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USING CONCEPT MAPS TO ENHANCE STUDENTS' COMPREHENSION OF TELECOMMUNICATIONS

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Abstract

The article deals with the use of concept maps for a constructive overview of the telecommunications subject. The use was two-fold: at a first level, concept maps were used for the presentation and classification of core telecommunication concepts and processes such as signals, transmission techniques, links networks and services while, at a second level, parts of the individual concept maps were correlated in order to identify basic features of specific telecommunication services and applications. Regarding the first level, the overall telecommunication subject was presented as a set of layers that, from bottom to top, are (i) the signals and information representation, (ii) the transmission techniques (classified into digitization, modulation and multiplexing), (iii) the link types (that is, cable, terrestrial wireless, satellite and fiber-optic links), (iv) the networks and services (classified into dial-up, data and broadcasting) and (v) the telecom market (mainly, involving standardization and regulation issues). 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. For example, the amplitude modulation (AM) and frequency modulation (FM), that are elements of the concept maps regarding transmission techniques, were associated with the terrestrial wireless links (element of the concept maps for links) for the radio broadcasting service while the phase shift keying (PSK) modulation technique combined with satellite links refers to satellite TV broadcasting. Other examples were 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 bit rate, bit error rate –BER– and transmission delay) with telecommunication services such as telephony, data transmission and broadcasting. The presentation took place during a two-teaching-hour lecture in the framework of the "Telecommunication Systems" course (an introductory semester course on communication principles) towards the end of the course in order students to have already encountered essential telecommunication concepts and processes. The active participation of students was encouraged particularly at the second level (correlation of the individual concept maps). The whole process was evaluated by means of a short questionnaire which included questions on whether concept maps had helped students improve their general knowledge of the telecommunications subject as well as their ability to associate basic concepts and elements in order to identify features of actual telecommunication services and applications. The above-mentioned course is 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.

Keywords: *Engineering education, electronic engineering education, telecommunications, concept maps.*

1. Introduction

Telecommunications is a very broad multiple-topic subject intersecting with scientific fields such as mathematics, physics and informatics (e.g., Taub & Schilling, 1986) and students often feel confused when it comes either to define telecommunication sub-fields or identify possible relations between its numerous individual topics that are often overlapping and/or interrelated.

With the aim to address the above issue and help students develop a clearer and well-structured overview of the telecommunication domain, a layered structure has been proposed (Pagiatakis, 2005) that, from bottom to top, it includes six modules with the lower-layer modules serving as the background for the higher ones with the latter providing the former with application examples. Those modules are: basic

concepts, signal basics, transmission techniques (digitization, modulation and multiplexing), link types (cable, wireless, optical), telecom networks and services (telephony, data networks, audiovisual services and broadband networks) and market issues. For example, each link type can be combined with specific transmission techniques while a network/service (e.g. telephony) usually employs all types of links (for example, the conventional telephony network consists of cable, optical and terrestrial/satellite wireless links).

A concept map, on the other hand, is a diagram that illustrates 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 and the more specific ones at the bottom of the diagram. Another form (the one used here) presents the concepts from left (more general ones) to right (more specific ones).

In this article, concept maps were used for a constructive overview of the overall telecommunications subject. The use of concept maps for teaching telecommunications was described by Pagiatakis et al (2024) but that use was limited to signal transmission techniques. Besides, 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 cover additional core topics such as signal types, telecommunication links and telecommunication network and services. The work also proceeds beyond the conventional use of concept maps in that it proposes individual elements of concept maps to be properly correlated in order to identify features of specific telecommunication services and applications.

2. Objective

The objective was to use concept maps to present a well-structured overview of the overall telecommunications subject. At the first level, the aim was to use concept maps in a rather conventional way regarding core telecommunication concepts and processes such as signals, transmission techniques, links, networks and services. At the second level, individual elements of the above concept maps were properly correlated and connected with the aim features of specific telecommunication services and applications to be identified.

3. Method

The applied approach in using the concept maps 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 and communication network and services. The main aim was the students to outline the telecommunication subject which is broad and with several overlapping and/or associated topics.

In 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 sought.

4. Design

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

In the first part, concept maps were used in order to outline the telecommunication subject as a whole. More specifically, the overall telecommunication area was depicted as a set of layers that, from bottom to top, were (i) the signals and information representation, (ii) the transmission techniques (classified into digitization, modulation and multiplexing), (iii) the link types (that is, cable, terrestrial wireless, satellite and fiber-optic links), (iv) the networks and services (classified into dial-up, data and broadcasting) and (v) the telecom market (mainly, involving standardization and regulation issues) (Pagiatakis; 2005). Special care was taken for telecommunication networks and services that were classified with regard to the kind of information (voice, data, video) and the switching technique (circuit switching, packet switching, no switching).

