Chapter # 25

THE COMBINED USE OF CONCEPT MAPS AND THE KAHOOT GAMING TOOL FOR A STRUCTURED TEACHING OF TELECOMMUNICATIONS

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ABSTRACT
The chapter presents the combined use of concept maps and the Kahoot gaming tool in the teaching of telecommunications. Concept maps were used for the presentation of the overall telecommunication subject through core concepts such as signals, transmission techniques, links, networks/services and market issues aiming at the students forming a well-structured overview of the telecommunication subject. At a second level, map elements were correlated to illustrate essential features of specific telecommunication applications. Kahoot, on the other hand, was used to help students visualize specific complicated topics such as electromagnetic propagation and signal transmission through optical fibers, the rationale being that visualization would help the students better comprehend the subsequent mathematical analysis. Kahoot was also used by the students to self-check the knowledge obtained by means of concept maps. The described approach was applied in the framework of telecommunication courses at the Department of Electrical & Electronic Engineering Educators, School of Pedagogical & Technological Education (ASPETE), Athens, Greece with the aim the students to develop technological and pedagogical content knowledge in accordance with the TPACK framework. The teaching process was evaluated through of two short questionnaires, the answer to which showed that the applied approach was successful and well received.

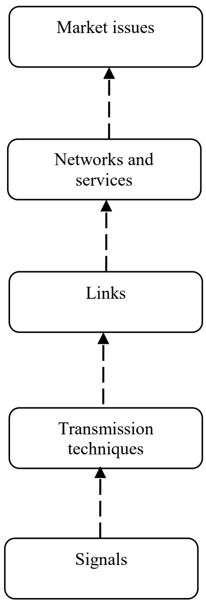
Keywords: electronic engineering education, concept maps, gaming tools, Kahoot, telecommunications, fiber-optics.

1. INTRODUCTION

Telecommunications is a very broad, multiple-topic subject intersecting with scientific fields such as mathematics, physics and informatics and this can be seen in most relevant textbooks (e.g., Taub & Schilling, 1986). Owing to that fact, students often feel confused when it comes to define certain telecommunication sub-fields or identify possible relations between telecommunication topics, the situation becoming more difficult since several of those topics may be overlapping and/or interrelated. However, despite the complications with regard to the teaching of telecommunications, the relevant literature is rather limited, especially when it comes to deal with the telecommunications subject as a whole.

With the aim to address the above issue and help students develop a clearer and well-structured overview of the telecommunication domain, a teaching model was proposed (Pagiatakis, 2005) that includes six modules with the preceding modules serving as the background for the subsequent ones and the latter providing the former with application examples. A modified layer-structured version of this model, that includes five modules, is shown in figure 1. From bottom to top, those modules are (i) signals, (ii) transmission techniques (digitization, modulation and multiplexing), (iii) link types (cable, terrestrial wireless, satellite, optical), (iv) telecom networks and services (dial-up, data, broadcasting and broadband services) and (v) market issues (mainly regarding the deregulated framework of the present telecom market). Taking the conventional telephony of the recent past (the most notable dial-up service) as an example, the application of this model in a top-to-bottom manner would result in stating that telephony was provided through the telephone network (with the information routing procedures being based on the so-called "circuit switching" technique) with the network comprising all types of links (cable, optical and, in some cases, wireless) and each link employing the appropriate transmission techniques (digitization, modulation and multiplexing) to transmit the voice signals. It has to be noted that the described approach can be used for either delivering a single overall course on telecommunications or developing a whole syllabus on telecommunication engineering (Pagiatakis et al, 2010).

Figure 1.
A layered model for the teaching of telecommunications.



Apart from the overall addressing of the telecommunication subject, there are certain difficulties and complications when it comes to the teaching of specific telecommunication topics. For example, electromagnetic propagation and signal transmission through optical fibers present several challenges to educators and students, mainly due to the complicated (and time-consuming) mathematics involved (the solution of the wave equation subject to specific boundary conditions) and the difficulty in associating mathematics with actual facts regarding the transmission process (e.g., Ming-Kang Liu, 1996). Even if a student is competent enough to follow the solution of such a problem, most probably he/she will find him/herself "lost in mathematics", unable to connect mathematical results with how an optical fiber actually supports and affects the transmitted signals. A similar situation has been observed with regard to the analysis of microwave waveguides and antennas due to the difficulty in handling Maxwell equations in combination with the appropriate boundary and/or far-field conditions.

The present article describes the combined use of concept maps and the Kahoot gaming tool with the aim to mitigate the above-mentioned difficulties regarding the teaching of telecommunication. More specifically, concept maps were used for the students to form a well-structured overview of the overall telecommunication subject and the inter-relation between the various telecommunication sub-fields while Kahoot focused on rather specific topics (such as the ones described above) that commonly cause difficulties to students mainly due to the complicated mathematics involved.

