Self-Directed Learning and Flip Teaching
Electric Circuit Theory Case Study

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INTRODUCTION

In the era of dynamic development of Information & Communication Technologies (ICT), their use in education is ubiquitous.
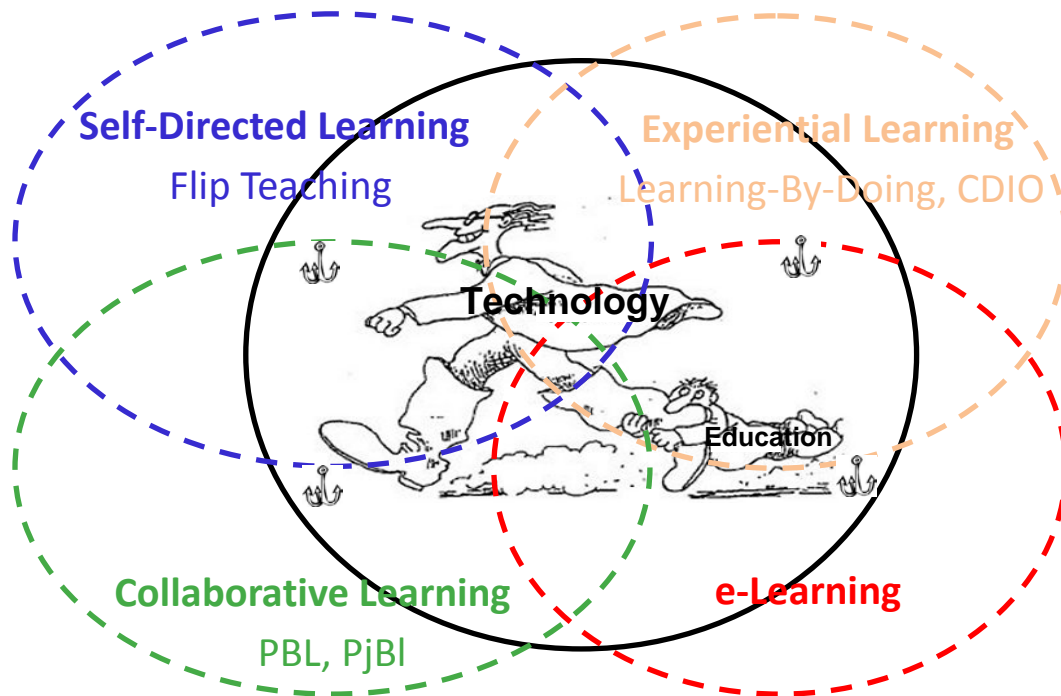

Fig. 1. Technology Enhanced Learning

The ICT, properly used, may significantly contribute to the quality of education, enable development of new forms of Technology Enhanced Learning (TEL), such as:

- e-learning,
- Collaborative Learning: Project Based Learning and Problem Based Learning,
- Experiential Learning: Learning-by-Doing; CDIO,
- Self-Directed Learning (SDL) and Flip Teaching,

as depicted in Fig.1. Thanks to ICT development we are at the heart of a global learning revolution. The act of learning itself is no longer seen as simply a matter of information transfer, but rather as a process of dynamic participation in which students cultivate new ways of thinking and doing through active discovery and discussion [1]. They migrate toward SDL experiences on computer and Internet. Then, an immediate attention to the conduct of teaching has to be given, such that both students' and teachers' expectations are met, worlds of "digital natives" (students) and "digital immigrants" (educators) merge. All four forms of TEL are strongly overlapping and sustainable development is essential. However, following literature reports, it looks that SDL is the most undervalued and promising form - it is predicted that by year 2020, all learning will be based on principles of SDL. Nowadays, video-recording of lectures is growing in significance. Such recordings create podcasts for playback on PCs and portable media players and enable new format of SDL called Flip Teaching (FT). In FT, also known as backwards classroom, reverse instruction, flipped classroom or reverse teaching, the student first studies the topic by himself, using podcasts created by the teacher. In the classroom, the student then tries to apply the knowledge by solving problems, together with the teacher and peers. That way, the traditional classroom evolves into discussion forum direction, assignment of Bloom's taxonomy layers [2] to classroom activities and homework activities is reversed. In Section 2, a brief overview of SDL and FT is presented, general definitions and conditions necessary for successful application are given, main benefits and challenges of both are underlined. In Section 3, the Electric Circuit Theory case study is presented. Some 200 students, of the 1st and 3rd semester have been involved in the experiment, with FT as the only and obligatory form of teaching. The paper main objective is an attempt to prove that FT works, that SDL is the ultimate way to go, regardless difficulties faced at the introductory stage.

