Adapting University Education to a Pandemic: Flexible Programs with Branching Structure for Engineering Courses

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Abstract

In 2020, the world has been faced with a number of big problems caused by the coronavirus (COVID-19) pandemic. For reducing the losses from attacks of infection, many countries had to repeatedly introduce emergency measures, up to a complete lockdown. This situation also affected university education. When any new wave of the disease was arising, it became necessary to transit the students from face-to-face education to a distant learning.

Such a change in the educational process requires a revision of the ways of presenting the material within each course.

The specific feature of engineering courses is that not all types of training sessions can be equally easy transformed into a distant learning. This refers to laboratory work, in which students must deal with real instruments and devices. In some cases, work with real devices can be successfully replaced by a virtual study using mathematical modeling packages. However, there are sections of the course content for which the transition to virtual laboratory work does not allow the student to acquire the necessary knowledge and skills.

The proposal of the authors is to change the style of the course program in advance, making it possible to operate with flexible sequence of the topics (sections). In other words, the program should have several branches with different order of sections. When lockdown occurs and the educational process switches to distance learning format, then the course supervisor can choose other branch of the program with sections that are closer in schedule, for which the laboratory work allows virtual execution. The new order of the sections requires the introduction of special transitional lectures into the content.

Thus, the course program becomes similar to the structure of a branching algorithm, where individual branches are linked by branching rules such as "IF – THEN".

The authors have experience in implementing the university course "Electrical Engineering and Fundamentals of Electronics" with a flexible branching program.

This experience has proven to be effective and can be applied due to uncertainty caused by the incomplete predictability of pandemic attacks.

Keywords: *engineering courses, pandemic conditions, flexible branching program.*

1. Introduction

The coronavirus (COVID-19) pandemic faced the world in 2020 has affected all aspects of society. It also had a major impact on university education, giving rise to many previously non-existent problems [1-4]. In some special cases, due to the pandemic and outbreaks of disease, a few universities have been completely closed. In such a situation, the students had interruptions in their studies. But more often the response of universities to the requirements of epidemiological safety was the transition from face-to-face studies to distance education [3, 4].

The most significant role began to be assigned to online classes (lectures, seminars, laboratory work), organized in a synchronous or asynchronous mode [4]. Naturally, universities are in dire need of licensed tools and facilities for such way of teaching and learning.

The necessity of periodic usage of distance learning has shown a number of features of engineering universities [5]. Within the framework of training courses in engineering areas of study, students must acquire not only theoretical knowledge, but also practical skills and abilities. From this point of view, laboratory exercises and experiments are of great importance. Physical presence in the laboratory allows students to get acquainted with technical devices and instruments as the objects of the real world, to carry out measurements and influence directly the investigated processes.

Unfortunately, distance education significantly reduces the resulted effect of laboratory work in engineering courses. In this case, interaction with real objects is replaced by mathematical modeling based on special software packages or virtual reality systems. Such an approach is not always able to give a complete picture of the properties and behavior of technical devices in practical conditions.

For this reason, it is understandable that the engineering faculties of universities are striving to keep face-to-face format at least for part of laboratory studies. The only possibility for this is to make optimal use of the pauses between pandemic waves when lockdown requirements are some weaker. This allows students to return to the classrooms.
The teaching strategy is becoming flexible, and the curricula of academic disciplines must also be flexible.
The authors' proposals for organizing such an improvement in the educational process are described below.

2. Generating branching structures for educational programs

In the conditions of repeatedly introduced and canceled restrictions caused by the pandemic, education at the university actually acquires a hybrid nature: one part of the classes is conducted in face-to-face, and the other part is in a distance format. The task arises in such a way to plan the sequence of classes so that the transfer of many topics of the course to the category of distance learning does not lead to significant losses in the quality of education. In the context of laboratory work, this means that it is necessary to implement the following series of actions:

(i) a preliminary analysis of the course content in order to classify the sections (topics) based on the extent to which the transfer of laboratory classes from each section to distance learning will not contradict the acquisition of the necessary knowledge and skills by students,
(ii) generating various sequences of course sections (program scenarios) in relation to the set of situations under consideration, when lockdowns occur at one or another stage of the course,
(iii) development of transitional lectures which contain brief information from the course to support the transition from earlier to more distant sections of the course, bypassing intermediate sections,
(iv) assessment of the time and methodological resources required for the implementation of each of the scenarios.