A concept map is a diagram that illustrates and helps build relations between concepts. As a notion, concept maps were first introduced by J.D. Novak in the early 1980s based on the idea that meaningful learning is greatly influenced by students' prior knowledge (Novak & Gowin, 1984; Novak, 1991; Stoica, Moraru, & Miron, 2011). One common form of concept maps is the one that includes a hierarchical organization of concepts with the more general concepts placed at the top of the diagram and the more specific ones at the bottom of it. Another form (which is the one used here) presents the concepts from left (more general ones) to right (more specific ones). Gamification on the other hand and its application to education (e.g., Disheva et al., 2018) has been associated with the enhancement of students' motivation and engagement which results in the educational process becoming more attractive and efficient (Lee & Hammer, 2011; Chapman & Rich, 2018). In this framework, the Kahoot gaming tool, which is a mobile-device application with a usable free version, lends itself for being embodied in engineering courses to facilitate the visualization of complicated concepts in an easy and user-friendly manner.

The use of concept maps regarding telecommunication teaching (limited, however, to signal transmission techniques) was described by Pagiatakis et al. (2024) while Freeman & Urbazewski (2002) used concept maps in a rather different context, that of assessing students' understanding of telecommunications. In this article, the use of concept maps was extended to help students develop a well-structured overview of the overall telecommunication subject (in combination with the layered model mentioned above) and also, through the proper correlation of individual map elements, to identify essential features of specific telecommunication services and applications. The Kahoot gaming tool, on the other hand (https://kahoot.com/; Voudoukis, Mantzios, & Pagiatakis, 2021), was used for the visualization of electromagnetic propagation and signal degradation phenomena in optical fibers (a specific topic with significant mathematical complexity) and, in addition, for the students to self-check the knowledge that was obtained with the aid of concept maps.

2. OBJECTIVES

As mentioned above, the difficulties associated with the teaching of telecommunications mainly stem from the broad and complicated structure of the overall telecommunication subject as well as the complex mathematics involved in the analysis of certain telecommunication topics such as the electromagnetic propagation and signal transmission either wirelessly or through optical fibers. Given the above-mentioned facts, the main objectives of the combined use of concept maps and Kahoot were:

(a) To help students obtain a clear and well-structured overview of the overall telecommunications subject. This was attempted by using concept maps in combination with the layered model shown in figure 1. At the first level, concept maps were used with regard to core telecommunication concepts and processes such as signals, transmission techniques, links, networks/services and market issues. At the second level, the individual map elements were interconnected with the aim to identify essential features of specific telecommunication services and applications.

(b) To assist students in visualizing complicated telecommunication processes (e.g., electromagnetic propagation and signal transmission through optical fibers) prior to their mathematical treatment. The rationale was that the visualization of those processes through a gaming tool such as Kahoot) would make them easier for students to approach (even in a rather practical manner) which, in turn, would facilitate the comprehension of the subsequent mathematical analysis.

3. METHOD

The framework for the described teaching approach is shown in figure 2. As mentioned above, this framework anticipates the use of concept maps for the students to view telecommunications in a rather general manner (and also identify possible interrelations between the various telecommunication topics and features) and the employment of the Kahoot gaming tool for focusing on rather specific topics that commonly cause difficulties to students mainly due to their complicated mathematical analysis.

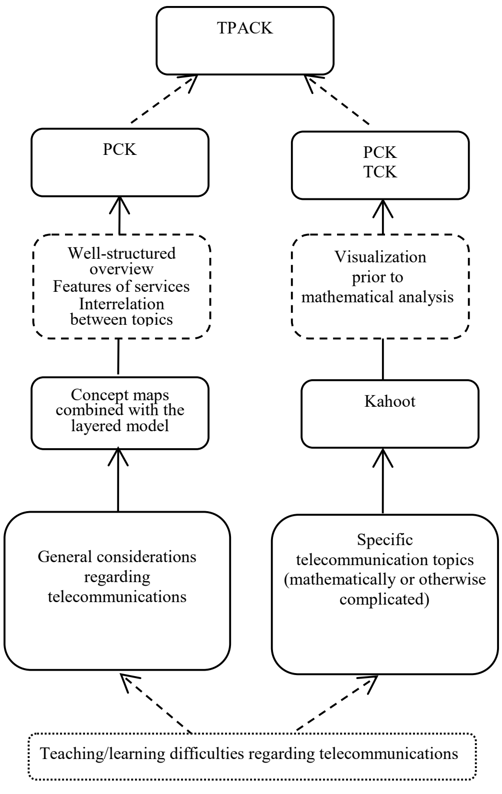
With regard to the use of concept maps, the applied approach anticipated two levels: At the first level, concept maps were used in a rather conventional way for the presentation of the overall telecommunication subject. More specifically, concept maps were used to illustrate the various types of signals, transmission techniques, types of links as well as communication network and services. The main aim was the students to outline and form a sound overview of the overall telecommunication subject which is broad and consisting of several often-overlapping topics. At the second (and more constructive) level, students were asked to correlate elements of the individual concept maps in order to identify specific telecommunication applications. This was the level where active participation of students was mainly sought.

As far as the Kahoot gaming tool is concerned, visualization was achieved by using Kahoot's free version since it is readily available and can be easily embodied in an engineering course. The basic rationale regarding the use of Kahoot for the presentation of electromagnetic propagation and signal transmission through optical fibers was that, if the students had first developed a qualitative grasp of the associated processes and mechanisms though visualization, this would help them follow the subsequent mathematical analysis as well as enhance their comprehension and practical aptitude, necessary for handling actual fiber-link problems. Active participation of students was sought and mainly achieved through the answering of relevant multiple-choice questions in an interactive manner.

