is presented in brief. Also, the structure of the system is introduced. Following that, communication and control mechanism of the system is discussed. Conclusions and future development plans are given in the 3rd paragraph.

2. The developed telepresence system

The developed telepresence system must fulfill the following functional requirements:

- Ensure attracting the attention of humans who are close to the device,
- Provide easy handling (by the user),
- Include appropriate security measures,
- Provide forward and backward movements,
- Provide turning movement,
- Provide forward and backward speed (from 0 to 0.2 m/s),
- Provide turning speed (from 0 to 1rad/s),
- Set the maximum width and length to 600mm,
- Set the maximum weight to 100N,
- Set the height (from 500mm to 1000mm),
- Provide tele-operated control,
- Enable multiple assembling and disassembly of all parts,
- Minimize the use of machined parts,
- Provide appropriate guidance and embedding,
- Provide easy maintenance,
- Embed the brushless DC-motors,
- Maximize the visibility of embedded products,
- Minimize the visibility of auxiliary parts.

Based on the defined functional requirements, a telepresence systemis developed, which fulfills the presented requirements. The model of the developed system is presented in Fig. 1, while the actual developed device is presented in Fig. 2.

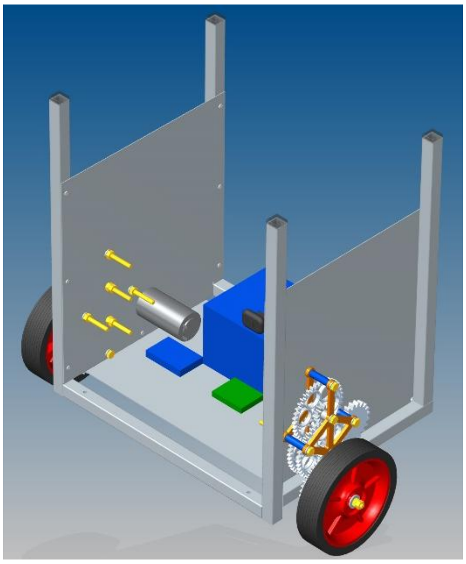

Fig. 1. Model of the developed system.

Fig. 2. Actual device.

The device consists of several subassemblies:

- Frame subassembly, which is used to hold together the system,
- Energy supply subassembly. This subassembly supplies the required electric energy for the control units, the sensors and the actuators,
- Actuators and gearbox
- Communication subassembly. This subassembly enables the communication between the telepresence system and the human-machine interface,
- Control unit subassembly. This subassembly enables the control of the device,
- Onboard visual supervision,
- Human-machine interface.

The frame subassembly is a welded design, which is dimensioned to be able to hold the subassemblies of the developed telepresence system. Overall dimensions are 480x520x560mm. That fulfills the functional requirements regarding the dimensions. Energy supply is provided by a battery (12V, 12Ah). The actuators are BGE3004 type motors, which are manufactured by Dunkermotoren GmbH. The nominal turning velocity of the motors is around 3000rpm, which indicates the necessity to use a gearbox to reduce the speed to the required one. For the reasons of the available technology to produce the gearbox (3D printing), a custom gearbox was designed, which enabled the gear ratio of 1:400. The exploded view of the developed gearbox is presented in Fig. 3.

The control of the telepresence system is realized using a laptop as a human-machine interface, which is connected to the developed device through a WI-FI network. The main role of the laptop, besides the role of a human-machine interface is to record and forward the input commands of the user. The graphical user interface is realized as a web page, where the inputs are given by arrows, which gives the desired movement direction of the robot and is presented in Fig. 4. The directions include linear movement forward and backward, rotation in both directions, and stopping. The movement speed and acceleration can be also preset on the interface.

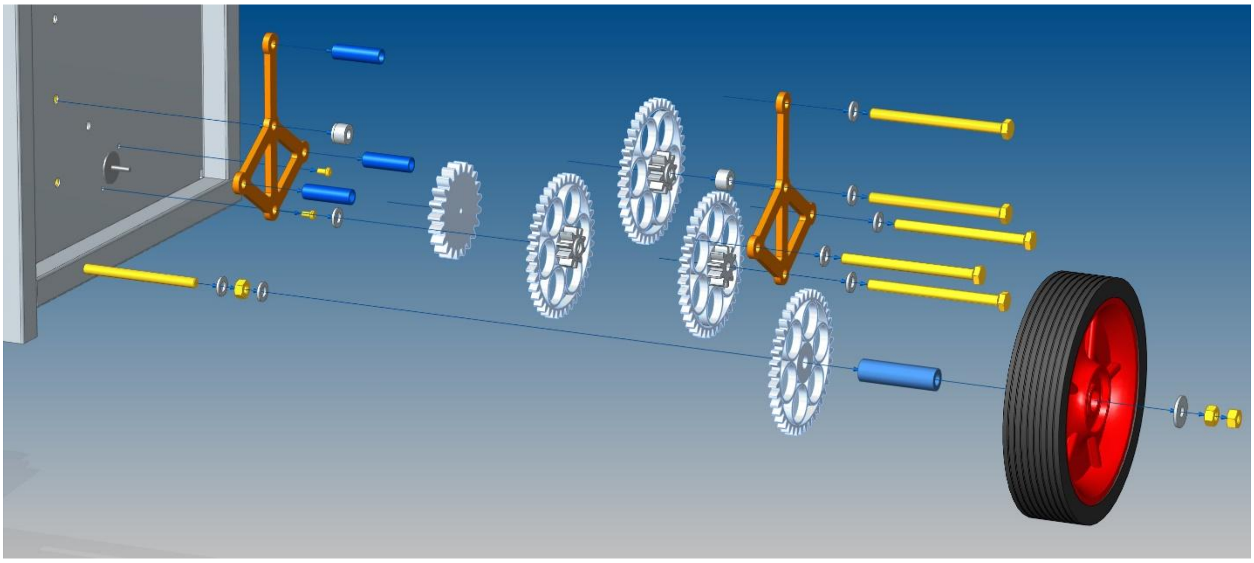

Fig. 3. Exploded view of the gearbox.

The laptop receives also a video stream from the robot, through which the user can follow the movement of the unit or make a conversation with someone in front of the robot. Beside the commands, the laptop sends also a video stream to the robot, so that the conversation partner can also see the user. This video stream is currently realized using Viber, which runs on a smartphone attached to the robot.

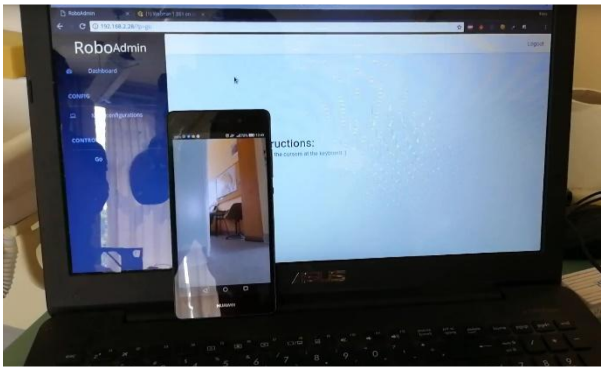

Fig. 4. The graphical user interface.

A Raspberry Pi board is used to receive the commands through the WI-FI network. The received commands are forwarded to a microcontroller-based Arduino UNO board via the serial port of the units. The Arduino translates the commands and drives the motors. BGE3004 type motor controllers are used, which are manufactured by Dunkermotoren GmbH. Since these motor controllers require a 0-10 V analog signal on their inputs for speed control and the microcontroller does not have any analog outputs, an additional circuit is added between the Arduino and motor controllers, which converts the Pulse Width Modulation output signal to an analog signal in the required range. As previously mentioned, BG42x30 motors are used as actuators. The corresponding rotation speeds of the motor are in a range from 500 rpm to 5000 rpm. The motor controllers also enable the setting of the direction of rotation and have a start/stop function. The control of these functions is realized using digital outputs of the microcontroller.

The motors drive two wheels on the sides of the telepresence system, and the system also consists a third wheel in the front, which is not driven. The software of the microcontroller executes one command for a previously defined length, which was 2 s during the tests. If a new command arrives, the current command is stopped and the new one is executed. This is done because of safety reasons, since if the connection is broken between the robot and the laptop, the robot could crash if it continues to execute the command.

The schematic overview of the developed system is presented in Fig. 5.

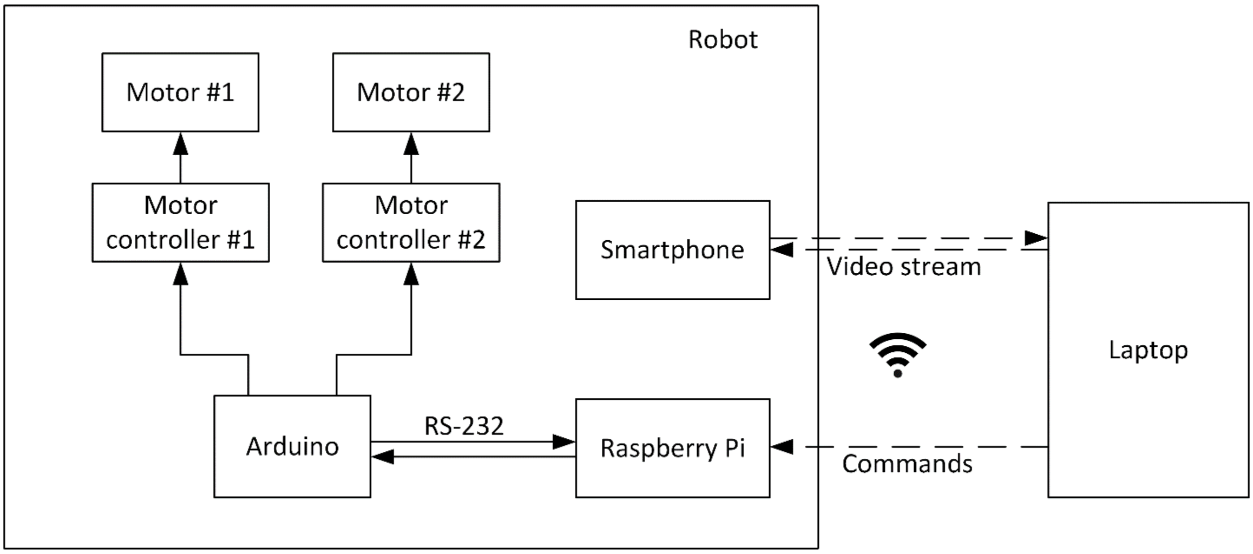

Fig. 5. Schematic overview of the developed system.

3. Conclusions

The presented research dealt with the problem of developing a telepresence system, which introduces the main aspects of Industry 4.0.The development process was an example of complex product development during the teaching process at Subotica Tech. This product development was done as a multidisciplinary project, which was incorporated into the curricula, namely into the course of Design of Mechatronic Devices and Project. By doing this, students from Mechanical Engineering, Electrical Engineering, Informatics, and Mechatronics could work in teams on a rather complex problem, producing results, which would be difficult to achieve if working alone. The basic goal was to enable the tele-operated control of the system, which is presented by a case study.

The result of the case study showed that the presented telepresence system could have worked properly with the given structure, which was a good starting point towards designing a more reliable telepresence system in the future.

Further developments should include the implementation of a microphone, a video camera, and a display on the robot, which could replace the smartphone in the current system and can be connected to the Raspberry Pi board. An application should be also developed which can send, receive and display the video stream besides sending the input commands. The robot could also work with two wheels as an inverse pendulum by adding inertial sensors and a proper algorithm. Additional sensors could be also added to the system to automatically avoid collisions.

4. Summary

Industry 4.0, a shift in the concept of what the industry is today, asks for a change in the teaching process at Universities and Colleges to be able to prepare the students to the professional challenges they will face after finishing their studies.

This research dealt with the problem of developing a telepresence system at Subotica Tech as part of the special interdisciplinary teaching process, which enables for students to work on rather complex problems in teams.

The problem was discussed by presenting a case study. The results of the development process showed that the developed system could have worked properly with the given structure, i.e. that this teaching approach, a project-oriented work involving students from different technical fields, could have led to success.

References

Dadhich, S., Bodin, U., &Andersson, U. (2016). Key challenges in automation of earth-moving machines, Autom. Constr. 68, 212–222.

Ellenberg, A., Kontsos, A., Moon, F.,& Bartoli, A. (2016). Bridge deck delamination identificationfrom unmanned aerial vehicle infrared imagery, Autom. Costr. 72(2), 155–165.

Fong, T.,& Thorpe, C. (2001). Vehicle teleoperation interfaces, Auton. Robot. 11(1), 9–18.

Fürstner, I., Gogolak, L. (2015). Presentation of the developed mechatronic devices for exhibition purposes, International Journal of Electrical and Computer Engineering Systems, 6(1), 23-28.

Gorecky, D., Schmitt, M., &Loskyll, M. (2014). Mensch-Machine-Interaktion im Industrie 4.0-Zeitalter. Industrie 4.0 in Produktion, Automatisierung un Logistik: Anwendung, Technologie, Migration.

Hermann, M., Pentek, T., Otto, B. (2015). Design principles for Industrie 4.0 Scenarios: A literature review. Technische Universitat Dortmund.

Higgins, C.C., Slaughter, S. (1993). Assessment of construction automation and robotics, ATLSS Reports, 194.

Kagermann, H., Wahlster, W.,& Helbig, J. (2013). Recommendations for implementing the strategic initiative Industrie 4.0, Final report of the Industrie 4.0 Working Group.

Livatino, S.,& Muscato, G. (2012). Robot 3D vision in teleoperation, World AutomationCongress 2012, Puerto Vallarta, Mexico, 1–6.

McGovern, D.R. (1991). Experience and results in teleoperation of land vehicles, Pictorial communication in virtual and real environments. Taylor & Francis, Inc., 182–195.