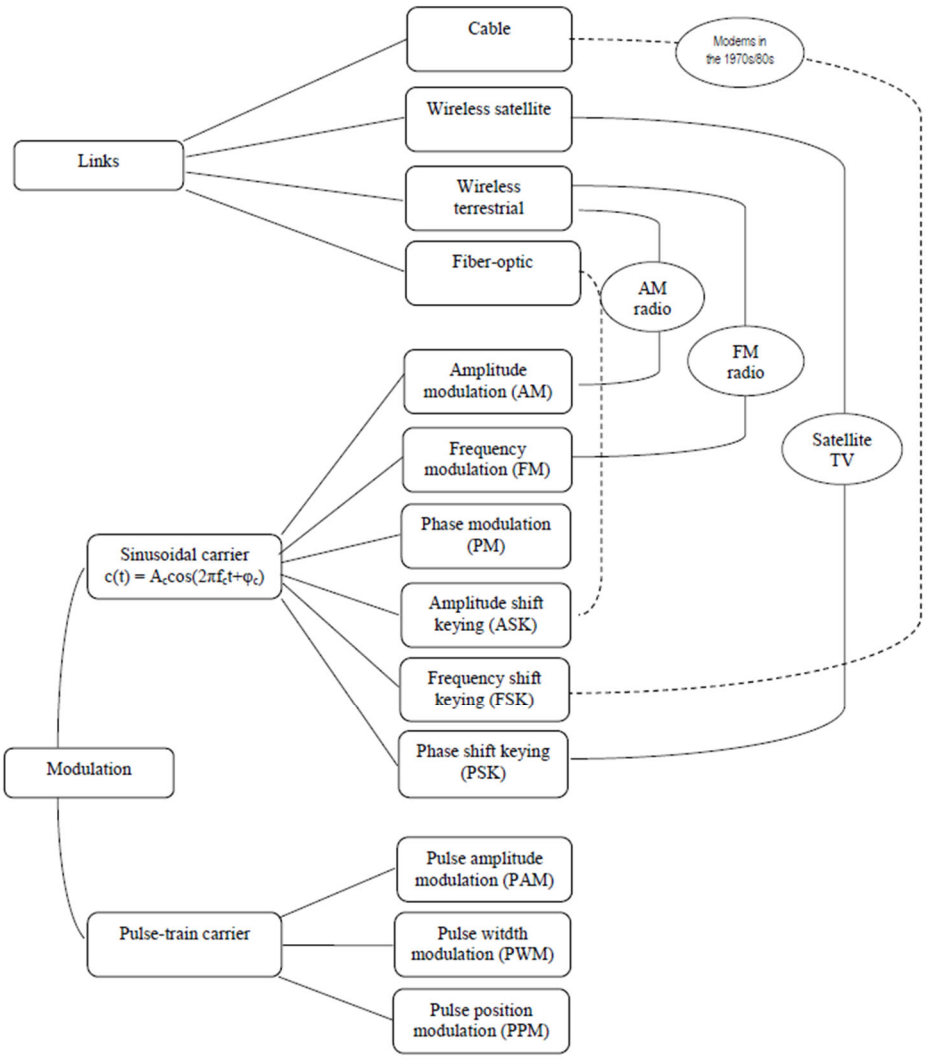
In the second part, students were asked to correlate elements of the individual concept maps in order to identify specific telecommunication applications. For example, the amplitude modulation (AM) and frequency modulation (FM), that are elements of the concept maps regarding transmission techniques, were associated with the terrestrial wireless links (element of the concept maps for links) for the radio

broadcasting service while the phase shift keying (PSK) modulation technique combined with satellite links refers to satellite TV broadcasting. 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 bit rate, bit error rate –BER– and transmission delay) with telecommunication services such as telephony, data transmission and broadcasting (figure 1).

The presentation 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 course is 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 also be employed as teachers in technological secondary schools, that is why students attend courses on pedagogy and didactics in parallel with their engineering courses. The potential employment of ASPETE's graduates as educators is an essential reason why particular emphasis should be given to the students developing a conceptual, and not just procedural, understanding of the concepts and processes of their field. This was the second time that concept maps were used in the context of telecommunications and the lecture took place at the end of the above-mentioned course in order students to have encountered basic telecommunication concepts and processes.

Following the lecture, and with the aim to evaluate the effect of using concept maps for enhancing students' comprehension of telecommunications, 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).

Figure 1. Concept maps regarding the layers of transmission techniques and links.



5. Discussion

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 taught topics. Regarding telecommunications, concept maps also help students outline the subject of telecommunications (and its individual sub-areas and topics) and, at the same time revise basic telecommunication concepts. Moreover, the interrelation of the concepts maps, as described in the present article, can help students associate essential notions and facts with actual telecommunication services and applications which is compatible with students' participation and active learning.

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 (table 1 and figure 2).

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.

Within the described approach, the use of concept maps regarded the Content Knowledge (CK) and Pedagogical Knowledge (PK) parts of the TPACK framework (Mishra & Kohler 2006). The aim was the students to develop Pedagogical Content Knowledge (PCK) in view of their possible future employment as secondary school teachers. Regarding Bloom's revised taxonomy (Armstrong, 2010) the presentation mainly covered layers 2 and 3 (understand and apply) and maybe layer 4 (analyze). A future presentation could anticipate the formation and elaboration of concept maps with the use of computer tools that would also add the Technological Knowledge part (TK) and also enhance layer 4.