The presentation that involved concept maps took place during a two-teaching-hour lecture in the framework of the 5th-semester "Telecommunication Systems" course (an introductory course on communication principles) in autumn 2023. The lecture took place at the end of the above-mentioned course in order the students to have encountered basic telecommunication concepts and processes. Kahoot, on the other hand, was used during five two-teaching-hour lectures in the framework of the 6th-semester "Optical Communications" course (spring 2024). Both courses are offered at the Department of Electrical & Electronic Engineering Educators of the School of Pedagogical & Technological Education (ASPETE), a tertiary educational institution, located in Athens, Greece. A unique feature of ASPETE is that its graduates, apart from working as engineers in their respective field, can be also employed as teachers in technological secondary schools (that is why the students, in parallel with their engineering courses, also attend courses on pedagogy, psychology and didactics).

The potential employment of ASPETE's graduates as school teachers is the main reason why particular emphasis is given to the students developing a conceptual and not just procedural understanding of the concepts and processes of their field. It is also essential the students to go beyond the primary forms of knowledge (content, pedagogical and technological knowledge) and build combined knowledge components as defined in the TPACK framework (Mishra & Kohler 2006). Taking that into account, the combined use of concept maps and Kahoot aimed at the students develop Pedagogical Content Knowledge (PCK) and Technological Content Knowledge (TCK) and, eventually, Technological Pedagogical Content Knowledge (TPACK). Regarding Bloom's revised taxonomy, on the other hand (Armstrong, 2010), the combined use of concept maps and Kahoot mainly regarded layers 2 and 3 (understand and apply) and maybe layer 4 (analyze).

Figure 2.
The framework for the combined use of concept maps and Kahoot in the teaching of telecommunications.



4. DESIGN

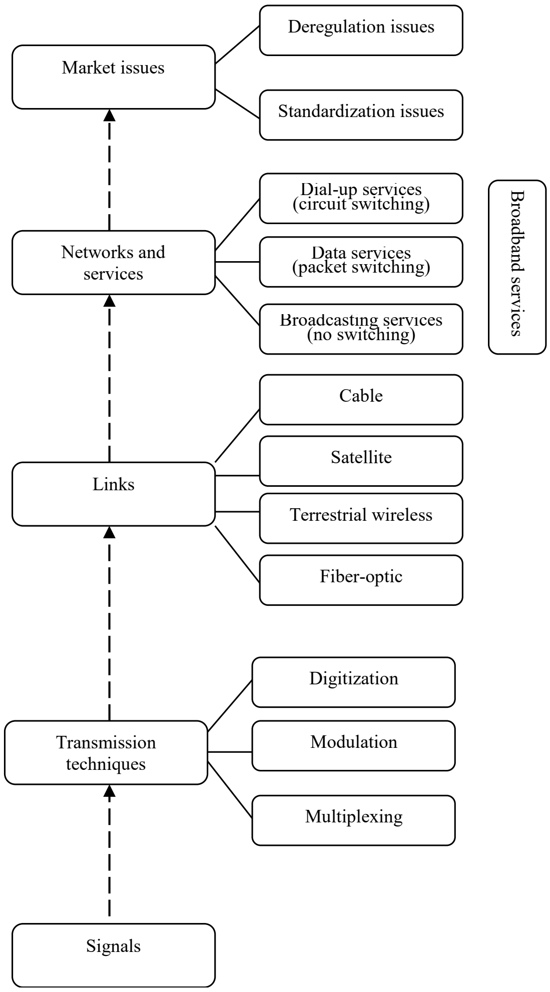
4.1. Use of Concept Maps (and Kahoot for Self-Checking Purposes)

The use of concept maps in the relevant two-hour lecture included two parts:

In the first part, concept maps were used to outline the telecommunication subject as a whole. In this part, concept maps were combined with the layered model of the overall telecommunication subject (figure 1) as illustrated in figure 3.

In the second part, the students were asked to correlate elements of the individual concept maps in order to identify essential features of specific telecommunication services and applications. For example, the amplitude modulation (AM) and frequency modulation (FM), that are elements of the concept maps for transmission techniques, were associated with the wireless terrestrial links (element of the concept maps for links) to make reference to the radio broadcasting service while the phase-shift-keying (PSK) modulation technique combined with satellite links made reference to the satellite TV service. Other examples could be the association of certain transmission techniques (e.g., digitization and amplitude shift keying –ASK–) and certain link types (cable and fiber-optic) with telephony and data services as well as the association of requirements for basic transmission parameters (such as the bit rate, the bit error rate –BER– and the transmission delay) with telecommunication services such as telephony, data transmission and broadcasting (figure 4).

Figure 3.
The use of concept maps (first part): Concept maps are used in combination with the layered model for the teaching of telecommunications.



Self-checking of students was attempted by means of the Kahoot gaming tool. Indicative screenshots are shown in figure 5.

