

Pre-Lecture Preparation As a Key-Component in Achieving the Goals and Objectives of IT Teaching: A Case of Networks-on-Chip

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Abstract — This paper is dedicated to pre-lecture preparation of Russian-speaking L2 students learning IT disciplines (in particular, “System Design of Digital Devices”) in English. Goals and objectives of IT teaching (acquisition of theoretical and practical skills in the development of networks-on-chip) are described. The peculiarities of Content and Language Integrated Learning, providing integration of language learning with content learning, are presented. Pre-lecture preparation practices, based on pre-lecture resources in networks-on-chip, scaffolding instructional techniques, and Project-Based-Learning technology support, are considered. The stages of pedagogical experiment (ascertaining, forming, and comparative ones) are described; obtained results undoubtedly prove the effectiveness of the method proposed.

Keywords — IT lecturing; network-on-chip development; pre-lecture preparation of L2 students; Content and Language Integrated Learning; Project-Based-Learning; pedagogical experiment.

I. INTRODUCTION

Lectures are still a very common form occurring even in very up to date higher and further educational environments. Lecturing involves the presentation of a detailed information pack of material to be covered, as well as a great deal of teaching and learning activities, setting a solid foundation for educational process as a whole [1].

One of the key components of these activities should be pre-lecture preparation which typically consists of a learning resource and short assessment, completed by students prior to the lecture, and helps them to understand new concepts and to ensure that they are ready to take in new terminology; different types of pre-lecture activities can be used (annotated screencasts, student created content, collaborative annotation, animations, podcasts, open educational resources, curated resources, and so on).

The need for pre-lecture activities is especially vivid when considering problems of L2 students who have to not only master educational subjects (for example, IT disciplines), but also a foreign language and, moreover, such its functional

variety as a scientific style of speech, or language of science [2–3].

Virtually, even in case when students were taught in their native language, the overall effect of the implementation of pre-lectures was a more appropriate level of teaching, lowering of the failure rate of first year students, and significant reduction of the gap between students with and without the background knowledge [4].

As for pre-lecture activities with L2 students taking part, it should be implemented within Content and Language Integrated Learning (CLIL) which involve an attempt to integrate language learning with content learning, usually by careful coordination of both types of input, or by focusing on the acquisition of skills needed to cope with both areas [5]. According to [6], there are several important points to be mentioned in the context of CLIL, namely: CLIL should not be perceived as an approach to language teaching and learning, because it is important to pay attention to both content and language; in CLIL, content and language are learnt in an integrated way, and the two subjects are related to each other and dealt with as a whole; in CLIL, another language is used to teach and learn content subjects, i.e. it is the medium of instruction. It should also be noted that there are 5 dimensions or reasons for introducing CLIL in schools and universities in order to strengthen the teaching and learning at these institutions: culture dimension – to build intercultural knowledge, understanding and to develop intercultural communication skills; environment dimension – to prepare for internationalization, integration, and access to International Certification; language dimension – to improve overall target language competence and to develop oral communication skills; content dimension – to provide opportunities to study content through perspectives and to access subject-specific target language terminology; learning dimension – to complement individual learning strategies and to diversify methods and forms of classroom practice. The above mentioned dimensions are good reasons for introducing CLIL into formal education, and all of them should be taken into account during pre-lecture preparation of L2 students learning IT disciplines.

II. GOALS AND OBJECTIVES OF IT TEACHING

Pre-lecture preparation is highly correlated with goals and objectives of IT teaching which can be exemplified by working program of the discipline “System Design of Digital Devices” [7]. According to the program, the goals and objectives of the discipline are: acquisition of theoretical and practical skills in the development, design, and programming of digital systems (portable systems, control systems and control, video / audio systems, networks-on-chip, etc.); training in digital synthesis using CADs, such as Altera Quartus II and ModelSim; studying of Verilog hardware design language (HDL) for design of digital systems.