Odry, A, Harmati, I, Kiraly, Z., Odry, P. (2015). Design, realization and modeling of a two-wheeled mobile pendulum system. Proceedings of the 14th International Conference on Instrumentation, Measurement, Circuits and Systems, pp. 75-79.

Pine, B.J. (1993). Mass Customization: The New Frontier in Business Competition. Harvard Business School Press, Boston, MA.

Schlick, J., Stephan, P., Loskyll, M.,& Lappe, D. (2014). Industrie 4.0 in der praktischen Anwendung. Industrie 4.0 in Produktion, Automatisierung un Logistik: Anwendung, Technologie, Migration.

SmartFactoryKL, Keyfinder production line. (2016, April 11). Retrieved from http://www.smartfactory.de/

Solis, J., Nakadate, R., Yoshimura, Y, Hama, Y, Takanishi, A. (2009). Development of the Two/Wheeled Inverted Pendulum Type Mobile Robot WV-2R for Educational Purposes, The 2009 IEEE/RSJ International Conference on Intelligent Robots and Systems, Oct. 11-15, St. Louis, USA, pp 2347-2352.

Su, J.H., Cai, X.H., Lee, C.S., Chen, C.W. (2016). The development of a half-size micromouse and its application in mobile robot education, Proceedings of 2016 International Conference on Advanced Robotics and Intelligent Systems, Taipei, Taiwan, 31 August – 2 September.

Yaguchi, H., Sato, K., Kojima, M., Sogen, K., Takaoka, Y., Tsuchinaga, M., Yamamoto, T.,&Inaba, M.(2014). Development of 3D viewer based teleoperation interface for HumanSupport Robot HSR, ROBOMECH J. 1 (10), 1–12.

Wen, M., Yang, C., Tsai, M., & Kang, S. (2018). Teleyes: A telepresence system based on stereoscopic vision and head motion tracking, Automation in Construction, 89, 199-213.

Zakeri, H., Nejad, F.M., &Fahimifar, A. (2016). Rahbin: a quadcopter unmanned aerial vehiclebased on a systematic image processing approach toward an automated asphaltpavement inspection, Autom. Constr. 72(2), 211–235.

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Causes of Early School Leaving in Secondary Education

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Abstract

Early school leaving is a considerable problem both for the individual and the family, as well as for the school and the whole society. Students who leave school without qualification have much worse opportunities in the future, regarding career, income, promotion, health conditions, etc. In Hungary, secondary school dropout is a current problem; however, its ratio must be under 10% by 2020 according to an EU strategy. There are several causes leading to school dropout, such as, family background, conflict between family and school, absenteeism from school, bad school achievements, weak school contacts, school failures, etc. The purpose of the research was to find the main causes of early school leaving – according to teachers' opinion. The research was carried out in a Vocational Centre among teachers in the form of self-administered questionnaire in 2017. In the questionnaire, five categories were identified (students' features, family, peers, teachers, and institution) that may contribute to dropout. The result showed that out of the five categories teachers think that mostly students and least the institution is responsible for dropout.

*Keywords:*vocational education; school dropout; contributing factors

1. Introduction

Dropout from secondary school is a severe problem not only for the individual but also for the family, the school system, and the whole society. A well-known and frequently proven fact is that students who do not finish secondary school have fewer opportunities on the labour market, and if they find a job, it typically requires lower qualification, e.g. badly-paid semi-skilled jobs, promising little prospects for promotion or career building. According to American statistics (Christle et. al, 2007), among the unemployed, there are mostly people not having secondary school certificate: while 56% of adult dropped out from secondary school is unemployed, this ratio is only 16% among the ones who have secondary school final examination. There are huge differences in salaries as well: dropouts' average wages are about $ 12.000, while the ones who have finished secondary school earn $ 21.000.

On the basis of other US data, school dropouts represent 52% of people who live on social maintenance, 82% of criminals, and 85% of juvenile criminals. Secondary school dropout is thought to be in relation with several other social problems, such as: 1) missing national incomes, 2) missing taxes for state services, 3) increased need for social services and maintenance, 4) increasing crime ratio and deviant behaviour, 5) decreasing political and civil participation in the life of the country, 6) decreasing generation mobility, 7) worse health conditions. All these form a huge financial burden, which might lead to social tension. That is why all countries consider youngsters' successful adaptation as well as the decrease of school dropout a national issue.

On the other hand, there are significant differences between dropouts and graduates according their socio-economic status: students with disadvantageous socio-economical background have two and a half more probabilities to drop out compared with their middle class peers. Moreover, ethnicity has a correlation with dropout: in the US twice more Afro-American students drop out from school than their white classmates, furthermore, this ratio is higher among Hispanic students. Students with cognitive or emotional challenges have little chance to finish secondary school.

Despite cultural differences, the attitudes, factors, and results of international studies could be applied to Hungarian situation as the challenges of globalized world is reasonably similar in different countries: several basic sociological, psychological or physiological dimensions of secondary school dropout are universal, such as, poverty, discrimination, prejudice, lack of knowledge, and gender socialization.

This paper describes the profile of students at risk. Besides students' cognitive and emotional attributes, family, friends, and schools are responsible for dropout. The researchwas carried out in 2017 in a Vocational Centre with a self-administered questionnaire. Teachers were asked about the factors contributing to early school leaving, as well as some preventive aspects.

2. Definition of School Dropout

The next paragraph summarizes the concept and aspects of Early School Leaving, Not in Employment, Education or Training and School Dropout.

2.1. Early School Leaving (ESL)

Before the detailed examination of the phenomenon of school dropout, the definition itself should be identified clearly. There are some definitions of the situation when a young person (adolescent or young adult) does not study. The best-known and a wide concept is Early School

Leaving (ESL). According to European Union's definition, early school leavers are 18-24-year old people, who have maximum ISCED 3c short level of education, and currently did not take part in any education or training during 4 weeks before the survey (http://oktataskepzes.tka.hu/en/early-school-leaving-and-dropout).

In 2008, the ratio of early school leavers in European Union was 15 per cent, which means that around 6 million young people dropped out of school. However, this figure washes away the differences between member states: while in some countries (Finland, Czech Republic, Lithuania, Slovenia), the rate of ESL students was about 10 per cent, in some southern member states this ratio increased over 30% (Spain – 34%, Malta – 31-40%, Portugal – 37%). (Andrei – Teodorescu – Oancea, 2011). Regarding Hungary, the percentage of early school leavers is higher than 10 per cent; however, a slight increase can be detected: in 2012 it was 11.2% and in 2015 it was 11.6% - which is higher than the European average in the same year (11,0%) (https://ec.europa.eu/education/sites/education/files/monitor2016-hu_hu.pdf).

Different regions in Hungary are differently concerned in early school leaving. The most endangered region is North Hungary, where the ratio of ESL has increased up to 15 per cent in the last 10 years. This region is followed by the North Plain and South Transdanubia regions, where the rate of early school leavers is in between 10-15%. The best data are from South Plain and West Transdanubia regions, where the ratio of school dropouts was lower than 10 per cent; which is better than the EU average. (Fehérvári, 2015)

The real problem is, that early school leavers are not likely to take part in further education or training in their lives, which leads to several other social problems and risks. Early school leavers are more likely to become unemployed, require different social supports and services, become dependent on government social programs, commit crimes, and live in poverty and are excluded from society (Christle, Jolivette, Nelson, 2007). In addition to this, the number of jobs requiring only low qualification is continuously decreasing both in the EU and in Hungary; and due to rapid technical and technological development, labour market needs more and more highly qualified employees (Kőműves, 2010).

2.2. Not in Employment, Education or Training (NEET)

Besides ESL, there is another category: NEET – which is less exact, though. The English acronym refers to young people who neither work, nor take part in education or trainings. In 2015, the ratio of NEET young people in Hungary was a bit lower than the EU average: while the average of EU member states was 12.0%, in Hungary it was 11.6%. However, it must be stated that this figure in 2013 was significantly higher in Hungary: 15.5%, which means that during 2 years a 4 percentage point decrease could be detected. Such a significant decline cannot be considered in any other European countries for such a short period of time. (http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&pcode=tesem150&language=en) The cause of this radical decrease might be the introduction and spread of public work program.

Unlike early school leavers, NEET youngsters form a heterogeneous group, as this category incorporates highly qualified career entrants, who were looking for a job in the period of data collection, as well as young women who are on maternity leave with their babies. Regarding NEET youngsters, EU countries could be divided into four groups on the basis of following factors: their ratio, gender, qualification level, previous work experience, etc. Hungary was ranged in a group together with Greece, Bulgaria, Romania, Poland, Italy, and Slovakia, where the ratio of NEET youngsters is high, mostly they are young women, usually well-qualified, and have no previous work experience.

On the other hand, Hungarian tendencies are unlike European tendencies in several aspects. The average of the 28 EU member states show only slight differencebetween men and women in 18-24 age group; moreover, the rate among women is lower. Regarding Hungarian figures, young women are much more likely not to work or study, than young men. (Fehérvári, 2015) High inactivity among women is probably in connection with having a baby and, of course, with the Hungarian child care benefit and maternity leave system.

Another difference between Hungary and EU is the ratio of NEET people. While the EU average (taking into consideration all 28 member states) has been decreasing in both 15-17 and 17-19 age groups, in Hungary their rate has been increasing since 2012, especially the number of those who has only ISCED 2 qualification, which means that they finished maximum the 8-form primary school. This phenomenon could be in connection with the legislation of 2011: the Act on Public Education of 2011 decreased the maximum age of compulsory education from 18 to 16 years. (Fehérvári, 2015) Taking into consideration the ratio of NEET youngsters who do not have secondary qualification, this figure is higher in Hungary than the EU average: while in 2015 in the EU it was 6.6%, in Hungary 8.3% among 20-24-year old people (http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do).

The rates of early school leavers as well as that of NEET youngsters are considered to be output indicators in education. Besides this, there is a so called process indicator about which there have been data since 2014. The process indicator provides data within the public education system about students' achievements. This concept is student dropout. Teachers, experts and even literature use the concept of school dropout parallel or instead of early school leaving.

2.3. School Dropout

Regarding school dropout, representatives of education identify the phenomenon in different ways, depending on the point of view. When defining the concept, some questions should be asked and answered first:

- Could the students who do not finishes the qualification they have started but start another one in the same school and do not leave the school be accounted as dropouts?
- Could the students who continue and finish the qualification in another vocational secondary school be accounted as dropouts?
- Could the students who leave both their original qualification and their school but do not leave the Vocational Centre and start a new qualification in another school of the same Centre be accounted as dropouts?
- Could the students who leave the original Vocational Centre but not the education system, and continue their original qualification or start a new one in another Vocational Centre be accounted as dropouts?

Regarding members' viewpoint, the answer can be yes to any questions. From the point of view of national economy, only the students can be considered to be dropouts who do not finish their qualification either in their original institute or in another one, and they do not start another qualification – so they leave education system without any qualification. Taking into consideration Vocational Centres' viewpoint, students are dropped out if they continue their studies in another Centre. As for the vocational institution (the school), students are accounted to be dropouts if they continue their studies in another school or if they start another qualification in the same vocational school. Due to non-flexibility and non-traversability of vocational education, especially the 3-year long one, if students change their vocational program, they have to start the whole training from the very beginning.

School dropout is defined by education experts as follows: 'A student is considered to be a dropout of they were registered as a student on the same day of the previous year but were not registered on 1 October of the current year (their student relationship has broken off) and they have not received secondary qualification.' (Fehérvári, 2015: 42.) The critical point of defining the dropout indicator is identifying the reference date. According to surveys, describing the process of dropout two reference dates must be identified: 1 October and 1 February.

Dropout can be taken as a single event when the document acknowledging that the student left either the qualification or the school is signed, but can be seen as a process, too. Dropout is often thought to be a long and complex procession during which several influencing factors can be identified in students' life until the point when they leave their qualification. This paper consider dropout as a process and examines what factors contribute to dropout.

As the two phrases (early school leaving and school dropout) are used parallel both in everyday conversations and in scientific literature referring to early school leaving among day time students in public education, this paper is going to use them as synonyms.

3. The Causes of Early School Leaving

Both national and international scientific literature lists several causes as indicators of early school leaving, but four groups of them can be usually identified: individual, family, school, and community/society.

- Bad family background: disadvantageous family, low-qualified parents.
- Dysfunctional family background, little family support.
- Difference, conflict between school and family values.
- Students belong to group at risk: live on child-welfare support, physically or mentally disabled, students with special needs.
- Students are regularly absent from school.
- Students do not like going to school, they are excluded from school community.
- Students belong to an ethnic minority group (Romani).
- Their place of living often changes, they often change school. (Archambault, 2009; Kőműves, 2010)

Neild, Stoner-Eby and Fursteinberg (2001) listed similar factors that can increase the probability of school dropout:

- If the student is a boy, older than his peers, and belongs to an ethnic minority group.
- If the student is brought up in a lone parent family or in a family with low income, or their parents has low qualification.
- If the student is not successful in their studies: they fail, have worse grades than their peers, or they are frequently absent from school.
- If the student has behavioural problems.

Family is one of the most significant indicators contributing to early school leaving. Based on an American study (Christle, Jolivette, Nelson, 2007), the socio-economic status of the family has a fundamental influence on school dropout: children from low-income families are 2.4 more likely to leave education than their middle class peers. Their research also proved that students whose families receives social maintenance are more likely to drop out of school when starting secondary education. Moreover, students are at risk whose parents have low qualification (only elementary). Archambault and her colleagues (2009) stated that the educational methods of the parents whose children leave school early are usually not effective, and these parents have low requirements regarding school results.

3.1. School as a Factor of Dropout

Besides family, the other significant factor is school. Failures that are experienced in the early period of school career may become the starting point of a negative spiral, the consequence of which is student’s weakening contacts to school, and this leads to school dropout (Christle, Jolivette, Nelson, 2007). Christenson and Thurlow (2004) also think that school dropout is a long process and can be predicted by particular indicators, such as disengagement (being absent many times), unsuccessful school experience (learning or behavioural problems). They usually start in primary school and get stronger through years when the feeling of being excluded and negative feeling towards school are added.