The result of the work done should be the formation of the educational program of a new type, namely, a branching program. In other words, the program should have several branches with different order of sections. When lockdown occurs and the educational process switches to distance learning format, then the course supervisor can choose other branch of the program with sections that are closer in schedule, for which the laboratory work allows virtual execution.
Thus, the course program becomes similar to the structure of a branching algorithm, where individual branches are linked by branching rules such as “IF – THEN”.
Such a program structure is fundamentally different from the traditional one (‘direct’ structure), where there is only one branch, consisting of the classic sequence of sections with direct order (Fig.1, a).
Transitional lectures are the most vulnerable components in the new structure of the course program (Fig.1, b). It takes a lot of experience of teaching staff in choosing the really significant information from the course to move to more distant areas of the program. Nevertheless, all efforts are paid off by providing students with the opportunity to visit laboratories and work with physical objects (materials, devices and instruments).
In some cases, successful completion of educational tasks can be achieved by changing not only the order of the program sections, but also the order of the types of classes.
For example, when a lockdown occurs, it is possible to conduct lectures and seminars from two or three consecutive sections of the program. At the same time, laboratory work from all sections is postponed to a later date, when the restrictions on face-to-face training will be avoided.
Such options should also be analyzed in advance in the preparation of the curriculum and included in it in the form of additional branches.
It is clear that planning the implementation of the educational process, taking into account the threat of a pandemic, is forecasting under conditions of a high level of uncertainty. However, the more circumstances and response versions we can foresee, the more effective will be the adaptation of this process to interfering factors and obstacles.
It should be noted that the use of branching programs for individual courses requires coordination with the strategy of administration of the educational process within the entire university. In addition, the load of university laboratories and classrooms should be optimized during the most critical periods of time in this regard (pauses between lockdowns).