The learners should have sufficient knowledge about existing approaches to the description of digital-systems, basic methods of their mathematical analysis and synthesis, processor core design, theoretical basis and hardware of FPGA, and basics of systems-on-chip design.

Learners’ practical skills, which they acquire through ongoing and specific training, can be referred to presentation of digital system as a hierarchy of individual modules, description of digital system modules in the form of digital machines, development of hardware and software parts of the system on a chip. Besides, they should have an experience in synthesis of MIPS processor cores [8], design in specialized software Altera Quartus II, synthesis of Nios II processor core in Qsys system integration environment and its programming in Nios II Software Build Tools for Eclipse [9], working in ModelSim modeling environment, and designing of digital systems in Verilog HDL.

As a result, students are capable to design individual software and hardware components of automated systems for collecting, processing, transmitting, and storing information, as well to develop applied software for computing means and systems of various functional purposes. They implement these tasks through execution of practical work on the computer using soft-processor cores and prototyping.

One of the key competencies, stipulated by descriptors of the working program, is closely connected with learners’ ability to use information retrieval systems for finding additional information so that the tasks, requiring study of special literature on the hardware and software, could be properly implemented. It is this ability which students’ pre-lecture preparation should be based on.

III. PRE-LECTURE PREPARATION OF L2 STUDENTS

The problem of teaching IT disciplines to L2 students, whose native language is Russian, is stipulated by the fact that most of professional literature on advanced development and new technologies is written in foreign languages, mainly in English, German, and Japanese. The language barrier often prevents students from full acquisition of theoretical knowledge and also frightens them away from preparing for lectures because the materials, provided by the teacher, are all in a foreign language.

A typical case is the topic “Network-on-Chip Topologies” in the course discipline “System Design of Digital Devices” [7]. When lecturing an unprepared audience,

teachers face difficulties due to complexity of the notions, as well as the lack of students’ knowledge in graph theory, organization of networks-on-chip, methods of routing, and so on. Consideration of all the aspects, related to the topic, on the basis of previous lectures is also impossible because the course does not allow sufficient time for presentation of all necessary materials. In order to achieve a greater progress in studying the topic within CLIL, the following outline for L2 students is proposed.

Prior to the lecture, as part of self-preparation and a kind of pre-lecture activity, students are given theoretical information (supportive notes based on scientific articles) [10] which outlines the basic concepts of building networks-on-chip, as well as the main types of regular and irregular networks-on-chip topologies, and formulas for calculating their metrics [11]. In addition, the exhaustive information about routing algorithms in networks-on-chip is given [12]. All the materials are given in English and provided with a short glossary, as well as an additional list of key terms and their explanations in Russian. Taking into account modern preferences of students and their dislike of reading, the audience is also invited to see an introductory lecture on the topic [13]. Backed up with tutors’ help, students have an opportunity to learn pre-lecture materials through university distance learning center and other on-line recourses.

Particular care should be given to Project-Based-Learning (PBL) – a teaching approach which organizes learning around projects, where learners become active constructors of their knowledge through cooperation in solving real problems and accomplishing tasks typical for world of work [14]. In [15] a series of insights are offered in the context of the use of wikis in project-based learning in higher education. In [14] as a technology support for PBL, the adoption of GitHub in a specific course, related to the teaching of emerging technologies employed for the development of apps for Android devices, is described.

Within the pre-lecture activity, PBL is applied so that learners could be able to unite in small groups of 3–5 participants and by the beginning of the lecture, to formulate and offer the optimal topology of the network-on-chip for a given number of nodes, and to think over the routing algorithm in it. Because of intra-team collaboration and extra-team competition, about 10–15% of groups independently come to topological solutions which are close enough to circulant topologies [16].