Figure 4.
The use of concept maps (second part): Concept maps are used to identify essential features of certain telecommunication applications and services.

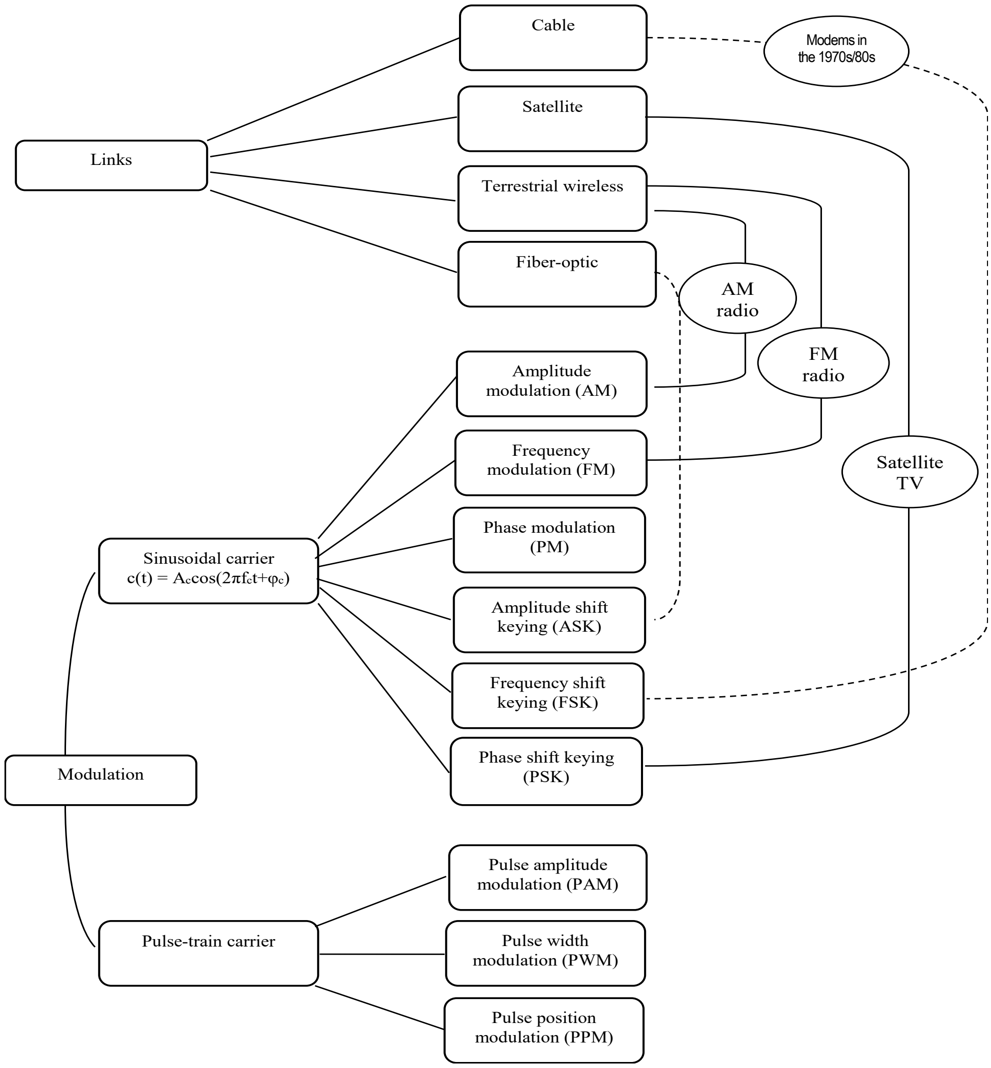
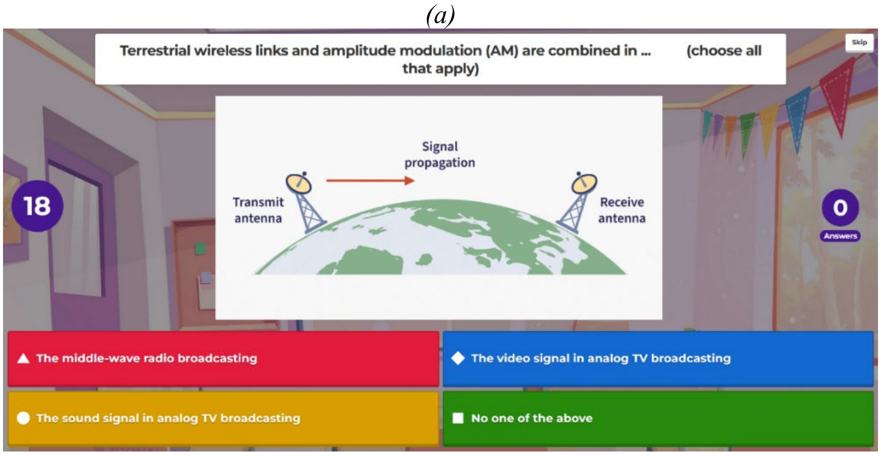
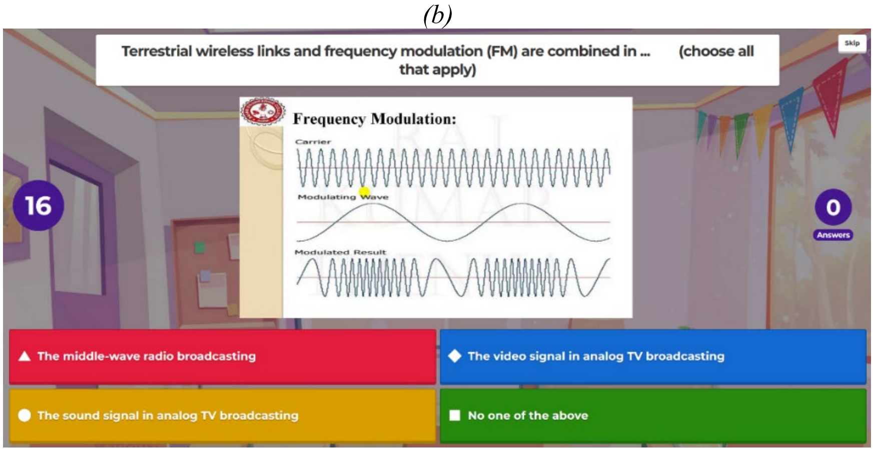