Early school leaving generally happens in secondary education. Adolescence is a period of time that can be described by huge behavioural, cognitive and emotional changes. At this age, a significant decrease in engagement towards school and learning can be seen, as peers become students’ references: they follow them in communication, behaviour, and decisions.

However, early school leaving does not endanger all students. Based on Christle, Jolivette and Nelson’s research (2007), some factors have a fundamental influence on school dropout. One of them is the student’s school achievements, while the other is attendance at school – both showed negative correlation with dropout. Neild, Stoner-Eby and Fursteinberg (2001) found that the way student start their secondary education has a significant impact on their school career. First-form students experience stress when they receive their first grades in secondary school. Although it is possible to overcome the shock of bad marks, not everybody succeedes: half of the students who received ones at the beginning of their secondary school, failed at the end of the academic year.

Early non-success has several background causes, such as parents could not provide enough support for their children; teachers did not have suitable competencies to be able to help their students; students had weak mathematical and reading competencies; and impersonal school atmosphere where students got lost. Researchers stated if the student has school failures or they fail at the end of ninth school year or they are usually absent from school, these factors have a significant impact on the probability of being dropped out.

Another important indicator of school failures and dropout is maladaptive or undesirable student behaviours. The rates of student law violations reported by schools were positively related to dropout. Experts stated that schools that often rely on exclusionary discipline practices, such as suspension, may impede the educational progress of students, perpetuating a failure cycle. Students who are excluded from school have fewer opportunities to gain knowledge and skills suitable for the labour market. (Christle, Jolivette, Nelson, 2007)

Lessard, Poirier and Fortin (2010) highlighted another important school factor: the quality of teacher-student relationship. Students who experience a bad relationship with their teacher are more likely to drop out than students who report a warm relationship – especially boys. Dropouts reported that conflicts with teachers were one of the causes motivating their decision to leave school before obtaining their qualification. Moreover, teachers also perceived that relationship with their students influences students' school achievements.

Another research (Christle, Jolivette, Nelson, 2007) notices that school culture has an important impact on early school leaving: teachers have an important social capital for their students. If students' social capital is mostly based on their teachers, it can decrease the possibility of dropout by 50%. They also stated that the physical environment of the school has an influence on early school leaving: in schools that were clean and neat and better equipped lower ratio of dropout could be identified.

Both national and foreign researches support the fact that dropout is a longer process and although it is typically appears in secondary school, most risk factors can be identified even in primary education (Bánkúti et. al., 2004). In Hungary, secondary education is divided into three levels, which show significant correlation with students' socio-economic background. Examining the different school types it can be stated that there are powerful differences between them. Although dropout can be seen in primary education as well, the highest ratio of early school leaving can be found in vocational education, especially in the one that does not provide general final examination (the socalled Hungarian érettségi vizsga). Taking into consideration the dropout ratio in the 3-year vocational education, it is 46.9 percentage. (Fehérvári, 2015)

In 2013-2015, in Hungary and in two other countries, Slovenia and Serbia, a huge project, named CroCoos was run focusing on early school leaving,. Participant of the project identified six fundamental factor leading to school dropout: absenteeism, grade repetition, deteriorating achievement, boredom, behavioural problems, bullying, violence and school harassment.

(http://oktataskepzes.tka.hu/en/crocoos-research-reports-171124120759) Absenteeism was found to be the most important early distress signal. It is important because it is easy to be followed up and measured by and well-targeted interventions can be built on it as well. Experts claim that the higher the rate of absenteeism the higher the chance for a dropout.

The practice of grade repetition significantly leads to dropout but seems to be problematic and contradictory. It is actually thought to be a punishment for student's under achievement; however, it is a costly way of it. These students stay longer in education with a higher possibility of not accomplishing school and not obtaining a certificate. Sometimes big differences between primary and secondary school expectations can be detected. Skills that were not learnt during the primary school can hardly be acquired on secondary level, and have a negative effect on students' achievements. The lack of key competencies leads to school failures which turn the person to be unmotivated and eventually to drop out of school.

Students at risk often display certain behaviour, such as aggression towards teachers or peers, a too intense or a too shy temper, which is in close connection with dropping out. However, these behavioural patterns are considered to be a distress signal that hides deeper conflicts inside the person or their circumstances. On the other hand, frustration that can derive from a long time school failure, lack of success or negative feedbacks from teachers may lead to behaviour problems. Although bullying on a certain level is thought to be the part of normal school life, it may end in isolation and exclusion of some students. The feeling of loneliness and humiliation can quickly lead to alienation from school and then dropping out. Harassment and school violence is the active mental or even physical abuse. The timely intervention of a professional adult is essential to solve the problem and stop the process before its escalation.

Surprisingly, there are students who, in spite of the fact that they are considered to be non-at-risk student, sometimes drop out of a school. They typically neither have bad achievements nor behaviour problems; they are uninterested in school and under- or unmotivated: they are bored. However, boredom and low motivation as distress signals are missing from most of the policy and practice of schools. The following symptoms may refer to boredom: unwillingness to go to school or participate on classes, not able to concentrate, or loss of enthusiasm in school. According to experiences there are a lot of methods that strengthen the motivation of students towards school: extra-curricular programs that involve students and provides a social event; practical approach to learning instead of theoretical knowledge sharing; interactive methods that require other than academic competencies, etc.

4. Research and Results

The research was carried out from February to May 2017 among the teachers of a Vocational Centre that has seven secondary vocational schools. The survey had two parts: a qualitative and a quantitative one: first directors of vocational schools and the representatives of the Centre were asked in a semi-structured focus group interview. Their answered were analysed and made the basis of the questionnaire that was spread among the teachers of the Vocational Centre. This paper focuses on the quantitative questionnaire survey.

Printed questionnaires were distributed in schools on a date discussed earlier with the principal. Out of the 314 questionnaires that were taken to the seven schools of the Vocational Centre 158 ones were answered. Based on the number of teachers in schools, it can be stated that the ratio of respondents was between one third and 50 per cent in all vocational schools. The sample made around 50% of the population and was selected from all schools relatively evenly. That is why the research can be considered to be representative regarding the given Vocational Centre.

Questionnaire data were manually recorded in Excel, then it was converted into SPSS database. The statistical analysis of the data was done by the program SPSS 22.0.

4.1. Result of the Research

According to gender division, 38% (60 people) of the respondents are men, while 62% (92 people) are women. Regarding to age differences, the youngest subject was 27 years old, while the oldest 63. The average age of respondents is 46.44 year. Even the average age refers to a serious problem of teachers: ageing. Based on age, a new variable was formulated (age groups) and it was examined how many teachers belong to each age group. The rate of teachers younger than 30 years was only 2.5%; on the contrary, teachers over 60 made nearly 6% of the sample. The biggest age group was people in between 41-50 years old, 55 teachers could be rated in this group giving 35% of the sample. The second biggest group was teachers of 51-60 years old: 42 people, 27% of the sample, while the third biggest group incorporated bit younger 40 people, aged from 31 to 40, giving 25% of the sample. The figures refer to the aging population pyramid of teachers.

Besides age, teachers were asked how many years work experience they have. The shortest time of work experience was less than 1 year, while the longest 40 years. The average period of work experience was 17.35 years. The data were recorded into a new variable in order to know the ratio of career starters, the ones who have experience, and the ones who have decades of experience. According to the table 1, very few teachers can be accounted to the career starter group and have maximum 3 years of experience. The biggest group is, nearly 40% of the sample, teachers who have 11-20 year of work experience.

Table 1. Work experience of teachers

Work experience (year)	number	%
<= 3	11	7%
4 - 10	32	20%
11 - 20	61	39%
21 - 30	30	19%
31+	19	12%

It was asked and analysed what qualification teachers have. According to the results, most teachers have the required qualification, which is mostly master degree in secondary schools. Three quarters of teachers have a master degree, while 16% has a bachelor one. Only 7.6% of the teachers does not have a degree, only a secondary school certificate.

It was examined by crosstable whether there is a difference between qualifications of teachers teaching general education subjects and that of the ones teaching professional subjects. Chi-square test is proved to be significant ($\chi2=51{,}945$; $p<0{,}000$): 100 per cent of teachers (21 people) who do not have a degree teaches only professional subjects. Moreover, 88% of teachers having a bachelor degree teaches professional subject, but only one fourth of teachers who owns master degree work as professional teachers, while two third of this group teaches general education subjects.

Analysing the data from another point view, the survey showed that less than half (47.7%) of teachers teaching professional subjects have master degree, while the same ratio among teachers teaching general education subject is 96.5%. One third (33.8%) of professional subject teachers has bachelor degree, but it is only 3.5% among general education subject teachers. Finally, nearly one fifth (18.5%) of professional subject teachers does not have a degree, while none of general subject teachers can be rated in this category.

The purpose of the questionnaire survey was to find factors leading to dropout according to teachers. First, teachers were asked to define the phenomenon of dropout.

Table 2. Qualification vs. Subjects taught

	General education subjects	Professional subjects	Both
Secondary school certificate		10 people; 100,0%	
Tertiary education certificate		2 people; 100,0%	
BA/BSc	3 people; 12,0%	22 people; 88,0%	
MA/MSc	82 people; 67,7%	31 people; 25,6%	8 people; 6,6%

Various definitions of school dropout were identified in the focus group interview and then included in the questionnaire. Teachers were asked to rank the statements on the basis of the level, which statement describes best school dropout. Five statements were listed in the questionnaire:

1) Leave the class, fail.
2) Leave original profession.
3) Leave school.
4) Leave Vocational Centre.
5) Leave education system.

Teachers were asked to give the lowest ranking point (1) to the statement they agree least, and the highest ranking point (5) to the statement they agree the most. Figures in the table refer to the number of teachers in each ranking place.

Table 3. Definition of dropout – ranking

	1.	2.	3.	4.	5.
Leave the class, fail.	46	17	18	21	**50**
Leave original profession.	25	43	**45**	35	4
Leave school.	9	36	**53**	39	15
Leave Vocational Centre.	29	43	30	**48**	2
Leave education system.	46	12	5	8	**81**

According to the table 3, most teachers (81 people, more than 50%) think that the best definition of school dropout is when the student leaves education system. But it must not be forgotten that another significant group (50 people, 1/3 of respondents) believes that dropout means if the student leaves the class, fails and has to repeat the school year. On the other hand, nearly the same amount of teachers (46 people) states that this definition does not describe the phenomenon of dropout at all. On the basis of table 3, it can be stated that opinions of teachers are different. Due to the fact that Vocational Centres were founded in 2015, Vocational Centres function as employers for all the teachers and the students. So it is not surprising that a significant amount of teachers (48 people) think that the definition ‘The student leaves the Vocational Centre’ remarkably correctly describes the concept of dropout.

The research wanted find an answer on the question what causes can be found behind early school leaving – from the teachers’ point of view. According to the primary socialization theory by Oetting and Lynch (2006), adolescent’s primary social contacts are: family, school and peers. These three factors link to the adolescents and, on the other hand, with each other forming a strong circle that supports the adolescent. If any element of the ring or their relationship weakens, it has an influence on the adolescent, too. Examining the causes of early school leaving, these three factors were taken into consideration with some modification. The school was divided into two parts: teachers and the institution. Moreover, a new category was included: personal features of the student. Finally, the following five categories were formulated: 1) Student’s personal features, 2) Family background, 3) Peers, 4) Teachers, 5) Institution (school). In each category, 5-7 states were listed. Respondents were asked to evaluate all statements on a 5-grade scale, expressing their agreement: to what level the factor contributes to dropout.

Regarding students’ personal features, seven statements were listed. Fig. 1 shows that students’ deviant behaviour influences most (3.99) school dropout. The second most important factor is if the students do not think that secondary qualification is important to gain (3.71) and they are satisfied with ISCED 2 level. Out of the seven statements, the factor referring to students’ primary school results is on the fourth place, which means that in teachers’ opinion this factor has less impact on early school leaving than deviant behaviour or career planning.

In adolescence, peers have an essential effect on the individual. Teachers agree that peers and friends influence students’ behaviour, achievements, and attitude to school. Teachers highlighted classmates’ deviant behaviour as the most significant impact on students (3.45). The other important factor is friends’ negative attitude to school (3.33).