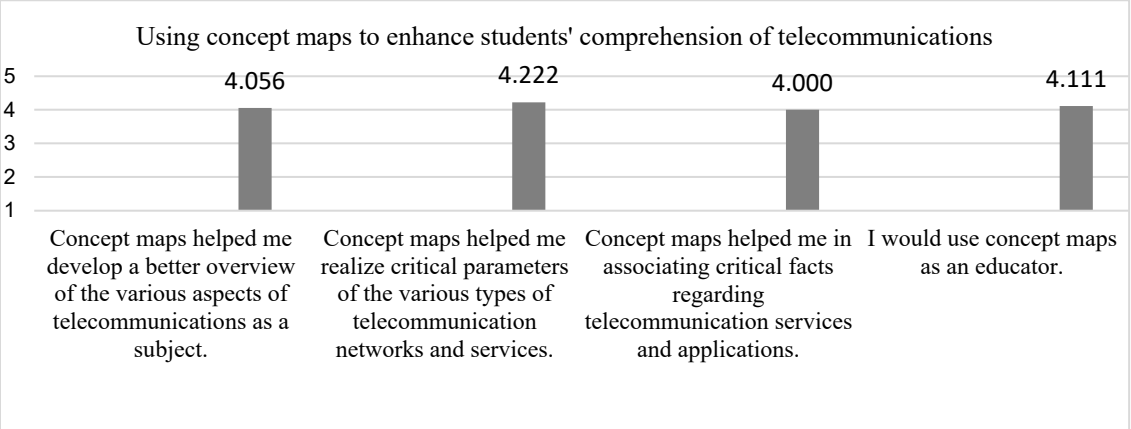
Though the described use of the concept maps regards an overview of the telecommunication subject in a pilot-like manner, concept maps could be also applied for the teaching of individual telecommunication topics, particularly those for which classification is necessary for students' comprehension (a characteristic example could be 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 could 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 concept maps by applying different classification criteria. Students' participation could be also assisted by interrelating individual concept maps as proposed in this article.

Concept maps could also help students regarding the literature review of individual telecommunication topics. Finally, the students could incorporate the use of concept maps in their teaching of electricity- and electronics-related topics in technological secondary-school classes in their potential future capacity as educators.

Table 1. Questions and answers regarding the use of concept maps to enhance students' comprehension of telecommunications (participation: 18 students).

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

Figure 2. Questions and answers regarding the use of concept maps to enhance students' comprehension of telecommunications (participation: 18 students).



6. Conclusions

The article proposes the use of concept maps with the aim to assist and enhance students' comprehension of telecommunications. Apart from the conventional use of concept maps (which, anyway was extended to cover the whole of the telecommunication subject), the article proposes a more advanced use in that individual map elements could be properly correlated in order to identify and illustrate features of specific telecommunication services and applications. Given that telecommunications are a vast subject with numerous topics and sub-areas that may overlap with each other and/or intersect with fields such as mathematics, physics and informatics, concept maps can assist students in defining and comprehending telecommunication topics and dissolving relevant misconceptions and missing points. This could be particularly helpful for graduates who would be employed as teachers and educators. 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 and it was also encouraging that students were eager to use concept maps as future educators. A future presentation of concept maps could anticipate their formation and elaboration with the use of computer tools.

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References

Armstrong, P. (2010). Bloom's taxonomy. *Vanterbilt University Center for Teaching*, 2010. Retrieved September 12, 2023, from: https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy

Freeman, L. A. & Urbazewski, A. (2002). Concept maps as an alternative technique for assessing students' understanding of telecommunications. *Proceedings of the 17th International Conference on Informatics Education Research (ICIER)*, Barcelona, Spain 13-15/12/2002.

Mishra, P. & Kohler M.J. (2006). Technological pedagogical content knowledge: A framework for inegrating technology in teacher knowledge. *Teacher College Record*, *108*, 1017-1054.

Novak, J. D. & Gowin, D. P. (1984). *Learning how to learn*. New York: Holt, Reinhart and Winston.

Novak, J. D. (1991). Clarify with concept maps: A tool for students and teachers alike. *The Science Teacher*, *58*(7), 45-49.

Pagiatakis, G. (2005). Teaching telecommunications to Electronics Technical Engineers: An integral course on telecommunication systems. *IEEE Trans. on Education*, *48*, 223-229.

Pagiatakis, G., Voudoukis, N., Uzunidis, D. & Karaoulanis D. (2024). Presentation of signal transmission techniques by means of concept maps. *Proceedings of the 16th Inernational Conference on Education and New Learning (EDULEARN-2024)*, Palma de Mallorca, Spain, 1-3/7/2024.

Stoica, I., Moraru, S., Miron, C. (2011). Concept maps – a must for the modern teaching-learning process. *Romanian Reports in Physics*, *63*.

Taub, H. & Schilling, D. L. (1986). *Principles of communication systems*, 1-55. Singapore: McGraw-Hill.