The educational materials, which students have mastered during the preparation, are fully presented at the lecture; solutions proposed are analyzed; characteristics of various topologies are given; concept of circulant topologies is introduced. Also, a comparative analysis of various topologies is carried out, and their metrics are analyzed. Although the whole course is mostly given in Russian, a number of lectures including this one, is taught in English due to scaffolding instructional techniques [17–18] used within pre-lecture preparation to move students progressively toward stronger understanding and, ultimately, greater independence in the learning process.

IV. PEDAGOGICAL EXPERIMENT

All above-mentioned activities should be carried out within the frame of a series of pedagogical experiments to validate the method proposed. A pedagogical experiment can be described as a specially organized study conducted to determine the effectiveness of the application of certain techniques or methods, and new content of education or training. Unlike studying the existing experience, using the methods that register only what already exists in practice, the experiment always involves creating a new experience in which the tested innovation should play an active role [19–20].

A. Need for a Pedagogical Experiment

It is generally recognized that the need for a pedagogical experiment can arise in the following cases.

- When new ideas or assumptions, requiring verification, are put forward.
- When it is necessary to scientifically test an interesting experience, pedagogical findings of practitioners, noticed and singled out by the researchers, and give them a valid estimate.
- When it is necessary to check different points of view or judgments about the same pedagogical phenomenon that has already been tested.
- When it is necessary to find a rational and effective way of introducing into practice a binding and recognized proposal.

B. Types of Pedagogical Experiments

The types of pedagogical experiments [21] are as follows.

1) *Natural experiment*. It is a real practical activity. It is conducted without disrupting the course of the educational or training process under the usual conditions with the usual contingent engaged.

2) *Model experiment*. It differs from the natural experiment because it is conducted in relatively strictly controlled conditions to eliminate side effects.

3) *Laboratory experiment*. It is conducted with one or more students under specially created conditions that significantly differ from the usual ones.

4) *Independent experiment*. It involves testing of working hypothesis by consistently applying the compared techniques to the same experimental group. In the course of experiment, changes, which should lead to a certain intended result, are made.

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6) *Comparative experiment*. In pedagogical experiments, as a rule, it is compared the effectiveness of various methods of teaching or training. Such experiments are called comparative, since they are always conducted on the basis of

comparison of two similar groups, one of which is an experimental group (where a new technique is used), and the other is a control group (where a conventional or other method than in the experimental group is used). Comparative experiments on the logical scheme of evidence are divided into direct experiments (a series of different exercises in the control and experimental groups, followed by the determination of the dynamics of the parameters studied), cross experiments (each of compared groups can be alternately a control group and then an experimental group) and multifactorial experiments (the factors, influencing the results of the experiment, are studied all together, varying on different conditions).

C. Purpose of the Experiments

The purpose of the experiments should be defining of means and ways for most effective pre-lecture preparation and answering the following key questions.

- Is there a strong connection between growth in IT knowledge and scientific L2 literacy?
- Is student science learning reliably associated with the use of language support tools? [22]

D. Series of Pedagogical Experiments

The series of pedagogical experiments is to include natural experiment (for the control group, where training is implemented under usual conditions), model experiment (for the experimental group under controlled conditions), independent experiment (to compare different techniques used in the experimental group), and comparative experiment (to compare results obtained in control and experimental groups).

E. Preparation for Experiments

Preparation for the series of experiments [21] consists of a number of tasks.

- Selection of the required number of experimental objects (number of students, groups, etc.).
- Determination of necessary duration of the experiment: a too short period leads to an unjustified exaggeration of the role of a particular training tool, while a too long a period may distract a researcher from solving other research tasks and increase labor intensity of the work.
- Selection of specific techniques for studying of the initial / final state of experimental facilities (questionnaires, interviews for creating appropriate situations, peer reviewing, etc.).
- Determination of characteristics by which it is possible to judge the changes in the experimental group caused by corresponding pedagogical influences.
- Group membership and level of skills (which should be preferably the same).
- Instructing of experiment participants about the procedure and conditions for effective conduct of the

experiment (especially when it is conducted by more than one teacher (IT teacher and probable L2 teacher)).