1. Self-Directed Learning and Flip Teaching

In majority of universities all over the world, lecture is the core component of a course, supported by classes and labs. The traditional way of lecturing with active lecturer standing in front of the students, delivering information relevant to the lecture content, using blackboard or slide (ppt) presentation and passive students, except for note-taking, today, with the advent of ubiquitous ITC, is absolutely not acceptable. Traditional lecturing is strongly criticized and new forms of lecturing, attractive for today's students have to be developed. The students, "digital natives" for whom learning itself is no longer seen as simply a matter of information transfer, but rather as a process of dynamic participation, in their majority rarely attend lectures or don't attend them at all. As reported in [3], only 16% of the case study students attend lectures regularly, 26% don't attend lectures at all – the first group has been called "Angels", the second "Ghosts". Application of the ICT enhanced SDL is foreseen as the best way of redevelopment of the traditional lecturing. What is SDL? In SDL, the individual takes the

initiative and the responsibility for what occurs. Individuals select, manage, and assess their own learning activities, which can be pursued at any time, in any place, through any means. The process of redevelopment of traditional learning into the SDL format is very flexible. The following eight underlying factors determine the readiness for this redevelopment [4,5]:

- Love of learning
- Self-concept as an effective independent learner
- Tolerance of risk, ambiguity and complexity in learning
- Creativity
- View of learning as a lifelong, beneficial process
- Initiative in learning
- Self-understanding
- Acceptance of responsibility for one's own learning

Teachers can work toward SDL a stage at a time and four stages can be distinguished:

1. Learners of Low Self-Direction: formal lectures emphasizing subject matter.
2. Learners of Moderate Self-Direction: lecturer as inspiring performer, teacher-led discussion.
3. Learners of Intermediate Self-Direction: seminar, student group project facilitated by the teacher.
4. Learners of High Self-Direction: term project, independent study, dissertation [6].

When lecture redevelopment is in force, then second stage is the target one. The literature on SDL asserts many benefits of this form of learning, especially when properly supported by the ICT, the following, among others [7]:

- SDL views learners as responsible owners and managers of their own learning process.
- SDL recognizes the significant role of motivation and volition in initiating and maintaining learners' efforts.
- SDL is, ironically, highly collaborative. Learners collaborate with teachers and peers.
- SDL develops domain-specific knowledge as well as the ability to transfer conceptual knowledge to new situations.
- Self-directed learners demonstrate a greater awareness of their responsibility in making learning meaningful and monitoring themselves.

The most valuable ICT support to SDL are e-materials and especially video-recordings of lectures. Historically, two basic models of such podcasting can be distinguished:

1. Substitutional: live recordings of entire f2f lectures, recorded in the lecture room.
2. Supplementary: short, 5 to 10 minutes podcasts providing additional material, recorded in the studio,

The third, relatively new model of FT, also uses short podcasts of single concepts, however their use is reversed with respect to f2f presentation. The first study on the FT have been reported some 20 years ago, its boom began in 2006, thanks to Salman Kahn. His non-profit Academy, educational website (https://www.khanacademy.org), provides some four thousand short video-tutorials of miscellaneous issues, originally in English, with translations to many other subtitled languages. The FT inverts traditional teaching methods, delivering theoretical content online, outside of class, and moving problem solving into the classroom. That way assignment of bottom layers of Bloom's taxonomy [2] to homework activities and classroom activities is reversed, as depicted in Fig.2. Students watch lecture podcasts at home, at their own pace - remembering and