Figure 5.
Indicative Kahoot screenshots for the students' self-checking regarding knowledge obtained with the aid of concept maps.

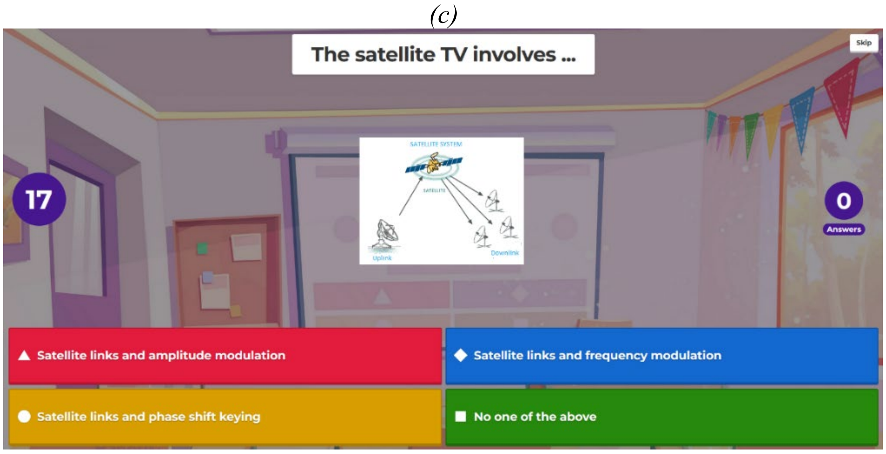
(a)



(b)



(c)



4.2. Use of Kahoot (for Visualization Purposes)

The main use of Kahoot regarded the visualization of electromagnetic propagation and signal transmission through optical fibers prior to the relevant mathematical analysis. The presented content was divided into two parts, the first one dealing with electromagnetic propagation (with emphasis to the notion of propagating modes) and the second one dealing with signal degradation mechanisms, particularly attenuation and dispersion. Typically, the first part requires the solution of the wave equation (combined with the appropriate boundary conditions) in cylindrical coordinates and it is the topic that causes most difficulties and misunderstandings among students. The second part is the consideration of the fiber as a transmission medium and the analysis of signal degradation processes such as attenuation and dispersion.

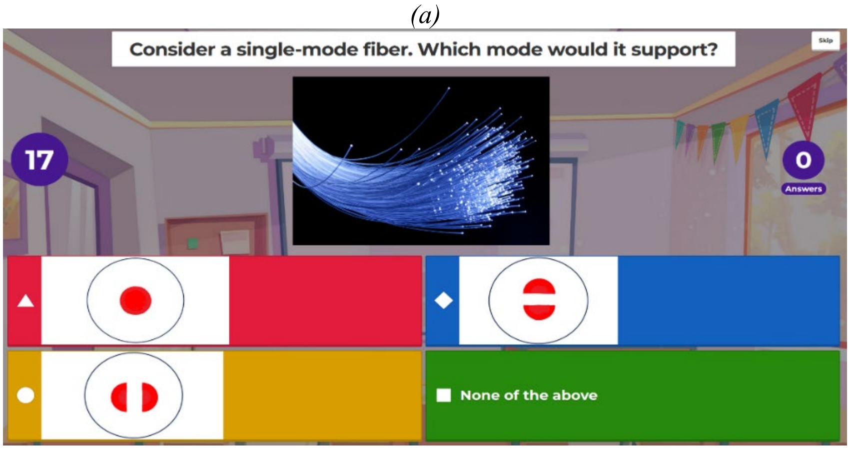
Lectures 1 and 2 were about electromagnetic propagation while lectures 3 and 4 addressed signal transmission (table 1). Visualization through Kahoot was an essential element of those lectures and, all in all, it took about half of the teaching time. Indicative screenshots regarding the above lectures are shown in figure 6 while indicative additional questions are given in table 2. The last lecture was dedicated to a discussion on the content of the preceding lectures.