- Fixing the data part way through the experiment based on intermediate tests characterizing the changes in students' skills while experimental influences.
- Indication to possible difficulties and typical shortcomings.
- Estimation of current expenses of time, means, and efforts.

F. Participants

The 2 groups (control group and experimental group) of 2016 / 2017 fourth year students in the "Information Science and Computation Technology" Bachelor's Program at Higher School of Economics Tikhonov Moscow Institute of Electronics and Mathematics (MIEM HSE) were purposively chosen for the study. Number of participants – 92 (46 students in each group, respectively).

G. Data Collection

Data was collected from: a) interviews on the content of pre-lecture resources; b) completed projects within pre-lecture preparation; c) testing of students' academic progress, and d) teaching quality assessment which gives students a chance to express their opinion on the quality of educational process.

V. RESULTS

The pedagogical experiment included 3 stages: ascertaining, forming, and comparative ones.

1) *Ascertaining stage.* At this stage, students' IT skills and L2 competence were tested. In control group and in experimental group, they were approximately of same level.

2) *Forming stage.* The students of control group were taught under usual conditions within the frame of natural experiment. In the experimental group, the research was not limited to the registration of identified factors, but allowed us to disclose the laws of the process of education and to determine the possibilities for its optimization. Best practices of pre-lecture preparation (annotated screencasts, student created content, collaborative annotation, animations, podcasts, open educational resources, curated resources) were identified within the same experimental group.

3) *Comparative stage.* Essential skills in the discipline "System Design of Digital Devices" and L2 competence were compared both in experimental and control groups. Content test in the discipline and L2 test were performed to verify the effectiveness of proposed educational method.

The stages of experiment, groups involved, and results obtained are shown in Fig. 1.

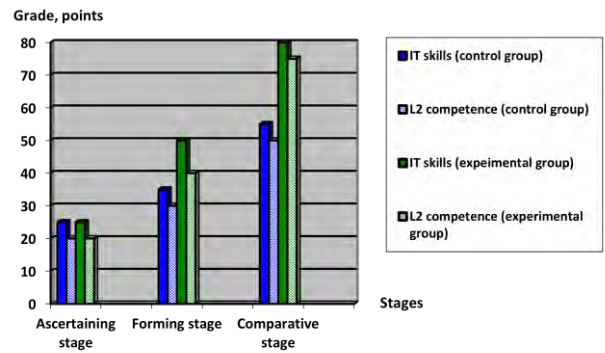


Fig. 1. Stages of pedagogical experiment and results obtained.

The results of teaching quality assessment are shown in Table 1.

TABLE I. TEACHING QUALITY ASSESSMENT GIVEN BY STUDENTS OF CONTROL AND EXPERIMENTAL GROUPS

Criteria of assessment	Grade (max. 5 points)	
	Control group	Experimental group
Clarity of requirements to students	3.79	4.21
Clarity and consistency of study materials	3.77	4.20
Communication between teachers and their audience	4.19	4.51
Teachers' availability for extracurricular discussion of any academic issues	4.47	4.88

VI. CONCLUSION

Obtained results of control and experimental groups strongly suggest that considered approach for training L2 students in IT disciplines gives a positive educational effect: the quality of IT knowledge (measured by complex test and oral exam at the end of educational cycle) and L2 skills is considerably (25 %) higher in experimental group when compared with the control group, especially at the comparative stage, upon completion of the experiment. The conducted experiments prove that there is a strong connection between growth in L2 skills and level of IT knowledge and that student science learning is reliably associated with the use of language support tools.

Higher grades, given for the quality of teaching by students of experimental group, show that pre-lecture preparation is more responsive to learners' needs; moreover, it creates additional incentives to study.

It may be concluded therefore that it is advisable to introduce pre-lecture preparation for L2 students by using most appropriate examples of pre-lecture resources, scaffolding instructional techniques, and PBL technology support to meet the goals and objectives of IT teaching.

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