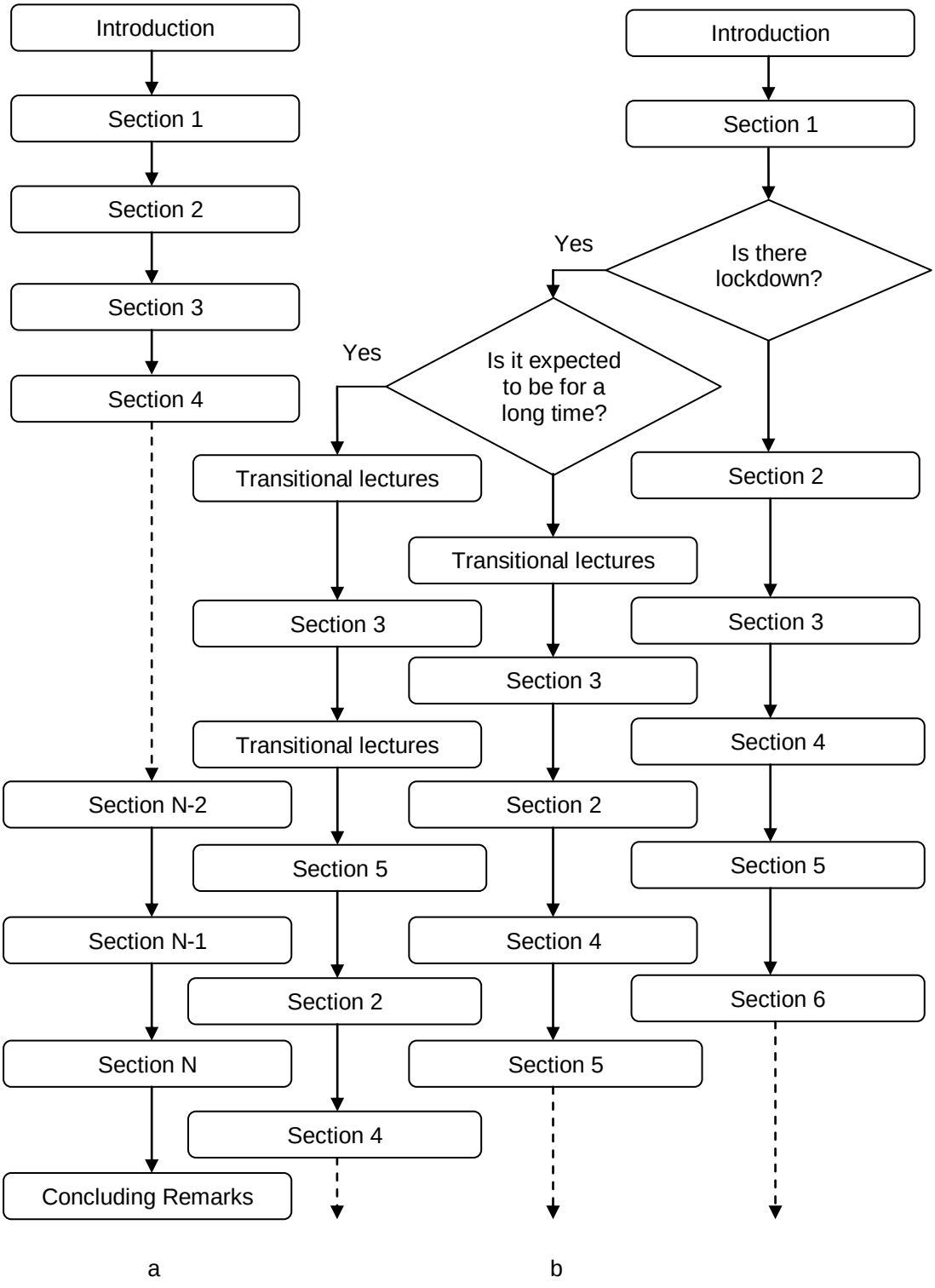

Fig.1. Examples of traditional ‘direct’ (a) and branching (b) structures of educational course program

3. Using a flexible branching program for university course "Electrical Engineering and Fundamentals of Electronics": practical experience

The authors have accumulated some experience in conducting the university course "Electrical Engineering and Fundamentals of Electronics" with a flexible branching program. It was created on the basis of traditional program with direct order of sections (Fig.2, a,b).