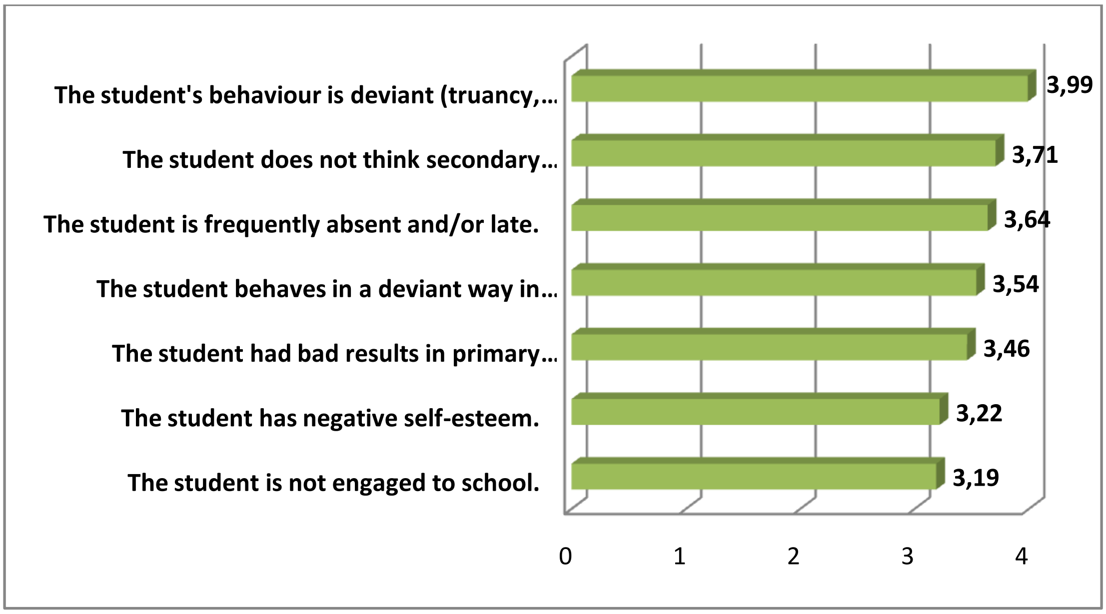

Fig. 1. Student's personal features

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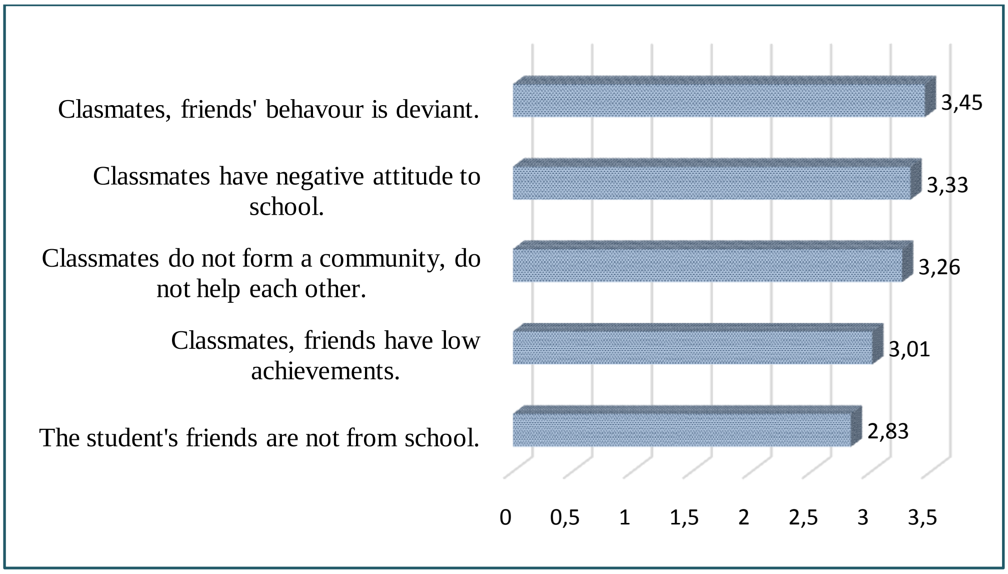

Fig. 2. Peers' influence

Comparing personal features and peers' effect, it can be stated that the most significant factors influencing dropout were deviant behaviour. Teachers think that the student's deviant behaviour as well that of their peers' have the most negative impact on early school leaving. On the other hand, the second most important factor in Peers category is classmates' negative attitude to school (3.33), while in Personal features category, low student engagement is the least important aspect (3.19).

Regarding family background factors, teachers suppose that a non-supportive family attitude (4.08) has a crucial impact on dropout. Another significant aspect is if the family lives in bad circumstances (3.46) – if there is no proper heating, lighting, bathing, washing, and learning facilities. However, teachers think that having many brothers and sisters (2.05) or being brought up in a lone-parent family (2.54) do not or just slightly influence dropout. The latter factor might have a small impact on early school leaving because divorce rate is quite high in Hungary, the result of which is that a lot of students live in a lone-parent or a reconstituted (mosaic) family.

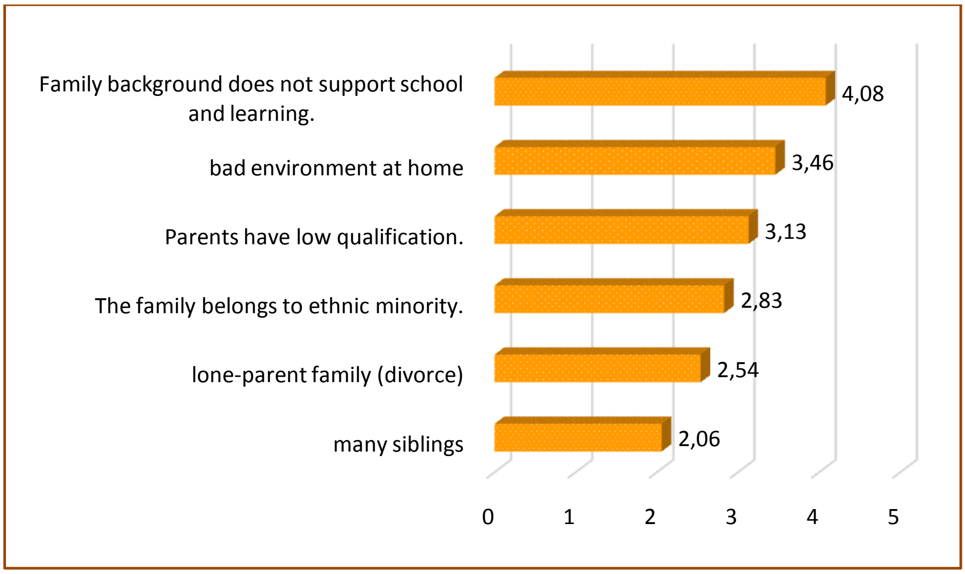

Fig. 3. Family’s influence

Regarding the influence of school on dropout, it was examined from two different points of view: from the teachers’ and from that of the institute. Factors in the ‘Teacher’ category referred to their teaching and education methods, as well as their mental state. The ‘Institution’ category listed some other important elements referring to the institutional culture and the management type. Comparing the means of factors in ‘Teacher’ category with those of the previous three ones, it is obvious, that the Teacher’s factors received the lowest points (the highest mean was 3.23).

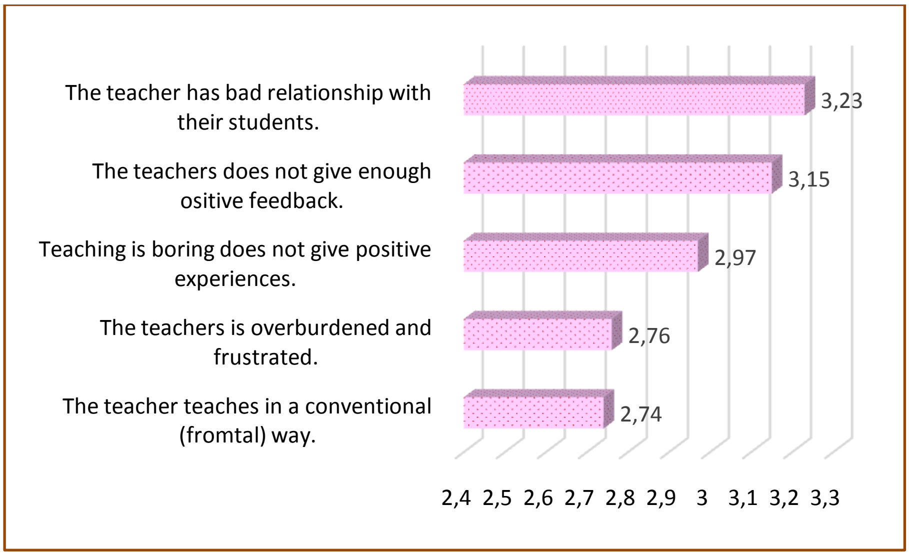

Fig. 4. Teachers' influence

Examining Diagram 4, the most significant factor is teacher's bad relationship with their students (3.23), followed by the factor not giving enough positive feedback to students (3.15). On the other hand, teaching methodology has a slight impact on early school leaving in teachers' opinion: the factors of teaching is boring (2.97) and methods are frontal, conventional (2.74) received low points. Moreover, teachers believe that conventional teaching methods have the slightest effect on dropout, they listed this factor on the last place.

The order of these factors should be thought over. In secondary schools, mostly generation Z studies; they love working in teams and prefer creative tasks where the focus is on activity instead of passive observation. Moreover, as they are brought up in digital world, they are able to pay attention to an issue only for 10 seconds, teachers' evaluation can be questioned: does teaching methodology influence school dropout only to little extent? On the contrary, principals in the focus group interview highlighted the significance of methodology as it has an effect on students' achievements, attitude, and therefore on early school leaving. The same conclusion was made in CroCooS project, which stated the boredom is one of the most significant causes of dropout. (http://oktataskepzes.tka.hu/content/documents/CroCooS/RP6_hu_Unalom.pdf)

Besides teachers, the school has an influence on early school leaving: if the student feels not OK at school, if the institutional culture is built on authoritarian management, if it does not support developing students' personality, it may contribute to dropout. Among the five categories, teachers found category 'Institute' the least significant: the highest mean does not reach 3.00, which means that teachers rather not agree that the school has an effect on school dropout.

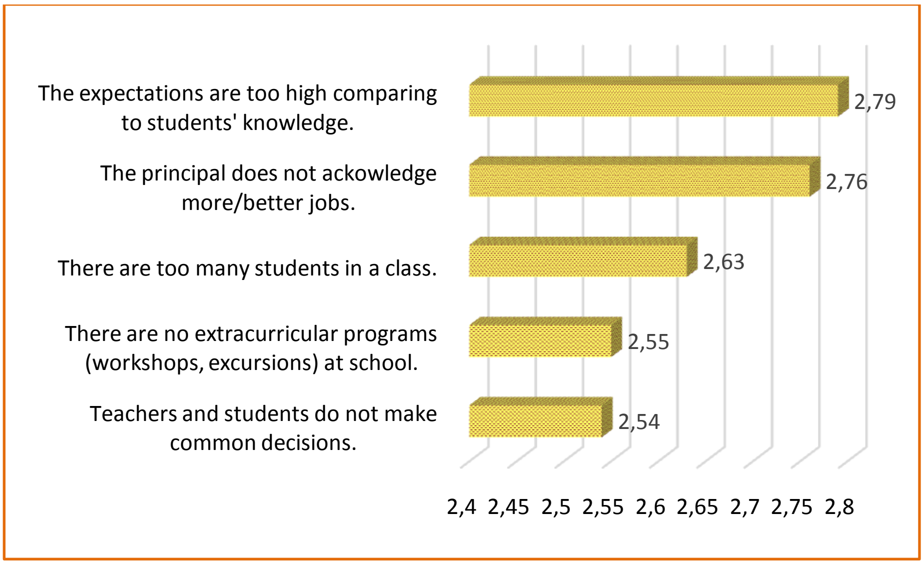

Fig. 5. Influence of the institute

Examining Diagram 5, it can be seen, that the most important factor on dropout is too high expectations (2.79), closely followed by the factor not acknowledging better achievements (2.76). The least significant factors are the lack or shortage of extracurricular activities (2.55), as well as if there is no common decision making (2.54).

There were altogether 28 factors listed in the questionnaire. In the previous pages these factors were examined by the five categories. Now all these factors can be seen, in decreasing order, regardless which category they belong to. To easily identify categories, five different colours were used: category of personal features is green, family is orange, peers is blue, teachers is rosy, and school is yellow – the same colours were used in the previous diagrams, too.

Table 4: Factors Influencing Dropout

Factors influencing dropout	**Mean**	**Category**
Family background does not support school and learning.	4,08	F
The student's behaviour is deviant (truancy, drinking, drugtaking, aggression).	3,99	S
The student does not think secondary qualification important.	3,71	S
The student is frequently absent and/or late.	3,64	S
The student behaves in a deviant way in lessons (deliberately annoys lessons).	3,54	S
The student had bad results in primary school.	3,46	S
bad environment at home	3,46	F
Classmates, friends' behaviour is deviant.	3,45	P
Classmates have negative attitude to school.	3,33	P
Classmates do not form a community, do not help each other.	3,26	P
The teacher has bad relationship with their students.	3,23	T
The student has negative self-esteem.	3,22	S
The student is not engaged to school.	3,19	S

The teachers does not give enough positive feedback.	3,15	T
Parents have low qualification.	3,13	F
Classmates, friends have low achievements.	3,01	P
Teaching is boring does not give positive experiences.	2,97	T
The family belongs to ethnic minority.	2,83	F
The student's friends are not from school.	2,83	P
The expectations are too high comparing to students' knowledge.	2,79	Sc
The teachers is overburdened and frustrated.	2,76	T
The principal does not acknowledge more/better jobs.	2,76	Sc
The teacher teaches in a conventional (frontal) way.	2,74	T
There are too many students in a class.	2,63	Sc
There are no extracurricular programs (workshops, excursions) at school.	2,55	Sc
lone-parent family (divorce)	2,54	F
Teachers and students do not make common decisions.	2,54	Sc
many siblings	2,06	F

Studying the table including all the 28 factors, it can be seen that students' personal features and a family factor can be found on the first five places, while on the next five places peers' influence is significant. However, the first factor that refers to teachers' effect can be found only on the 11th place; moreover, the first factor referring to the influence of the institute appears on the 20th place. This order indicates that teachers think both they and the school have a slight impact on early school leaving: only two factors referring to teachers' significance can be found in the first part of the table (bad relationship with students, not enough positive feedback); regarding the school, all the factors are in the second part of the table. However, all the seven factors of student's personal features are listed in the first part of the table. Teachers assign the same importance to peers as well: all the five factors can be found in the first part of the table.

The conclusion of the survey is that teachers attribute much less significance to their role and that of the institute in early school leaving than to students and their peers. Although it is obvious that peers have essential influence in adolescence, it is surprising that teachers underestimate their own role in students' life, well-being, and in dropout. Based on the research, it cannot be identified properly whether teachers evaluate the situation in a wrong way, or do not want to take responsibility.