partially understanding is a homework that precedes classroom f2f discussion. Then, concept engagement: fully understanding, applying and analyzing, takes place in the classroom with the help of the teacher. The teacher's role changes from **Sage on the Stage,** in the Traditional Classroom, to **Guide on the Side,** in the Flipped Classroom [8].
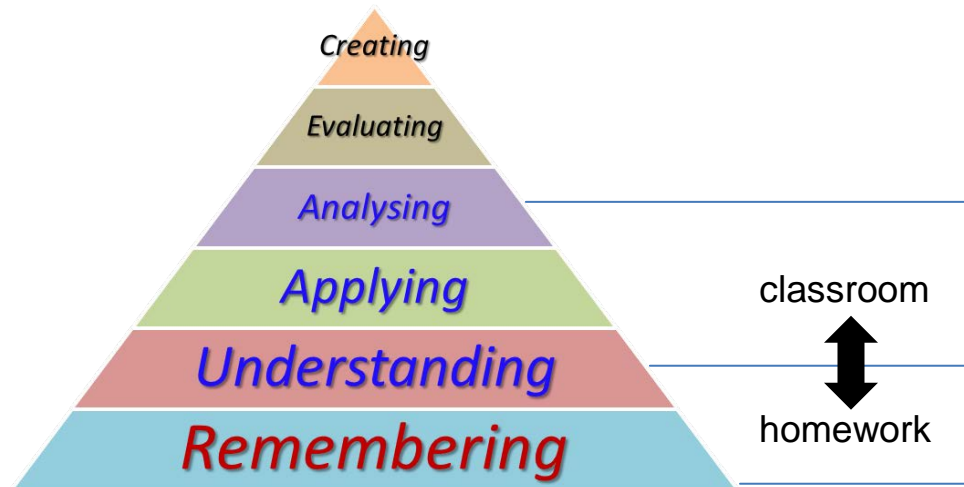

Fig. 2. Revised Bloom's taxonomy [2]

The main benefits of lecture redevelopment into the FT model, for both students and teachers, are as follows:

- Students learn at varying speed and are provided opportunities for review, they take ownership of their learning, are actively working with peers. Materials are ready and prepared for students who are absent or sick.
- Teachers spend more time supporting students with practice, are involved with students learning rather than lecture, are not spending extra hours tutoring and re-explaining to students who didn't understand the theoretical content.

Fostering interaction with content, teachers and peers, enhancing quality of learning at the same time, is evidently the main benefit of the FT. The FT model proves the commonly accepted thesis of the ICT enhanced learning: the real power of interactive ICT is that they let us learn in ways that aren't otherwise possible or practical.

2. Electric Circuit Theory Case Study

The Electric Circuit Theory (ECT) lecture has been fully redeveloped into the FT model in the academic year 2012/2013. This model became obligatory for all ECT students of the Faculty of Automatic Control, Computer Science & Electronics: 102 freshmen taught in Polish (1P), 54 freshmen taught in English (1E) and 49 third semester students also taught in English (3E). This redevelopment has been preceded by more than one year of preparations. The following preceding steps have to be completed to successfully adopt the FT model.

- Lecture redevelopment into the modular structure.
- Preparation of e-materials, video-recording of all modules that explain theoretical topics, ppt slides, animations and simulations
- Preparation of comprehensive bank of questions, with special attention paid on practical problem solving.