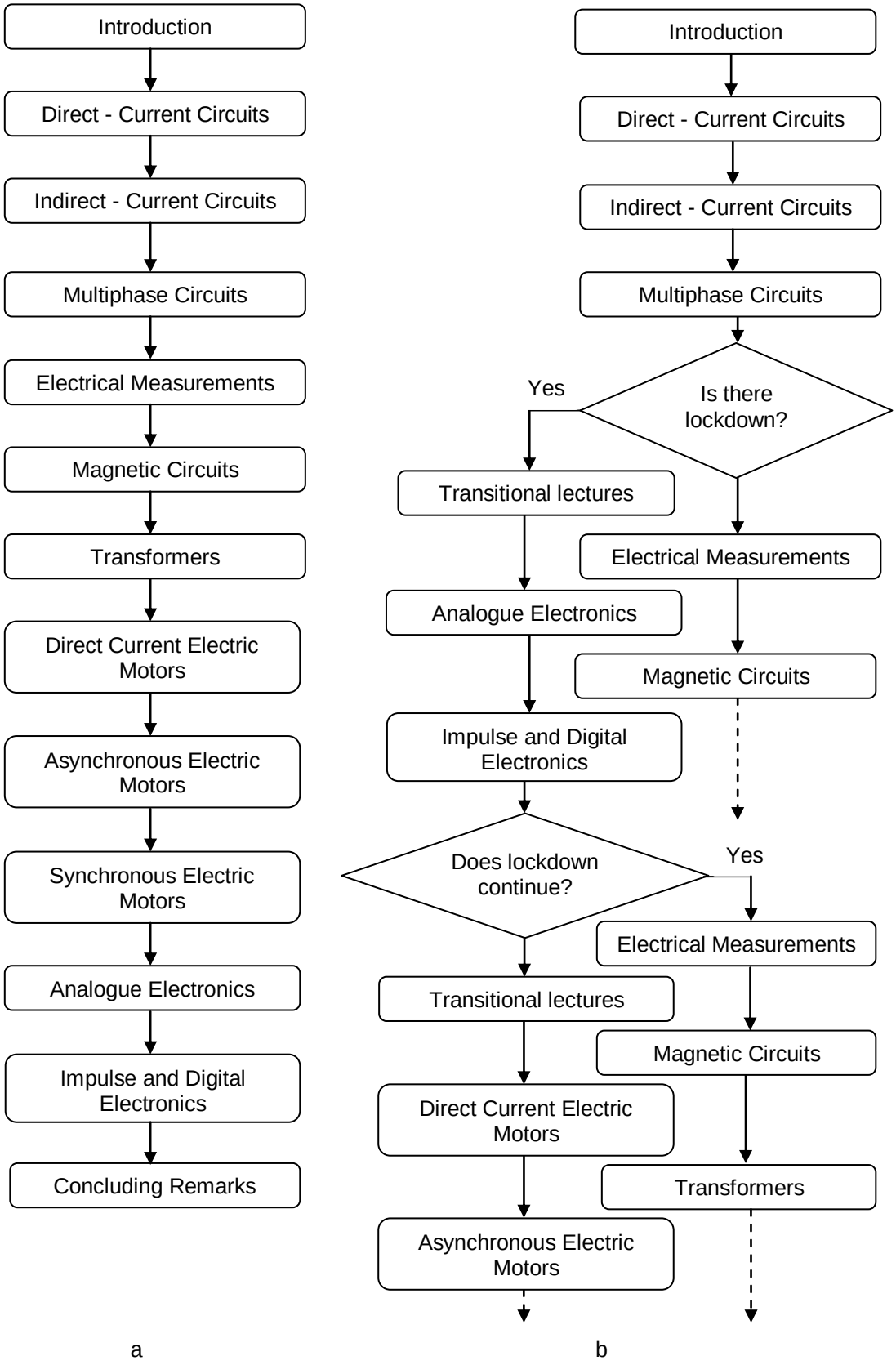

Fig.2. Traditional structure (a) and fragment of branching structure (b) for program of the course "Electrical Engineering and Fundamentals of Electronics"

The labs associated with the theory of electric circuits and electronics can be conducted successfully in virtual form. The existing well-known software tools such as Micro-Cap packages for computer simulation of circuits are powerful enough for this purpose [6]. So, the most critical from the point of view of the need for face-to-face (regular) format of laboratory work are the sections related to electric motors. These motors are complex electromechanical objects with moving components, and it is extremely imperative to monitor their functioning and operate them under real-world conditions, with safety in mind. The drawn branches of the program demonstrate the intention to defer these sections during a lockdown, or to quickly jump to these sections in the pauses between lockdowns. At the same time, a quick transition to the topic of “Electric Motors” is impossible without knowledge of the basic concepts in the field of magnetic circuits. To make up for this problem, two transitional lectures on relevant issues are introduced into the program.

The use of a flexible branching program of the course allowed giving more "degrees of freedom" to the teaching staff in responding to the restrictions caused by the pandemic. Subsequent tests and exams showed that students mastered the course in a pandemic at the required level of knowledge and skills.

4. Conclusion

Extraordinary circumstances due to the outbreak of a pandemic force university staff to think about special adaptation of the educational process to this new situation. Due to the fact that pandemics of infections such as COVID-19 usually attack the society in a series of waves, there is a need to regulate the studies by periodically switching the learning formats.

One of the ways to effectively respond to such threats can be the practice of developing flexible branching programs for academic disciplines. This approach opens up expanded opportunities for organizing combined (hybrid) education of students, when they stay mostly in the framework of distance learning, but the pauses between lockdowns are used for face-to-face studies.

According to the authors, this strategy is especially effective for engineering courses, in which it is desirable to retain face-to-face laboratory classes for a number of sections of the program.

The authors believe that their experience can be useful and will be extended to a fairly wide range of university courses.

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