Table 1.
Lectures on the electromagnetic propagation and signal transmission through optical fibers.

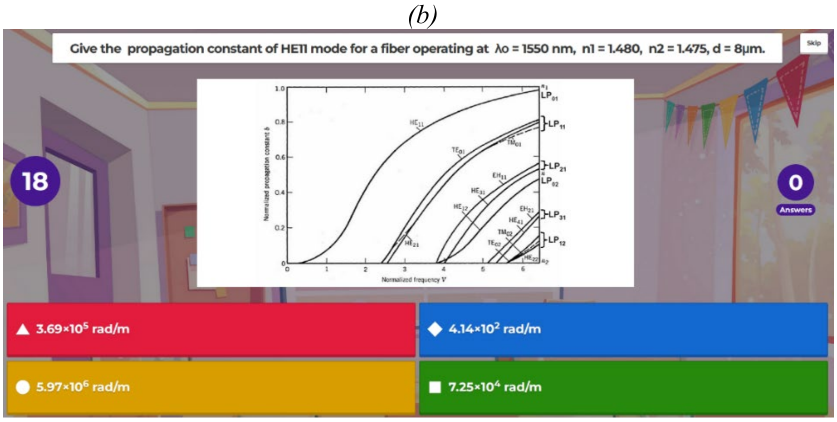
Lecture	Topic	Objective	Topics to be presented and discussed (indicative list)
1 & 2	Electromagnetic propagation through optical fibers	The students to comprehend the basic mechanisms and processes regarding electromagnetic propagation through an optical fiber.	• Visualization of the concept of propagating modes. • Visualization of the dispersion diagram. • Practical issues. • Association with the solution of the relevant boundary-value problem (wave equation combined with boundary conditions).
3 & 4	The optical fiber as a transmission medium	The students to comprehend the transmission properties of optical fibers and the phenomena and parameters regarding signal attenuation and dispersion.	• The attenuation process. • The dispersion process (with emphasis to chromatic dispersion visualized by means of Kahoot).
5	Discussion	To evaluate the effectiveness of the applied approach through student feedback and quantitative assessment.	

Figure 6.
Indicative Kahoot screenshots regarding electromagnetic propagation and signal transmission through fibers.

(a)



(b)



(c)

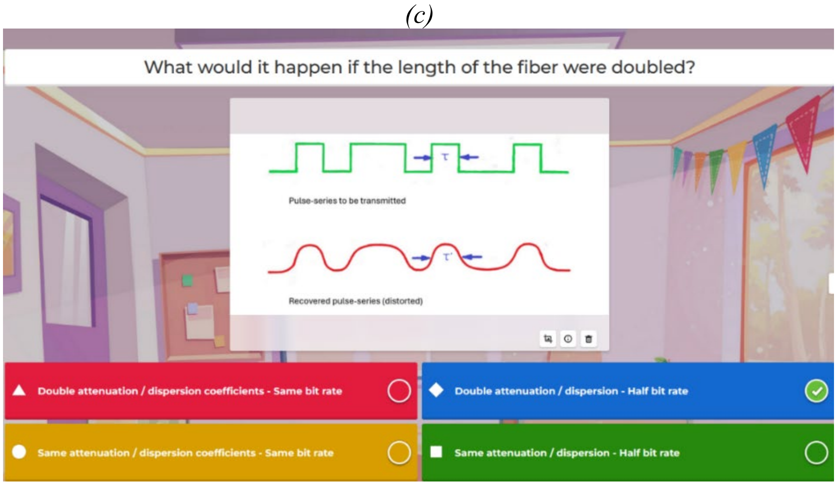


Table 2.
Indicative additional questions regarding electromagnetic propagation and signal transmission through fibers.

Question	Relevant figure
1. What would be the profile of the LP11 mode?	3a
2. Suppose that the picture depicts mode's profile, i.e. the distribution of the optical power over a cross-section of a single-mode fiber at an instant considered as the starting one ($t_o = 0$). What comments can you make on the mode's profile at distances L such as $\beta L = \pi/4$, $\pi/2$ and π (where β is the mode's propagation constant)?	3a
3. What would be the mathematical expression of the electric field in a fiber with indices n1 = 1.480 and n2 = 1.475 and diameter d = 12 μm operating at a wavelength λ_o = 1550 nm?	3a
4. Could there be an optical fiber with no propagating mode?	3b
5. Suppose we have an optical source operating at a wavelength λo = 1550 nm and optical fibers with refractive indices n1 = 1.480 and n2 = 1.475 and diameters (d) equal to 8 μm, 12 μm, 16 μm and 20 μm. Identify the propagating modes supported by each fiber.	3b
6. In what way, e.g. modes HE21, TE01 and TM01 can be considered as the LP11 mode?	3b
7. Suppose that the figure depicts a signal with bit-rate R = 2.5 Gb/s. What will happen if the bit-rate increases considerably (e.g. to R' = 10 Gb/s)?	3c

5. DISCUSSION

5.1. Use of Concept Maps

There is no doubt that the use of concept maps assists educators in conveying a clearer picture of the presented notions and facilitates students' understanding by helping them create a well-structured overview of the topics of interest. Regarding telecommunications, concept maps can help students outline the subject of telecommunications (including its individual sub-areas and topics) and, at the same time, revise basic telecommunication notions and concepts. Moreover, the interrelation of the concept maps, as described in sub-section 4.1 and depicted in figure 4) can assist students in associating essential notions and facts with actual telecommunication services and applications which is compatible with students' participation and active learning.