Modularity of components of online learning is essential for the FT development. Modularity means not only presentation of lecture content in the block diagram form but also designation of main links between modules-blocks. Modularity enable learners to construct understanding by connecting information to prior knowledge, provide them with frameworks for how concepts relate to main idea of a course and each other, enable successful learners to develop mental models and strong frameworks of related concepts, allowing them to access information more quickly and easily. The block diagram for DC Analysis (10 lectures), with hyperlinks to video-podcasts (15 out of 26 modules), is presented in Fig.3.
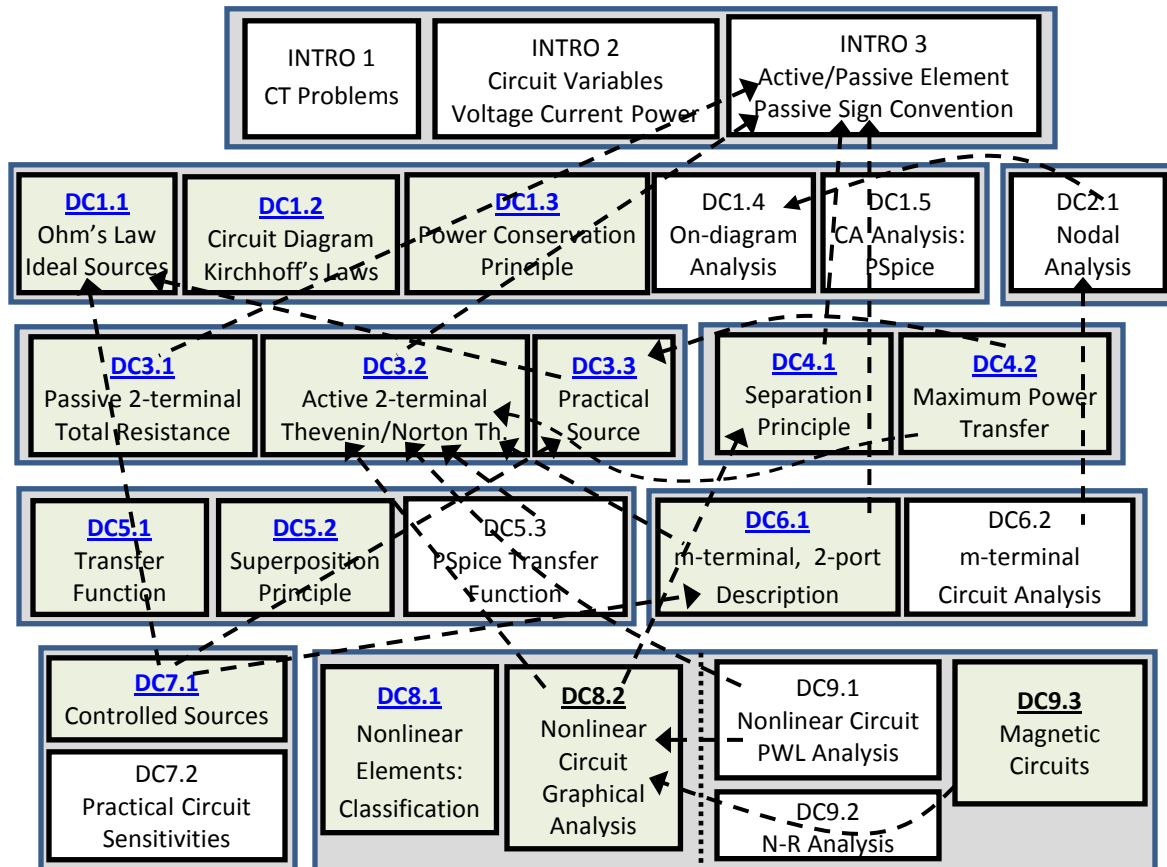

Fig. 3. Modular structure of ECT lecture, Part 1. DC Analysis

The complete set of e-materials supporting the ECT lecture, all in English, consist of:
- Studio video-recorded 5-10 min podcasts of individual modules with Polish subtitles: 36 podcasts out of 69 modules.
- Slides (ppt) with theoretical content: average 50 slides per lecture, total of around 1200 slides.
- Slides with problems, to be discussed f2f, including slides with links to computer animations and simulations (PSpice), screenshots of simulation responses: total of around 700 problems, 1500 slides. Solutions to all problems are given, for around 50% of them step-by-step reasoning is also given.