Table 3 presents how teachers defy dropout. It was examined whether correlation can be found between variables regarding the definitions and the causes of dropout. The variable 'Student leaves the school system' has positive significant correlation with two causative variables: the teachers does not give enough positive feedback ($r= 0,244$; $p<0,01$), there are no extracurricular activities (r= 0,173; p<0,05). It must be stated that both factors belong to the category 'Institute', therefore belong to teachers and school's competence, which means they have the opportunity to change the situation. The first factor (not enough positive feedback) is in close connection with evaluation and measurement. Teachers must be aware of the fact that giving marks is not equal with evaluating students' achievements. Teachers evaluate students in different other ways (orally and even non-verbally) – sometimes even not consciously. But these feedback are often as important to students as marks.

Although the correlation is weak with extracurricular programs, their significance must not be abandoned. During the focus group interview, principal agreed that teachers can build a better, more personal relationship with their students in extracurricular programs. Taking into consideration other surveys, relationship between teachers and students may crucially influence early school leaving. These programs provide opportunities for students to strengthen their relationship both with their teachers and their classmates, and these close contacts decrease the possibility of dropout. However, teachers did not think that the factor 'students do not form a community' has a big effect on dropout: the mean of the variable is 3.26.

The second most frequently selected definition of dropout was: the student leaves the class because he/she fails. This variable has positive significant correlation with two causative variables: bad results in primary school (r= 0,161; p<0,05) and brought up in a lone-parent family (r= 0,176; p<0,05); the correlation is very weak, though. The first correlation is obvious: if the students finishes primary school with bad marks, they have a big opportunity to not meet the requirements of secondary school and fail at the end of the 9^{th} form. Although failure and grade repetition does not mean that the student leaves the school system, several studies stated that bad achievements significantly correlate with early school leaving. According to an American study, dropout does not start by the first failures but underachievement and failures experienced in the first form of secondary school suggest dropout.

Finally, teachers were asked to evaluate factors that contribute to decreasing dropout. The focus of this question was not the family or peers but teachers and school. Researchers believe that teachers have a significant impact on their students, and they are responsible for what is happening during and between lessons. Respondents had to evaluate the five given factors on a 5-grade scale on the basis of the extent they contribute to the decrease of dropout. Results show that teachers cannot see big differences between the significance of the factors; on the other hand, they do not find any of them highly important as the highest mean is 3.85.

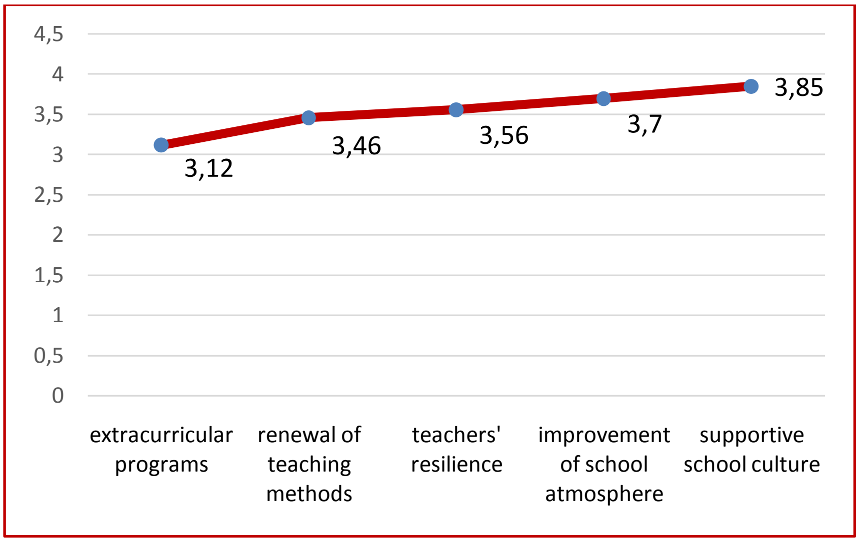

Fig. 6. Factors decreasing dropout

Examining the diagram it can be stated that supportive school culture (3.85) was believed the most significant factor, while extracurricular programs (3.12) were thought to be the least important one. The renewal of methodology also needs attention as it received the second lowest points (3.46), which means that teachers assign little significance to this factor.

There were some very similar causative and preventive factors, and it gave the idea to compare the means. According to Table 5, it is obvious that teachers believe a factor less significant if it is a causative one. Moreover, the difference between the means regarding the same variable is rather big: extracurricular programs – 0.57; pedagogical methods – 0.72; and teachers' resilience – 0.8. In a further survey, it should be researched why the same factors seem more important of they are named as preventive ones rather than causative ones.

Table 5: Comparing the Means of Causative and Preventive Factors

Causative factors	**mean**	**Preventive factors**	**mean**
There are no extracurricular programs (workshops, excursions) at school.	2,55	extracurricular programs	3,12
The teacher teaches in a conventional (frontal) way.	2,74	renewal of teaching methods	3,46
The teachers is overburdened and frustrated.	2,76	teachers' resilience	3,56

5. Conclusion

Early school leaving is a serious problem in secondary vocational education affecting all members of it: the student, the family, the school, and the Vocational Centre. Moreover, dropout has a long-lasting effect on individual's life often generating a social problem, such as having lower labour market opportunities, more probability of being unemployed, falling back on social aid, having worse health conditions, etc. According to a European Union strategy, by 2020 Hungary intends to decrease the ratio of vocational school dropouts under 10%. All this means that both the interests of the national economy and the expectations of the European Union give direction for the development of vocational education: take measures for decreasing early school leaving. To be able to reduce the rate of dropout exactly elaborated prevention and intervention actions should be introduced in vocational schools. The actions can be the most effective if it is realized what background factors contribute to dropout and to what extent they influence school leaving.

According to the results of both national and international researches, the following factors are considered basic in dropout: student, family, peers, and school. In these researches, all the factors were examined; and the data were collected from teachers of vocational schools. Teachers believe that student's personal features and family background have the most significant effect on early school leaving. Although neither of these factors can be eliminated from the process of dropout, teachers can fundamentally influence students' attitude to school – either in a negative or in a positive way. Students' attitude to school and learning definitely impacts on their school achievements, the extent of absenteeism, and students' behavior during lessons.

Teachers stated that students' deviant behavior (truancy, drinking, drug taking, aggression) has an essential effect on early school leaving. Although peers' influence is the most significant, in adolescence and the role of friends is extremely important in copying deviant behavioral patterns, the effect of teachers must not be ignored. If students have a good relationship with their teachers, if they trust teachers and could turn to them in case of problems, students are less likely to behave in a deviant way and more likely to have positive attitude towards school – unless they rely on only their peers' onion and regard them as references.

In the conclusion, teachers and schools have a very important role in reducing school dropout. Teachers' responsibility is to build and maintain a good teacher-student relationship, to prioritise rather educational task to the teaching ones, to apply cooperative techniques instead of frontal work, and to intend to increase their resilience. Besides teachers, schools have a significant role:

schools should emphasise organizing extracurricular programs and involving students into them, and should more appreciate form teachers' work.

However, there are some system problems. Due to the rigidity of Hungarian vocational education, is students have enrolled to a vocational training, they have no chance to change it during their training, unless they start a new one from the very beginning. The consequence of this inflexibility that several students leave vocational education because they realize that the trade they have chosen does not suit for them, they cannot have good achievements. So they leave their original training but it is absolutely not sure whether they enroll another one or leave educational system – especially if they are over 16, the compulsory age of education.

References

Andrei, Tudorel - Teodorescu, Daniel – Oancea, Bogdan (2011): Characteristics and causes of school dropout in the countries of the European Union. In: Procedia - Social and Behavioral Sciences 4. 328 – 332.

Archambault, Isabelle, et. al. (2009): Adolescent Behavioral, Affective, and Cognitive Engagement in School: Relationship to Dropout. In: Journal of School Health. 79. (9.) 408-415.

Christenson, Sandra L. – Thurlow, Martha L. (2004): School Dropouts: Prevention. Considerations, Interventions, and Challenges. In: Current Direction in Psychological Science. 13. (1.) 36-39.

Christle, Chritine A. – Jolivette, Kristine – Nelson, C. Michael (2007): School Characteristics Related to High School Dropout Rates. In: Remedial and Special Education. 28. (6.) 328-339.

CroCooS Research Reports. http://oktataskepzes.tka.hu/en/crocoos-research-reports-171124120759 [Time of download: 25. 10. 2016.]

Early school leaving and dropout http://oktataskepzes.tka.hu/en/early-school-leaving-and-dropout [Time of download: 10. 05. 2017.]

Eurostat. https://ec.europa.eu/eurostat [Time of download: 25. 03. 2017.]

Fehérvári Anikó (2015): Lemorzsolódás és a korai iskolaelhagyás trendjei. Neveléstudomány. 3. 31-47.

Kőműves Ágnes (2010): Tegyünk a korai iskolaelhagyás ellen! In: Család, Gyermek, Ifjúság. 4. 51-56.

Küzdelem a korai iskolaelhagyás ellen a jobb életminőségért http://www.schooleducationgateway.eu/hu/pub/practices/early_school_leaving.htm [Time of download: 08. 03. 2017.]

Lessard, Anne – Poirier, Martine – Fortin, Laurier (2010): Student-teacher relationship: A protective factor against school dropout? Procedia Social and Behavioral Sciences 2. 1636–1643.

Neild, Ruth Curran – Stoner-Eby, Scott – Carolina, Chapel Hill (2001): Connecting Entrance and Departure: The Transition to Ninth Grade and High School Dropout. In: eScholarship, University of California. http://escholarship.org/uc/item/48m0122w#page-3 [Time of download: 10. 06. 2017.]

Oetting, E. R. – Lynch, R. S. (2006): Peers and Prevention of Adolescent Drug Use. In: Sloboda, Zili – Bukoski, William J. (2006, edit): Handbook of Drug Abuse Prevention. Theory, Science, and Practice. USA: Springer. 101-129.

Oktatási és Képzési Figyelő 2016. Oktatás és képzés. Magyarország. https://ec.europa.eu/education/sites/education/files/monitor2016-hu_hu.pdf [Time of download: 25. 03. 2017.]

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Digital Transformation in Higher Education

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Abstract

Generally speaking the contemporary modern innovations in information and communication technologies (ICT) on the one hand foster the development of operation processes and marketing of products and services, and, on the other hand, provide a model of the use of information technology, which reduces the initial investment in IT and moderate the operational cost of ICT. Higher educations are organizations that offer services and are interested in the benefits of contemporary ICT. The new buzzword 'Digital transformation' refers to the business approach implementing the latest ICT technologies (cloud computing, Internet of Things-IoT, big data, blockchain, artificial intelligence-AI and machine learning-ML), adjusting these to the users in terms of their ability to use these novel ICT technologies. The paper includes a proposal of a possible and applicable ICT Ecosystem model for higher education, which can further enhance and accelerate the digital transformation in higher education.

*Keywords:*digital transformation, cloud computing, internet of things ;

1. Introduction

Since its origin ICT has continuously played a special role in organizations and recently this role has been extended to all spheres of life. ICT has always aimed to ease everyday tasks and to automatize routine, well-defined activities in organizations. With time the completion of these tasks have been performed improved and today ICT is inevitable in gathering and memorizing data, and also in finding, processing and presenting the stored and/or processed data. This continuous data availability and functionality of each process individually and also on an integral level, the high speed of transactions and other processes as well as the short term of investment return (ROI) have all resulted in the fact that today ICT is present in all spheres of life. The appearance of social networks and intelligent devices (Internet of Things –IoT) that can mutually communicate through the internet has led to a fast increase of newly-created data in the unit of time. That process has initiated new techniques for data memorizing and processing (big data, on line analytics), as well as storing data (cloud computing). Due to the fact that recently with the application of artificial intelligence, knowledge management, statistical analysis and the application of data mining techniques which reveal hidden knowledge, new regularities, undiscovered connections, data patterns present in large data bases or anywhere on the internet, it is possible to obtain any information which qualitatively changes the significance and application of ICT in organizations and contributes to their efficient and successful operation.

This paper provides an analysis of the above-mentioned new technological tendencies and concepts already realized and available for application, from the aspect of their applicability in higher education. The basic cohesional technique for implementing the mentioned advanced technologies is certainly cloud computing, similarly to the role electrical energy played a hundred years ago. This similarity was described by Nicolas Carr, the main editor of Harvard Business Review in 2008: "A hundred years ago, companies stopped producing their own power with steam engines and generators and plugged into the newly built electric grid. The cheap power pumped out by electric utilities not only changed how businesses operated but also brought the modern world into existence. Today a similar revolution is under way. Companies are dismantling their private computer systems and tapping into rich services delivered over the Internet. This time it's computing that's turning into a utility. The shift is already remaking the computer industry, bringing new competitors like Google to the fore and threatening traditional stalwarts like Microsoft and Dell. But the effects will reach much further. Cheap computing will ultimately change society as profoundly as cheap electricity did." (Carr, 2008).

Social networks function in cloud, and IoT devices deliver the data received from their sensors into big data also placed in a cloud, so the data can continually analyzed (on line) and based on the current results generate reactions to the occurred events. These reactions/functions are realized by actuators in intelligent devices. These innovative technologies provide the possibility to improve the development process of functioning and placement of company goods and services on one hand, and ensure a model of using information technologies that reduce initial investments into IT with modest cost of operation, on the other.

This paper describes a proposed ICT ecosystem composed of the earlier mentioned innovative technologies for supporting, advancing and accelerating the digital transformation in higher education.

2. Digital transformation

The concept of digital transformation is the reengineering of all manufacturing and sales processes, so that they would become more efficient, though this does not lead to the automatic modification of existing new services and products, or automatically creating new ones. Digital transformation covers a lot more than the simple implementation of new ICT technologies (cloud computing, IoT, big data, blockchain, AI and ML). If the employees and/or users do not support the suggested approaches, then the ICT technologies recommended towards the goal of digitalization might even be counterproductive.

There are numerous definitions for digital transformation which summarize the facts listed above.