Following the use of concept maps, and with the aim to evaluate their effect on students' comprehension, a short questionnaire was distributed to students that should be answered by means of a 5-grade Likert scale ("1" strongly disagree, "2" disagree, "3" neither disagree nor agree, "4" agree, "5" strongly agree). The questions and the answers' essential metrics are included in table 3.

Table 3.
Questions and answers regarding the use of concept maps to enhance students' comprehension of telecommunications (participation: 18 students). The Linkert scale was used (ranging from 1 to 5).

Question	Average (m)	Standard deviation (s)	Ratio m/s	Percentage with answers "4" or"5"
1. Concept maps helped me develop a better overview of the various aspects of telecommunications as a subject.	4.056	0.639	0.16	83.3%
2. Concept maps helped me realize critical parameters of the various types of telecommunication networks and services.	4.222	0.808	0.19	77.8%
3. Concept maps helped me in associating critical facts regarding telecommunication services and applications.	4.000	0.639	0.16	83,3%
4. I would use concept maps as an educator.	4.111	0.471	0.11	94.4%

Students' answers to questions 1, 2 and 3 (with averages 4.056, 4.222 and 4.000, respectively and a small m/s ratio) illustrate the fact that students generally agree that the use of concept maps had a positive effect on their comprehension of telecommunication issues.

The aim of question 4 was to evaluate the intention of the participating students to use concept maps as future educators. This question was included in the questionnaire given the fact that the department's graduates have the option to be employed as teachers of electrical and/or electronic engineering in technological high schools. It is encouraging that the majority of students would agree that the use of concept maps should be part of their teaching practice.

It is worthwhile noting that the percentage of students that gave a "4" or a "5" answer to the questions above was quite high (ranging from 77.8% to 94.4%).

Though the described use of the concept maps regards the overview of the telecommunication subject, concept maps could be also applied for the teaching of individual telecommunication topics, particularly those for which classification is necessary for students' comprehension. A notable example is the modulation and multiplexing techniques where correlation of individual concept maps would be helpful if not necessary. To enhance the effect of the associated teaching approach, concept maps could also refer to essential relevant information. For example, regarding modulation, concept maps might include information such as the signals involved, the spectral requirements, the modulation and demodulation arrangements etc. Active participation of students could be accomplished by asking them to create particular concept maps or develop alternative ones applying different classification criteria. Students' participation could be also assisted by interrelating individual concept maps in the manner shown in figure 4.

Through the clarification and structured classification of telecommunication notions, concept maps are also expected to help students in the literature survey related to specific telecommunication topics for which a usual complaint was that when they had to do such a survey, they often felt lost and confused. Finally, as future educators in technological high schools, they could also incorporate the use of concept maps in their teaching of electricity and electronics related topics, e.g. in the classification of electrical components or electronic amplifiers to name a few.

5.2. Use of the Kahoot Gaming Tool

Following the use of Kahoot, a short questionnaire was distributed to students that should be answered by means of a 5-grade Likert scale (as for the concept maps). The questions and the answers' essential metrics are included in table 4.

Table 4.
Questions and answers regarding the presentation of the use of the Kahoot gaming tool for the presentation of electromagnetic propagation and signal transmission through optical fibers (participation: 19 students). The Linkert scale was used (ranging from 1 to 5).

Question	Average (m)	Standard deviation (s)	Ratio m/s	Percentage with answers "4" or"5"
1. Kahoot gaming tool was easy to use.	3.632	0.895	0.25	68.4%
2. Visualization through the Kahoot gaming tool helped me comprehend EM propagation process through an optical fiber.	4.167	0.898	0.22	78.9%
3. Visualization through the Kahoot gaming tool helped me comprehend signal degradation phenomena such as dispersion.	4.105	0.658	0.16	84,2%
4. I would use Kahoot as an educator.	4.053	0.621	0.15	84.2%

The answers to question 1 (m = 3.632) show that regarding the usability of Kahoot, there is certainly room for improvement. This is compatible with the moderate percentage (68.4%) of students that gave a "4" or "5" answer to this question. A possible solution would be the students to be given some time to practice with Kahoot as a preparatory homework (prior to its use in the class).

The answers to questions 2 and 3 (m = 4.167 and 4.105 with a small m/s value) show that visualization through Kahoot prior to the mathematical analysis, did help the students comprehend the facts and issues of electromagnetic propagation and signal transmission through optical fibers.

The aim of question 4 was to evaluate the intention of the participating students to use Kahoot as future educators. This question was included given the fact that the department's graduates can be employed as teachers in technological high schools. It is encouraging that the majority of students agree or strongly agree with using Kahoot as future educators.

The above conclusions are compatible with the high percentage of students that gave a "4" or "5" answer to questions 2, 3 and 4 (78.9%, 84.2% and 84.2%).