The podcast is created by three streams: camera recorded video, microphone recorded audio (image and voice of the teacher) and computer presentation (slide image) - Adobe
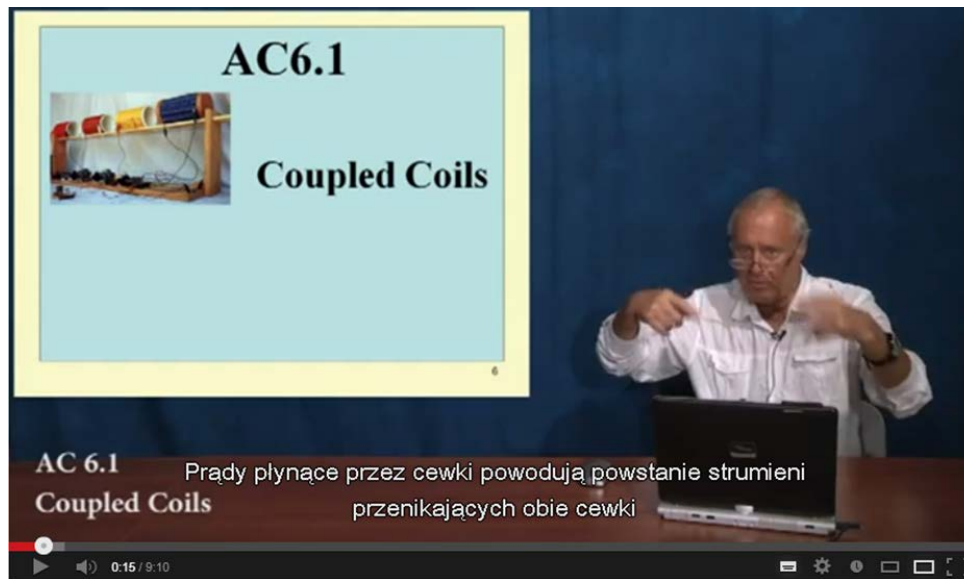
CS5.5 Premiere, Audition software is used. Layout of the podcast screen is presented in the Fig.4 screenshot.

Fig. 4. Podcast screenshot

The Author's intention is to make all these materials accessible not only to own students but to all members of Internet community. The podcasts are uploaded on YouTube video-sharing website while slides are uploaded on Google Drive file storage service. The links are displayed on Author's personal blog (http://professorrnr.blogspot.com), podcasts can be watched online, slides can be watched online or/and downloaded.

All 205 ECT students have been surveyed after the winter semester, before the examination session. At first, the attendance have been investigated. From 50% (1E) to 61% (1P) of freshmen confirmed regular attendance, with only 20% (3E) students. This confirms the Angels-Ghosts distribution for non-freshmen [3]. Then, students have been asked to evaluate usefulness of e-materials. From 80% to 90% confirmed reading e-slides, from 45% to 75% confirmed watching podcasts. Students' answers to the survey question: "podcasts/slides help in understanding" are presented in Fig.5a/5b. Students that have chosen "not sure" are students that have declared their disinterest to e-materials. They evidently belong to "I don't like learning" community, don't want to study any materials during the semester. Then, (strongly agree + agree)/(strongly disagree + disagree) ratio *R* has been calculated, as presented in Fig. 5.
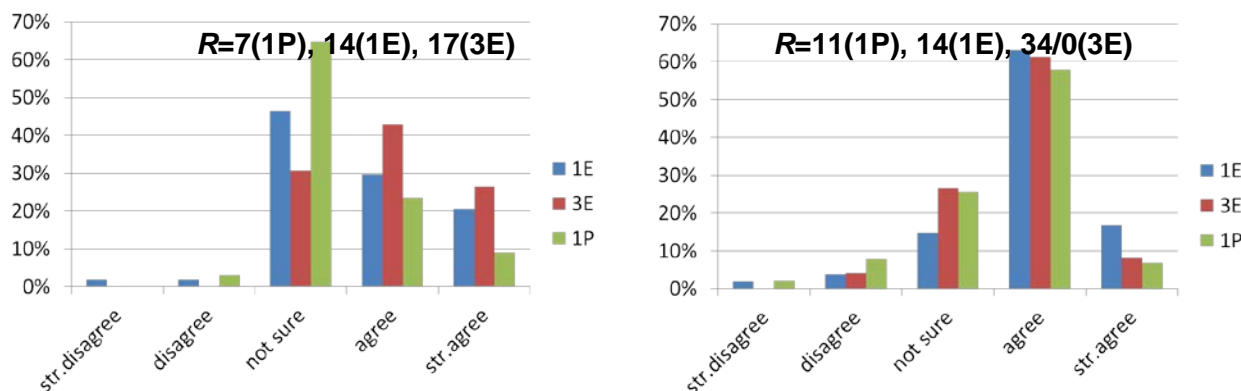
Fig. 5a. podcast usefulness   *Fig. 5b. slides usefulness*