“Organizations must begin to look at digital holistically and transform by applying digital thinking across every-thing they do -- how they win, serve, and retain customers; how they operate internal processes; and how they source business services. In short, they must become a digital business” (Forrester) (McLellan, 2018).

“The goal of digital transformation isn’t better social or faster analytics... it’s to remake brands to be more adaptable, better at learning and above all, able to tie together the strands of product, sales marketing and service that make up the customer experience” (Adobe) (McLellan, 2018).

The main drivers of digital transformation are presented in Figure 1. (Altimeter), (McLellan, 2018).

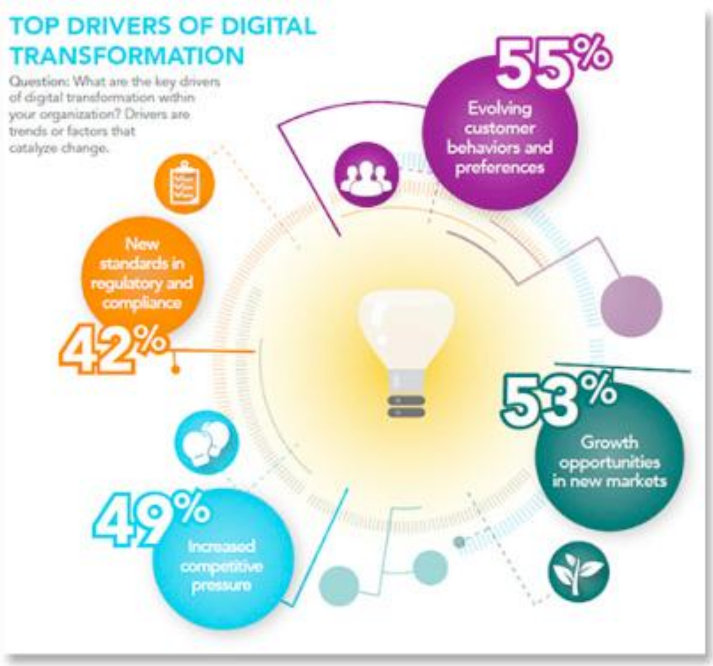

Figure 1. Top Drivers of Digital Transformation

2.1. Cloud Computing

Cloud computing (CC) designates a service of using an ICT resource (hardware, communication, software platforms, DBMS servers and application software) through the internet (public telephone or any other network) based on payable utility services as well as other public services that are paid according to how much the service is used. There is no universally accepted definition despite the fact that the idea is more than fifty years old (formulated by John McCarthy in 1961). The appearance of cloud computing has been influenced by numerous factors such as the internet, the bandwidth of communication lines (speed of transfer), standardization and virtualization of computer hardware, service orientation of applicative software, the global economic crisis, etc.

Characteristics (advantages) of clouds providers frequently emphasize include:

1. "Multitenancy – a single instance of an application serves multiple consumers (tenants) with the possibility (for the tenants) to customize some details (GUI or business rules) of the software applications",
2. Identity management and access control – application of advanced techniques in identity checks and access control in order to provide legitimate data use,
3. Security of services – implementation of the most stringent cutting-edge security measures for service provision" (Petkovics et al., 2014),
4. On-demand self-service with high flexibility and scalability (rapid elasticity),
5. Access to services from optional geographical locations (if internet connection is provided) at all times (ubiquitous network access),
6. Division of resources for services in server farms at different geographical locations (location-independent resource pooling),
7. Pay-per-use or pay-as-you-grow and
8. Low costs of use and reliability.

Apart from emphasizing the advantages of cloud computing providers of this service regularly point out the following savings when cloud is used:

1. there is no initial investment into hardware, communication network and premises for equipment,
2. there are no costs for software: purchase, licensing and update,
3. energy costs (and costs of cooling) can be saved and
4. there are no costs payable to experts/information experts (salaries and costs of further training).

Fears and drawbacks with regard to the application and use of cloud computing has been expressed even by renowned and famous experts including:

1. services with the same name have different content and conditions of delivery at various providers,
2. problem of service transferability between suppliers (danger that the user of cloud computing might become dependent of the provider),

3. limited number of services, poor offer of software solutions in cloud, lack and rigidity (offering unfavorable conditions for the user – user unfriendly) of existing contracts on providing services (SLA Service Level Agreement),

4. immature technology and its market,

5. availability of services and bottlenecks in transfer (power cuts and halting the use of the internet, problems occurring at the provider obstructing the service, limited ranges in transfer/communication and

6. the likelihood of troubles halting the service is great (the type of service is very complex).

2.1.1. Services, models and ecosystem

”The National Institute of Standards (NIST) differentiates three today well-known services (service model) with classic contents (from the standpoint of the user) for which all the previously cited essential characteristics:

1. Software as a Service (SaaS). Software rent (software on demand) via the Internet for using on thin client (web browser) on all computers and mobile devices,

2. Platform as a Service (PaaS). The rent of computation platform (platform on demand) with necessary software of special use (developmental environments, i.e. program languages, different libraries of programs for development purposes, tools and services) for applications development and

3. Infrastructures as a Service (IaaS). It is the rent of basic computer equipment in the form of virtual machines and networks.” (Petkovic, et al., 2013).

From the aspect of publicity of usage there are four models, the Community cloud is rarely used, so in practice only three models are used. The deployment models are (Petkovics et al., 2014):

1. Private cloud: The cloud services are dedicated for exclusive use to a single organization with a large number of end users. That model is physically often realized at the user itself,

2. Community cloud: This deployment model provides cloud services for a specific group of persons or organizations with common interest (hospitals, universities, etc.),

3. Public cloud: The public cloud provides offer to any consumer for open use over the public Internet and

4. Hybrid cloud: Represents a combination of two or three earlier described deployment models (private, community or public).

CC is an extremely complex service: one provider can provide only one type of service (IaaS, PaaS or SaaS), but also any combination of these services only in one form (public, private, community or hybrid), but also in all possible forms. According to the latest opinion markets, hierarchies and ecosystems are the pillars of modern business thinking (Moore, 2006). In the ecosystem the principal objective is the perfect cooperation in innovation development among partners, which entirely describes the CC service itself. Due to its simplicity in this paper the e3-value methodology (Gordijn, 2002)is used for the illustration of CC ecosystem - the interconnection between the actors (roles). "A value model shows actors who are exchanging things of economic value with each other." (Gordijn, Akkermans, 2003).The actor (in Figure 2 represented by a rectangle) is a legal or physical person, characterized by the name or role in the CC ecosystem. Composite actors (actor-partnerships) include two or more elementary actors, where actors mutually supply or demand products and/or services (but elementary actors of composite actors can appear alone with their own supply and demand). Actors exchange (presented by arrow) value objects (service, product, advice, money, etc.) through value ports (it is illustrated by a small shaded circle). The name of the value object reflects the essence of exchange, and it is indicated on or near value exchange. The value ports are in the value interfaces in pairs (illustrated by a rounded rectangle on the edge of the rectangle of the actor). Figure 2 shows how the services are created (appeared) and exchanged and how and in how many ways new, subtle, rich services in CC service ecosystem are composed (by adding new values or recombination of the current services) from the simple ones (Petkovic, et al., 2013).

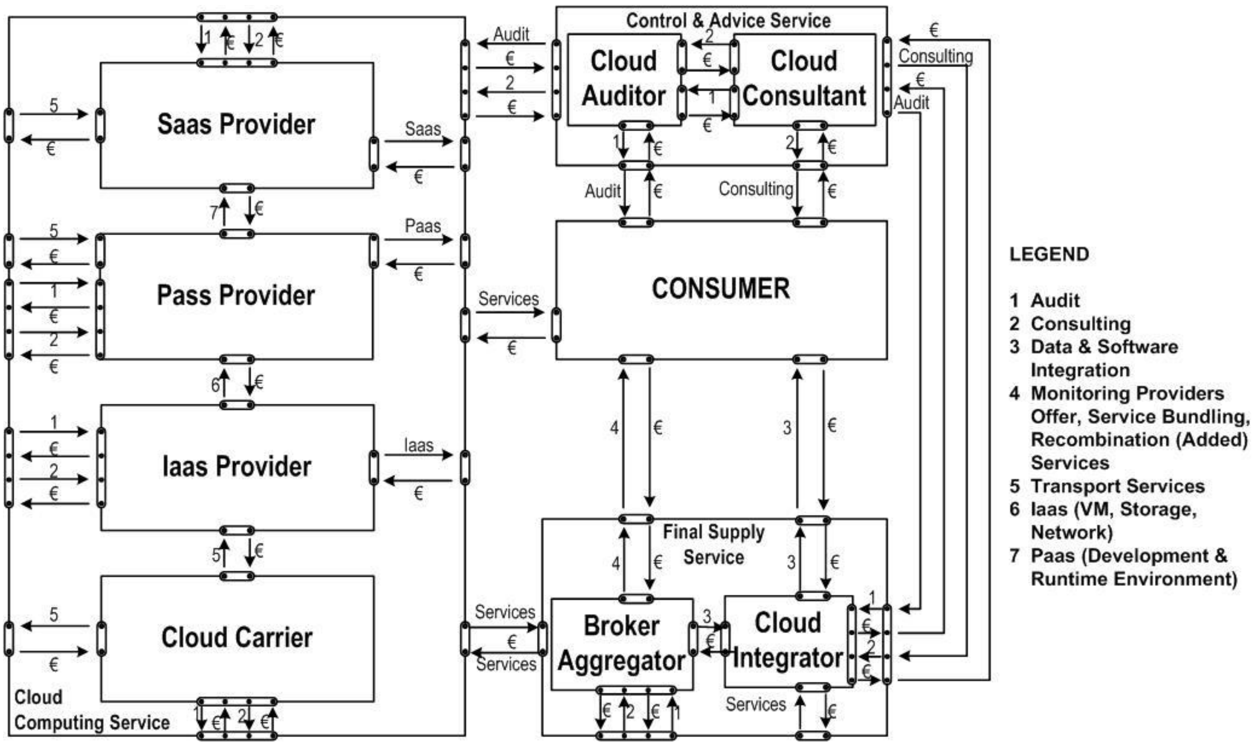

Figure 2. Cloud computing Value Network – Detailed Actor View

2.2. Internet of Things

IoT refers to Internet of Things, to fixed or mobile intelligent devices which can communicate and exchange data automatically via the internet without human intervention. Simply stated, IoT (sometimes machine-to-machine communications abbreviated as M2M is used for IoT) is a concept through which devices around us will receive their addresses on the internet and using sensors and actuators become intelligent. That will enable every one of us to control the technology we already use in a new way (Rodić, 2012).

The advantages listed below can serve as a motivation to apply the Internet of Things in organizations (Petkovics et al,2013):

(a) gathering and storing (memorizing) data monitored by intelligent devices in real time,

(b) more efficient control of devices connected into a network (and supplied with sensors),

(c) processing and analyzing data from intelligent sensors located in the data bases or storages (data warehouse) in the computer center of the organization or computer cloud,

(d) current data and their just in time processing or/and analysis for important reports create a basis for making good business decisions, and the appropriate decisions provide functional efficiency contributing to maintainable development of the organization and

(e) such a realization of monitoring the operation of devices relevant for the functioning of the organization provides cost-cutting in business.

The motivation of implementing the Internet of Things:

(a) a follow-up of the functions of organism, parameters of illnesses with the possibility of receiving information about them,

(b) reducing and control of electric and heat energy consumption and

(c) follow-up of the transportation of goods, materials (logistics), monitoring production processes, etc.

2.2.1. Characteristics of Functioning and Models of IoT

The Internet of Things was discovered by organizations in search for innovations, new business models under the pressure to achieve higher productivity and profit. Higher education worldwide lacks financial means. IoT is a great aid to them because the cheap gathering and sending of data through IoT and their integration into a system of data in higher education institutions enables to improve the current processes and services with significant reduction in operational costs. The intelligent devices represent nodes of the local network, but in some networks it is also necessary to use local servers or gateways in order to perform real-time analysis (autonomously or with the help of a server in a cloud).

There are two models represented for IoT: the service model and the building model. There is a great number of service models with the very different granulation (level of detail) but those models can generally be represented as three-level models similarly to CC with the following (sometime variously termed) level names: network (context-aware tier or physical layer), service (fundamental resource layer or M2M platform) and application (application layer or service platform access) level (Figure 3) (SPAN Systems Corporation, 2014). The building model illustrates mainly the method of the realization of IoT network level (Figure 4) (McLellan, 2013).