Kahoot could be also used for the visualization of additional topics of Optical Communications, e.g. the operation of optical amplifiers and receivers or the wavelength division multiplexing technology, to name a few. Active participation of students could be enhanced by encouraging them to create their own Kahoot displays (probably with proper guidance and/or hints) in view of their possible employment as future school teachers. In the framework of more advanced applications, Kahoot could be also used for developing self-teaching educational material, e.g., for incoming international students.

6. POSSIBLE FUTURE DIRECTIONS

Regarding the use of concept maps, a future action could be the use of concept mapping software tools that would provide flexibility and greatly increase the didactic potential of concept maps. The use of software tools would enhance students' familiarity with concept maps and encourage the students to employ them in their potential capacity as educators in technological secondary schools. Such an action would also help students enhance the Technological Content Knowledge (TCK) part of the TPACK framework as well layer 4 ("analyze") of Bloom's taxonomy

As far as the Kahoot gaming tool is concerned, given the dynamic nature of electromagnetic waves (and waves in general) the use of video tools for the presentation of electromagnetic propagation and signal transmission through fibers, (which, however, would require more effort and more sophisticated equipment) could be also considered as an option.

7. CONCLUSIONS

All in all, the combined use of concept maps and Kahoot aimed at mitigating difficulties and complications regarding the teaching of telecommunication. The use of concept maps mainly referred to the telecommunication subject as a whole while Kahoot aimed at visualizing mathematically complicated topics (such as propagation and transmission through optical fibers) prior to their mathematical analysis and was also used for students' self-checking.

Regarding concept maps, the aim was to assist and possibly enhance students' comprehension of telecommunications in a rather overall manner. Apart from the conventional use of concept maps (to present a structured overview of the overall telecommunication subject), the article proposes an additional use which anticipates the correlation of individual map elements to illustrate essential features of specific telecommunication services and applications. Given that telecommunications is a vast subject with a large number of specific sub-areas and topics that may overlap with each other and/or intersect with other scientific fields, concept maps can assist students in defining and comprehending telecommunication concepts and processes and dissolving relevant misconceptions and missing points. This could be particularly helpful for graduates who would choose to be employed as teachers and educators in electronics and telecommunications related fields. The students' answers to the distributed questionnaire were a strong indication that the described use of concept maps had a positive effect on their comprehension of telecommunications. It was also encouraging that students appeared eager to use concept maps as possible future educators. A further employment of concept maps could anticipate their formation and elaboration with the use of computer tools.

Regarding the use of the Kahoot gaming tool, the aim was to facilitate a qualitative comprehension of mathematically complex telecommunication topics (such as the electromagnetic propagation and signal transmission through optical fibers) by means of the visualization of the relevant processes. The rationale was that visualization of such topics would facilitate students in approaching the subsequent complicated and time consuming mathematical analysis. Student feedback was encouraging and this could motivate further use of Kahoot. Given the dynamic nature of electromagnetic waves (and waves in general), the use of video presentations in combination with Kahoot (which, however, would require more effort and more sophisticated equipment) could be also considered as an option.

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KEY TERMS & DEFINITIONS

Digitization: The conversion of an analog signal to an equivalent digital one.

Modulation: The mixing of an information signal (representing voice, a still or moving image, data etc.) with an auxiliary signal (called "the carrier") with the aim to enable and/or optimize the information signal's transmission. Depending on the type (analog or digital) of the information signal, the form of the carrier (sinusoidal or pulse-train) and the particular parameter of the carrier to be affected (modulated) by the information signal (amplitude, frequency or phase of the sinusoidal carrier or amplitude, width or position of the pulses in the pulse-train carrier), there occur the various types of modulation shown in figure 2.

Multiplexing: The simultaneous transmission of multiple signals through the same medium. A typical example is radio and TV broadcasting where several stations broadcast within the same area and at the same time.

Dispersion: The widening of digital pulses during the transmission of a digital signal (e.g through an optical fiber) that may result in pulse overlapping and bit-rate limitations. Dispersion has various forms (e.g. intramodal dispersion, polarization-mode dispersion) and its effects are more obvious in long, high bit-rate links (length above 100 km and bit-rate above 1 Gb/s) that is why it is usually associated with fiber-optic links.

Dial-up services: The most notable example is conventional telephony. A characteristic feature of dial-up services is the so-called "circuit switching" which anticipates that the communicating parties are assigned a dedicated circuit for the whole duration of their communication (to enable uninterrupted transmission of information with negligible delay).

Data services: The most notable example is computer communication. A characteristic feature of data services is the so-called "packet switching" which anticipates that the overall information is divided into packets (each one including bits regarding the starting and the destination point) that can follow different routes before they reach their final destination.

Broadcasting services: They include radio and TV broadcasting.

Broadband network: The integrated digital network that is capable of accommodating in a unified manner all types of services (dial-up, data and broadcast) and gradually replaces the conventional dial-up, data and broadcasting networks. Fiber-to-the-home connections are part of the broadband network.

ACKNOWLEDGMENTS

The authors acknowledge financial support for the dissemination of this work from the Special Account of Research of ASPETE through the program "Strengthening Research of ASPETE Faculty Members".

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