Evaluation of acceptance of FT is presented in Fig. 6. As can be observed, freshmen are more skeptical to FT, (1P) students are the most skeptical. This confirms their attachment to traditional learning and resistance to innovation, unreadiness to accept SDL and FT. Improvement of students' SDL Readiness (SDLR) [4,5] is a long-term process and a big challenge for educators, especially for those that start this process and teach freshmen. According to Rogers theory [9], diffusion of innovation, among both teachers and students, is the staggered process.
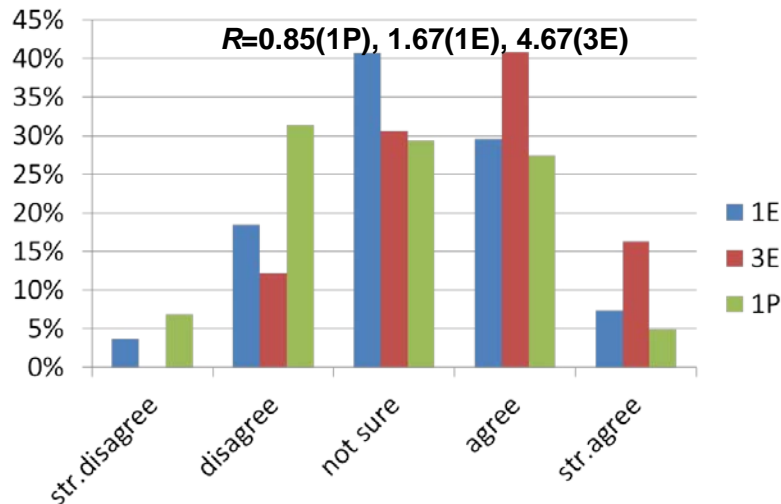

Fig. 6. Students' acceptance of Flip Teaching

Watching video-podcasts tonight, discussion forum f2f today is the ideal model of FT and the target stage of ECT lecture redevelopment. At the intermediate stage, short revision of topics delivered through video-podcasts is necessary. The ECT lecture is generally delivered to freshmen and giving up their habit of Traditional Classroom, acceptance of new model of teaching, is a big problem and challenge for the teacher. It has to be assumed that freshmen's SDL Readiness [4,5] is not satisfactory. Then, the following question could be formulated: "Is it any sense in replacement of Traditional Classroom by Flipped Classroom if students' SDLR is not satisfactory?". Such question is false and the following true question should be formulated instead: "How to convince students to give up bad habits and accept all eight factors of SDL, "love of learning" especially?". The Authors do not pretend to give a definitive answer to this question. Improving attractiveness of e-materials and their presentation has been pointed out by the students as the best remedy [10]. The attractiveness may be improved by:

- solving practical engineering problems when explaining theoretical topics, engaging of students to f2f discussion, motivating them to more active participation,
- increasing number of interactive animations and simulations – students are digital natives, in their majority they are computer-game addicts and appreciate moving pictures that can be manipulated by them.

4. Conclusions

Redevelopment of the Traditional Classroom model into the FT model has been discussed. Some guidelines have been given for both preparatory steps and future

steps necessary to leave the introductory stage, reach all benefits of the FT. It has to be clearly stated, that the described research is in progress. The effect of online videos and FT on lecture attendance and exam scores has not been statistically investigated. After the first semester of this new model being in force, no significant changes have been observed. Numerous authors [11] report enhancement of learning outcomes, none of them study this enhancement in conjunction with SDLR improvement. It is the Authors' conviction, that improvement of SDLR is essential. If high level of SDLR is reached, and only then, great benefits of FT: significant improvement of students satisfaction and performance, could be obtained. Then, at the introductory stage, monitoring of students' satisfaction and improvement of SDLR, seems more important than measuring FT impact on exam scores. This thesis require confirmation by the future research.

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