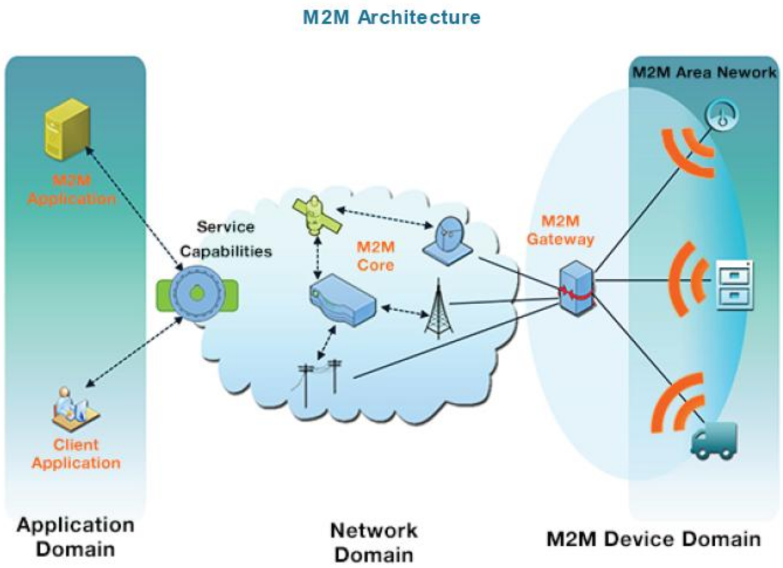

Figure 3. IoT –service model

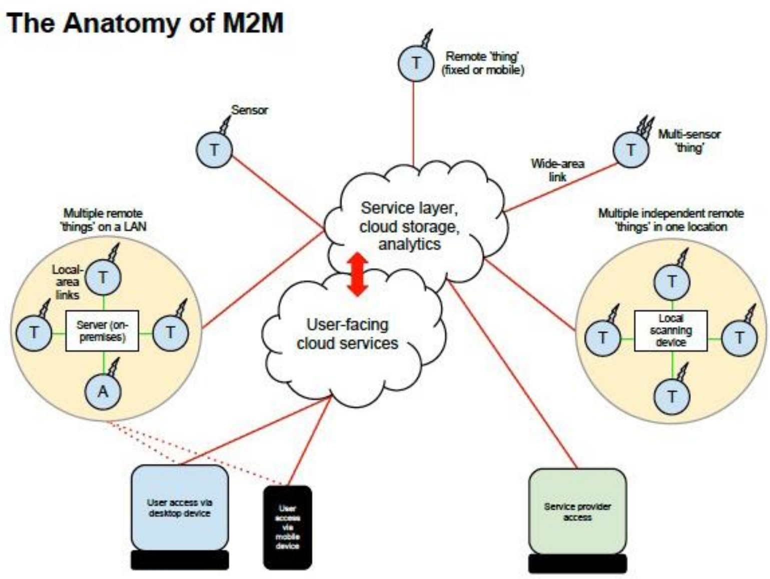

Figure 4. IoT – building model

3. Discussion

CC provides an ICT infrastructure which ensures a suitable quality and capacity for any type of user (physical, SME, big international companies), as well as higher education. The theoretical analyses describing the advantages of the model from the aspect of publicity of usage for higher education institutions generally prefer the application of hybrid clouds, having in mind the wide spectra of activities of the institutions (Petkovics et al., 2014), (McLellan, 2013). In practice the higher education institutions often opt for a private cloud because it functions safely and reliably, but under the condition that they have a loyal, safe and reliable private cloud provider (Petkovics, 2014).

The new procedures and techniques in data processing and communication, as well as the new applications (social networks, big data, on-line analytics, NoSQL data base systems) blend into the CC ecosystems entirely (practically they cannot exist without CC), that is why the CC ecosystem can be accepted for the ICT ecosystem. The appearance of IoT, however, strains the limits of ICT ecosystem because there is a new physical level which seeks its place in the ecosystem. That level is the level of intelligent devices and local networks which links them and connects them to the internet. That is the reason why some experts expand the CC (ICT) ecosystem with an additional level which includes them and is called things and communication networking. In my opinion the ICT (CC) ecosystem does not require the introduction of a new level, only a fine granulation of IaaS, PaaS and Saas cloud provider (Figure 5).

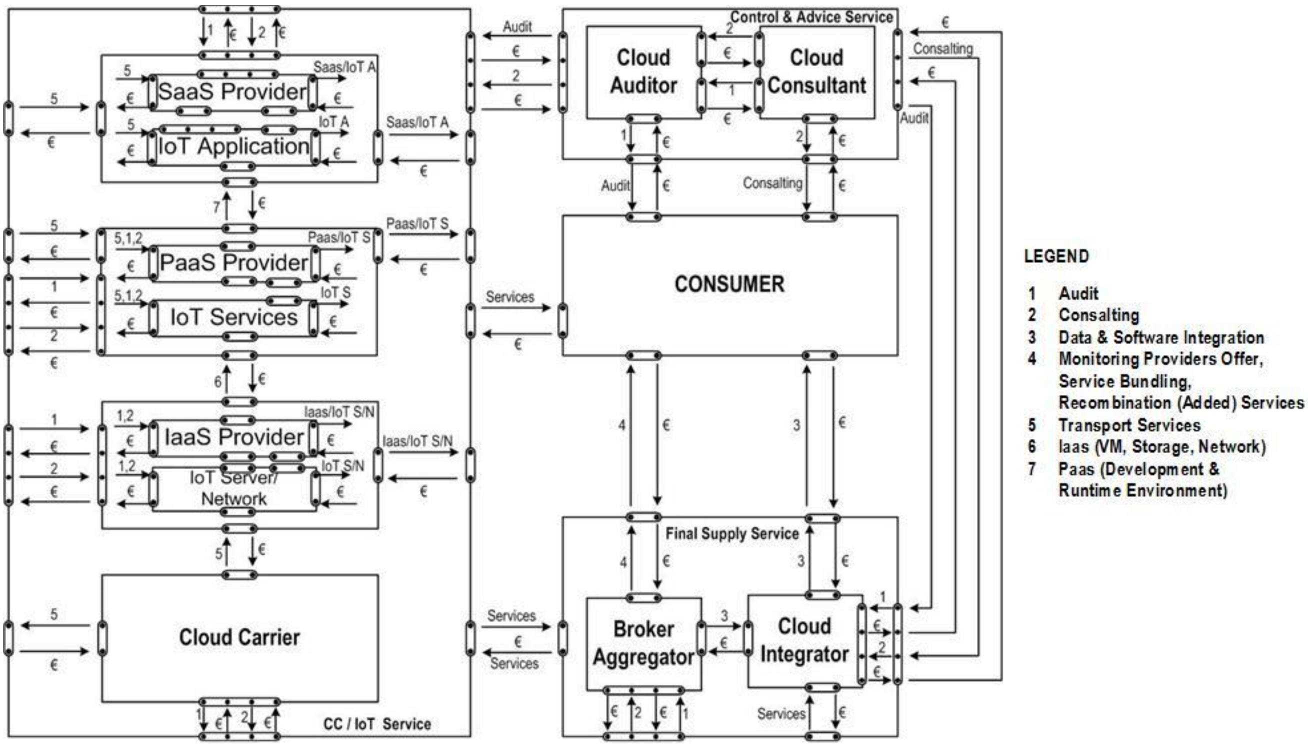

Figure 5. ICT value network – detailed actor view

A detailed description of the implementation of CC as one of the most important technologies in terms of the realization of digital transformation in higher education is given in (Petkovics et al., 2014). Though it must be pointed out that in that period the terms CC and digital transformation were much farther apart than they are today.

IoT in higher education can provide classic functions used in any field associated with surveillance and control of various devices ensuring work conditions and operation. These operations include surveillance and control of lights, electrical charges, temperature (i.e. heating and cooling), ventilation and locking and unlocking sealed spaces, as well as fire protection monitoring and building surveillance using cameras. The upgraded, modified fitness bands and wearable specific IoT devices can serve various purposes: apart from the well-known data collection (measuring blood pressure, pulse, body temperature and physical activity), they can also be used for monitoring individuals' movements, logging when borrowing books from the library, paying at the cafeteria, in bookstores and photocopy booths on campus. The class of IoT devices that contains all forms of personal mobile devices (cell phones, laptops, tablets, etc.) can also efficiently improve the students' academic advancement, if the students' academic activities are constantly monitored using AI on these mobile devices (monitoring knowledge acquisition and submission /uploading of obligatory tasks as well as the evaluation of the mentioned hand-in projects). There is even mention of measuring brain waves in order to monitor the students' cognitive activities during the classes. Another interesting class of IoT devices is that of virtual reality headsets, augmented reality headsets and adaptive learning systems. "The adaptive learning devices can track how well individual students understand course content and can provide new content or offer supplemental teaching in various forms including video, text, experiments, or even virtual field trips." (Asseo et al., 2016).

To improve the quality of learning and students' life on campus it is important to store and later study and analyze all the data collected by the IoT devices.

Depending on the skillfulness of the students, the huge amount of data usually stored in the cloud (Barbaschow, 2018)is likely to significantly improve the students' lives and academic advancement. By using predictive analysis of the IoT data combined with data from other sources, it is possible to predict the student's advancement, detect expected problems, and even offer an estimate of student dissipation with a great degree ofaccuracy.

Data analysis will offer students a way to track their campus movements and gain a deeper insight into how they spent time and resources.

The greatest amount of information stemming from IoT devices in higher education describe parameters of a highly private nature for individuals, people, or, in fact, students. Such data must not be collected and stored (as well as analyzed) without their explicit prior consent, as that data is protected by law.

IoT networks as systems are distinct from other, traditional IT and information management systems. Five factors distinguish IoT systems from other technology systems: "(1) the large number of devices; (2) the high variability of types of devices; (3) the lack of language and conceptual frameworks to discuss and easily categorize and classify devices; (4) the fact that they span many organizations within an institution; and (5) the fact that the hundreds or thousands of devices embedded in the physical infrastructure around us tend to be out of sight and out of mind." (Benson, 2016).

The IoT network, and especially the specific devices are the weakest links at the moment in this entire infrastructure or ecosystem of higher education institutions. Thus it is absolutely vital to pay close attention to and spend considerable funds on the security of this network.

4. Conclusion

This paper describes two new ICT technologies that are being increasingly implemented in the process of digital transformation in higher education. These two technologies bring countless new services developed in the last decade, and are well applicable in higher education. Due to the development of ICT a new model of CC is being increasingly applied. The latest tendencies of development (IoT) force the modification/expansion of classical CC service model to cover IoT services too. The ecosystem illustrated in Figure 5 can serve as ICT model for contemporary Higher Education. The coming years will show how long it will be applicable and how that model will develop. The new types, new classes of IoT devices, including fitness bands, wearables, virtual and augmented reality headsets and adaptive learning systems, are also well-developed and readily available on the market to the public, awaiting a wider spectrum of implementation.

References

Asseo, I., Johnson, M., Nilsson, B., Neti, C. (2016) Costello TJ., The Internet of Things: Riding the Wave in Higher Education, Educause Review, Vol. 51, No. 4, 11-31.

Barbaschow, A. (2018)., Study Group moving from manual DR to an "Always-On" Education Provider, ZDNet-TechRepublic. Retrieved from https://www.zdnet.com/topic/digital-transformation-a-cxos-guide/. Taken 28.08.2018.

Benson, C. (2016). The Internet of Things, IoT Systems, and Higher Education, , Educause Review, Vol. 51, No. 4, 34-43.

Carr, N. G.(2008). The Big Switch: Rewiring the World, from Edison to Google, W. W. Norton & Company.

Gordijn, J. (2002). Value-based Requirements Engineering-Exploring Innovative e-Commerce Ideas, PhD thesis, Vrije Universiteit, Amsterdam, NL.

Gordijn, J., Akkermans, H. (2003). Value Based Requirements Engineering: Exploring Innovative e-Commerce Ideas, Requirements Engineering, 8(2):114–134.

McLellan, C. (2018). Digital Transformation: Retooling Business for a New Age, ZDNet-TechRepublic. Retrieved from https://www.zdnet.com/topic/digital-transformation-a-cxos-guide/. Taken 28.08.2018.

McLellan, C. (2013). The tech behind M2M and the Internet of Things, in The Executive's Guide to the Internet of Things, TechRepublic, Retrieved from http://www.techrepublic.com/whitepapers/the-executives-guide-to-the-internet-of-things/32603017. Taken 02.01.2013.

Moore, J.F. (2006). Business ecosystems and the view from the firm, Antitrust Bulletin, Spring 2006, Vol. 51, No. 1.

Petkovic, I., Petkovic, Dj., Tesic, A., Suljovic, E. (2013): Value network of Cloud Computing Service Ecosystem, TTEM Journal, ISSN 1840-1503, Vol.8, No.4, pp.1689-1698.

Petkovics, I. (2014). A felhőinformatika szerepe a XXI. századi felsőoktatásban, International Conference A tudásgyárak technológiaváltása és humánstratégiája – a felsőoktatás kihívásai a XXI. században, Győr Hungary, 05. 29-30.

Petkovics, I., Trninić, J., Đurković, J. (2013). The Role of Information Technology Support in Sustainable Development, Strategic Management, ISSN: 1821-3448, Vol. 18, No 4, pp. 3-13.

Petkovics, I., Tumbas, P., Matković, P., Baracskai, Z. (2014). Cloud Computing Support to University Business Processes in External Collaboration, Acta Polytechnica Hungarica, ISSN 1785-8860, Vol. 11, No 3, 2014., pp. 181-200.

Rodić, V. (2012). Kuda ide Internet (Where is the Internet Going). Retrieved from http://www.topsrbija.com/index.php-?option=com_content&view=article&id=2929:vojislav-rodi-kuda-ide-internet-&catid=310:najava&Itemid=400. Published 28.11.2012. Taken 06.03.2013.).

SPAN Systems Corporation. (2014). Machine to Machine (M2M), Retrieved from http://www.spansystems.com/Industry/UniComms-M2M.htm. Taken 05.28.2014.

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Composite Amplifier with Extremely High CMRR

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Abstract

The purpose of the research was to analyse details in the application of operational amplifiers in precision analog circuits. Special attention was given to deviations caused by common mode rejection ratio, not thoroughly analysed in the literature. The research is started with theoretical analysis. Composite amplifier circuits are proposed to achieve better performances than with a single operational amplifier could be achieved. Benefits of the proposed circuits are shown by simulations based on the simulation models and measurements on the real model. The theory and practice introduced below could be well included in undergraduate course in analog electronics.

Keywords: operational amplifier; composite amplifier; high common mode rejection ratio (CMRR);

Nomenclature

A	amplifier gain
CM	common mode
CMRR	common mode rejection ratio
IC	integrated circuit
R	resistor
U_I	input voltage
U_O	output voltage

1. Introduction

Building high precision instruments needs almost ideal operational amplifiers. Effects of offset, common mode rejection ratio (CMRR) and other imperfections have to be reduced as much as possible. One way is to apply precision operational amplifiers but their parameters are limited and their price is high. Another approach is to use composite amplifiers proposed in this text. Instead of a single operational amplifier, composite amplifiers are built from two or more operational amplifiers with significant improvements in resulting parameters.

This topic is not covered in the literature and in usual analog electronics courses so finished students could have problems in their professional carrier. This material could be included in undergraduate or graduate lectures and laboratory practice to open new ideas in construction of precision analog circuits.

2. Construction of Composite Amplifiers

The idea is to combine two or more operational amplifiers to achieve the common mode rejection ratio (CMRR) of the composite amplifier higher than for a single operational amplifier (Horowitz & Hill, 2017) (Mancini, 2001). Adjusting the power supplies of the operational amplifier, the common mode (CM) input voltage could be eliminated. This could be done with the composite amplifier (Radetić, 2014) in Fig.1.

The first operational amplifier (IC1 - OP37) is with low offset voltage (<50 μV). Its CMRR is over 120 dB. This will insert, for input CM voltage of 1 V, change of the input offset voltage for 1 μV. We want to reduce this component even more. To achieve that, we introduced power supply voltages with floating ground voltage equal to the input voltage (U_I). The floating ground voltage is achieved by another operational amplifier (IC2 - TL081) adjusted to a unity gain amplifier.

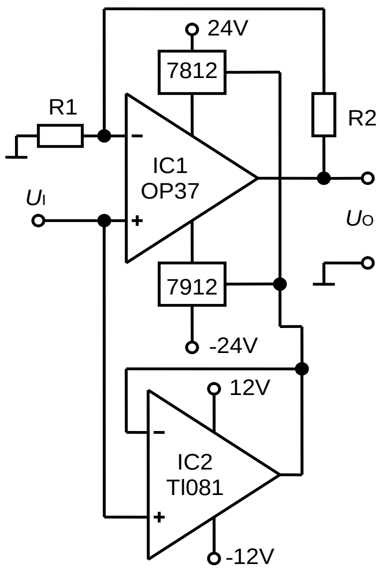

Fig.1. High CMRR composite amplifier with two operational amplifiers.

There are no special requirements for this amplifier, only its speed has to be acceptable and its bias current has to be low to follow well the input voltage and do not impose significant loading on the source of the input signal (its input bias current is about 100pA).

For this composite amplifier, the offset voltage component for IC1, caused by CMRR is:

$$\left|\Delta U_{I,CMRR,IC1}\right| = \frac{U_{I,CMRR,IC2}}{CMRR1} = \frac{U_I}{CMRR1}\left(\frac{1}{CMRR2} + \frac{1}{A_{0,2}}\right) \quad (1)$$

This way the resulting CMRR for this composite amplifier is:

$$CMRR = \frac{U_I}{\left|\Delta U_{I,CMRR,1}\right|} = \frac{CMRR1}{\frac{1}{CMRR2} + \frac{1}{A_{0,2}}} = \frac{CMRR1 \cdot CMRR2 \cdot A_{0,2}}{A_{0,2} + CMRR2} \quad (2)$$

Resulting CMRR for the composite amplifier is now very high, about 200 dB. Besides the error voltage caused by CMRR, there is an error component caused by high but limited gain of IC1.

The output voltage is not referred to real ground (it is referred to the floating ground). It is calculated as:

$$U_O = U_I + \frac{R_2}{R_1}U_I = U_I\left(1 + \frac{R_2}{R_1}\right) \quad (3)$$

Referred to the floating ground of the supply voltages, the output voltage is:

$$\Delta U_O = \frac{R_2}{R_1}U_I \quad (4)$$

This voltage inserts to the input of IC1 the following voltage:

$$\left|\Delta U_{I,A_0}\right| = \frac{\Delta U_O}{A_{0,1}} = \frac{U_I}{A_{0,1}}\frac{R_2}{R_1} \quad (5)$$

This voltage has the same order of magnitude as the error caused by CMRR. Elimination of this voltage is also desirable.

Consider now the amplifier in Fig.2 (Mancini, 2001). By this circuit, the output of IC1 is on the same potential as its input, so there is no unwanted feedback caused by the limited gain A_0 of this operational amplifiers. To achieve stability, it is necessary to add a local feedback on operational amplifier IC3.

For DC voltages the output voltage of IC1 is equal to the input voltage, augmented by offset voltages of IC2 and IC3. The input offset voltage component of IC1, caused by CMRR is:

$$\left|\Delta U_{I,CM}\right| = \frac{U_{I,OP2}+U_{I,OP3}}{CMRR1} = \frac{1}{CMRR1}\left(U_{I,OP2}+U_{I,OP3}\right) =$$
$$= \frac{1}{CMRR1}\left(\frac{U_I}{CMRR2}+\frac{U_I}{A_{0,2}}+\frac{U_I}{CMRR3}+\frac{AU_I}{A_{0,3}}\right) = \qquad (6)$$
$$= \frac{U_I}{CMRR1}\left(\frac{1}{CMRR2}+\frac{1}{A_{0,2}}+\frac{1}{CMRR3}+\frac{A}{A_{0,3}}\right) \approx \frac{U_I}{CMRR1}\frac{A}{A_{0,3}}$$

The resulting CMRR is now:

$$CMRR = \frac{\left|\Delta U_{I,CM}\right|}{U_I} = \frac{1}{CMRR1}\left(\frac{1}{CMRR2}+\frac{1}{A_{0,2}}+\frac{1}{CMRR3}+\frac{A}{A_{0,3}}\right) \approx \frac{1}{CMRR1}\frac{A}{A_{0,3}} \qquad (7)$$

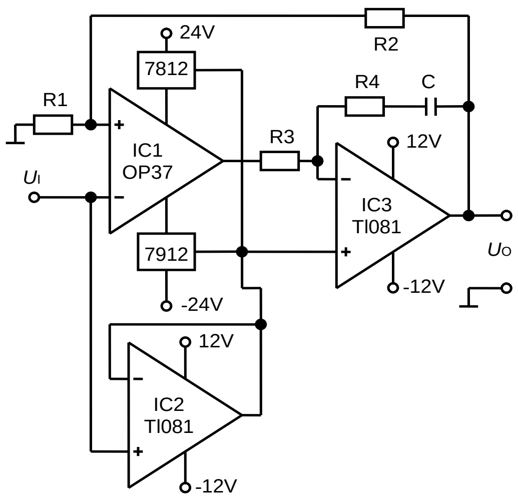

Fig.2. High CMRR composite amplifier with three operational amplifiers.

This way the voltage component of the input offset voltage, caused by input CM voltage of IC1, is eliminated up to such level that the CMRR value for the composite amplifier is over 200 dB.

Open loop voltage gain of the composite amplifier for DC is equal to the product of gains of operational amplifiers IC1 and IC3:

$$A_0 = A_{0,1}A_{0,3} \qquad (8)$$

3. Simulations

Simulations of the suggested composite amplifiers are done in software LTSpice (Analog Devices). The simulation model is shown in Fig.3. High open loop voltage gain for DC voltages is achieved, A_0>200dB. The 3 dB bandwidth of the open loop gain is 1 mHz. For a closed loop amplifier with gain *A*=1000, the 3dB badwidth is over 20 kHz as shown in Fig.4.

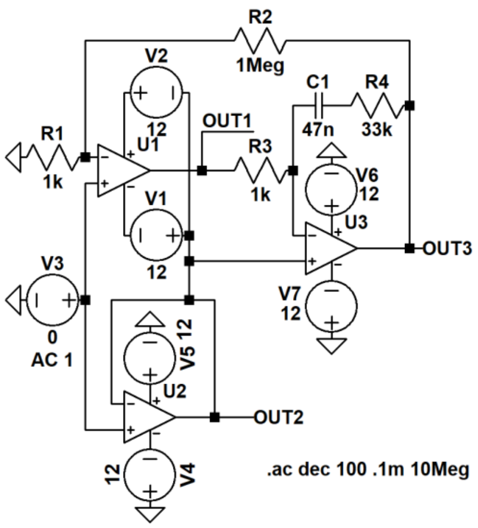

Fig.3. LTSpice simulation model for high CMRR composite amplifier in Fig.2.

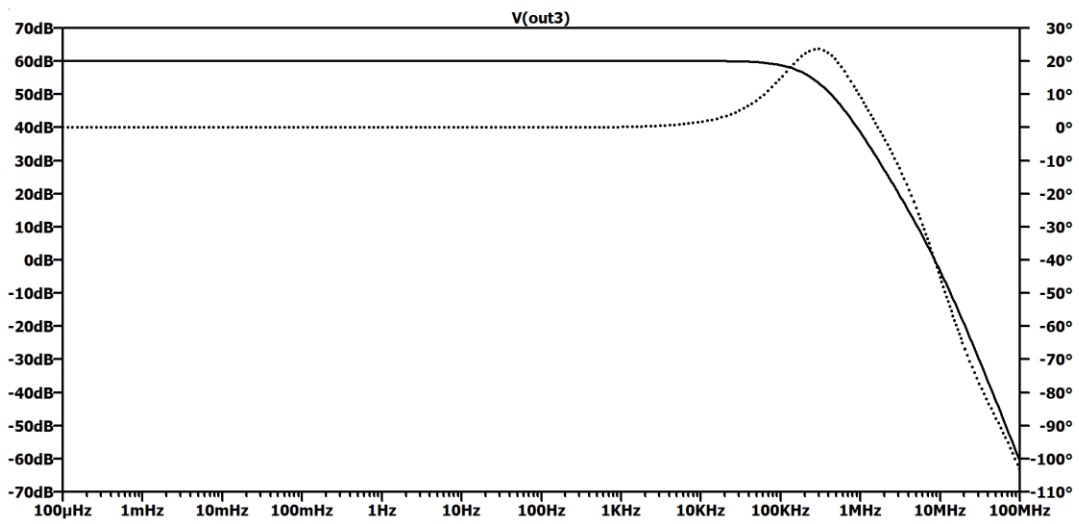

Fig.4. Gain and phase characteristics of the composite amplifier in Fig.2.

4. Measurements

The composite amplifiers are built according to schematics in Fig.1 and in Fig.2. Stability of the local feedback loop in Fig.2 is obtained.

CMRR of the composite amplifier can be measured according to the setup in Fig. 5. OP stands for the composite amplifier under test, OP1 is an auxiliary amplifier closing the feedback loop. Input voltage is changed by a switch from -0.5V to +0.5V. Output voltage of the composite amplifier is forced to 0 V by the auxiliary amplifier. Capacitor 100 pF stabilize the feedback loop. Voltage measurement have to be done between test points in the figure. Change of this voltage, by change of input voltage, represents the amplified input CMRR voltage component:

$$\Delta U_O = A\frac{\Delta U_I}{CMRR} \text{ which gives: } CMRR = A\frac{\Delta U_I}{\Delta U_O} \quad (9)$$

For A=1000 and ΔU_I=1V, CMRR=1000/ΔU_O. For example, operational amplifiers OP07 shows ΔU_O=5mV so its rejection ratio is 200 000 or CMRR(dB)=106 dB.

This measurement can be done with an ordinary millivoltmeter available in school laboratories. Precise measurement of much higher CMRR values, typical for the composite amplifier, is not so straightforward but the significant improvement can be detected.

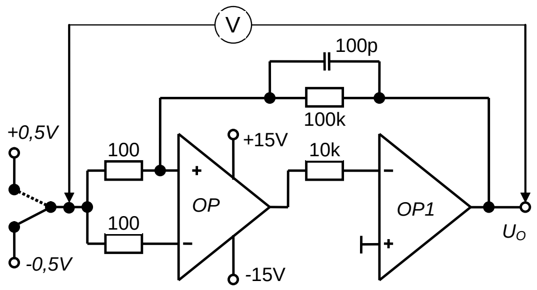

Fig. 5. Test circuit for measuring CMRR of operational amplifier OP.

5. Conclusions

Composite amplifier with extremely increased CMRR (CMRR>200dB) and high open loop gain is obtained (A_0>200 dB). The resulting amplifier is with low noise and with low offset voltage (<50 μV). Even the frequency band is improved. Tests of the ideas introduced here are done with free simulation software and ordinary laboratory equipment available for courses in analog electronics. Based on the acquired knowledge gained with high precision systems like the one presented in this paper, the students will be able to design, simulate, and use the acquired knowledge and skills in practice. They can build more complex electronic circuits with the application of composite operational amplifiers.

References

Horowitz, P. & Hill, W. (2017). The Art of Electronics. Cambridge: Cambridge University Press.

Mancini, Ron (2001). Op Amps for Everyone, Texas Instruments

Radetić, R. (2014). Operacioni pojačavači sa zbirkom šema, M Kops centar, Niš.
Analog Devices. Circuit Design Tools & Calculators, http://www.analog.com/en/design-center/design-tools-and-calculators.html [20.11.2018]

Short professional biography

Radojle Radetić was born in 1957 in Buđevo, Serbia. Graduated at Faculty of Technical Sciences in Novi Sad in 1981, master thesis done at Electrotechnical Faculty in Belgrade in field of power electronics, doctor thesis done at the Faculty of Technical Sciences in Novi Sad in electrical measurement. From 1981 to 1987 was working in the Department of Power Converters at Faculty of Technical Sciences. From 1987 to 1999 was working in Research Centre of the Copper Institute in Bor, was developing power electronic and electrothermal equipment, electrochemistry and measurement devices. From 1999 is with Serbian Distribution Company – Department in Bor. Owner of several awards for his outstanding work. Built numerous instruments and apparates in the given fields. Author of over 60 scientific articles. Author of over 10 text books.

Nándor Burány was born in 1958 in Ada, Serbia. Graduated at Faculty of Technical Sciences in Novi Sad in 1982, master thesis and doctor thesis done at Electrotechnical Faculty in Belgrade in field of power electronics in 1990 and 2008 respectively. From 1982 to 1991 was working in the Department of Electronics at Faculty of Technical Sciences. From 1993 he is with the Technical Engineering College in Subotica giving lectures in electronics courses. Author of over 30 scientific articles. Built numerous instruments and apparates in field of analog electronics and power electronics.