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Using interactive semantic networks as an augmented reality element in autonomous learning

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Abstract. This paper focuses on the using augmented reality elements in the educational process, in particular in autonomous learning. The possibility of using interactive semantic networks in learning foreign languages is considered. The technology of selection and structuring of specialised terminology on the basis of interactive semantic networks for their further use in the study of foreign languages and mastering automated translation systems has been developed and proposed. The criteria for creating and supplementing terminological databases with appropriate structuring of the domain terminology selected on the basis of interactive semantic networks have been defined, namely universality, structurability, convertibility, extensibility. The possibility of further use of terminology bases for foreign language learning using mobile applications, mastering Computer Aided Translation (CAT) systems, mastering Computer Aided Interpretation (CAI) are outlined. Based on the practical use of the developed technology in the process of autonomous training of translators, positive results have been concretised and areas for further activities in their technological training have been identified.

1. Introduction

In a changing world at the beginning of the 21st century, education is also changing rapidly. Learning is now seen as a lifelong process that is essential for adapting to new environments, and therefore for ensuring personal economic and social success. Such learning implies that people have to 'learn to learn'. Consequently, providing students with the knowledge and skills to enable them to manage their own educational process effectively becomes one of the aims of higher education. During the evolution of the education system, the issue of autonomy has become one of the main themes of language education research, and in the context of recent global developments (the coronavirus pandemic, COVID-19, restrictive quarantine measures and lockdowns, the transition to distance learning [1–9]) it has become particularly relevant.

At the same time, the new format of the educational process puts forward new requirements regarding the ways of realising learning objectives, methods of learning communication and teacher-student interaction, means of ensuring the effectiveness of learning subjects and



achieving the programme learning outcomes envisaged in the standards and curricula for training specialists, including translators. Both in terms of learning activities and in terms of the future work of translators, technological training is becoming increasingly important. The present is forcing, on the one hand, a strengthening of the technological aspects of university translator training and, on the other hand, a rethinking of the organisational forms of training, the search for appropriate means, the combination of students' independent mastering of individual study materials with the technologicalization of the educational process. Using elements of augmented and virtual reality can meet such complex objective requirements of the current situation.

2. Theoretical background

An analysis of the psycho-pedagogical literature has shown that there has recently been increased interest in certain aspects of autonomous learning by researchers in different fields of science. Philip Benson, noting the recent increased attention to learning autonomy and self-organised learning, including in foreign language learning, emphasised the importance of different levels of student autonomy in distance learning [10]. Sara Cotterall identified five principles on which a stand-alone language course should be based and attributed them to learners' goals; language learning process; theory – task, design; learners' strategies; reflection on learning [11]. Stella Hurd, Tita Beaven and Ane Ortega emphasise one of the main problems of autonomy in distance learning, which in their view is the difficulty of selecting learning material for students to learn independently. This decision is complicated by two factors. On the one hand, in order to be successful in the programme, students must develop a number of strategies and skills that will allow them to work individually. At the same time, the syllabus of an academic course has a definite structure in which the scope, pace and content of the syllabus are determined by the teacher. Exploring the notion of autonomy in distance language learning, scholars have identified some of the skills that distance learners need to achieve successful outcomes [12]. Similar views are held by Linda Murphy, who emphasizes that the success of autonomy in distance learning depends largely on the teaching materials, and demonstrates the role of the teacher in the process of autonomy in the language distance-learning programme of The Open University in the UK [13].

While considering the organisation of autonomous language learning, scholars have also explored the possibilities of using information technologies in this process. In highlighting the changes in educational philosophy reflected in the theory of language learning, Richard Pemberton, Edward S.L. Li, Winnie W.F. Or and Herbert D. Pierson noted the need to adapt to the rapid changes in the areas of technology, communications, and the labour market and to realise that the ability to learn is now more important than knowledge. In his view, it is advisable to take full advantage of the opportunities for expanding educational services that come with the development of technologies [14]. In this context, it should be noted that foreign scholars and practitioners are increasingly hoping for the integration of augmented reality elements into the training of university programmes in philology and translation. Indiana University, in particular, has initiated one such project, which involves the multidimensional deployment of elements of AR technology that can meet precisely the specific needs of these programmes in the form of individual modules: “We plan on compiling the following learning modules 1) listening comprehension; 2) pronunciation practice; 3) animated 2D and 3D vocabulary introduction; 4) vocabulary quizzes; 5) roleplay dialogues where students interact with an avatar and 6) videos with cultural content, geography, and history. In contrast to other digital technologies available at IU, such as embedded videos in Canvas, we will be able to bring real objects into language classrooms, such as cultural artifacts, culinary samples, maps and other objects, and connect them virtually to an augmented world” [13,15].

According to Terry Lamb and Hayo Reinders, in order to provide students with easy access to learning materials during offline foreign language learning, it is advisable to create an appropriate

e-learning environment. The main aim is to support students in their self-directed learning by structuring self-study by providing a recommended sequence of steps, providing students with information on learning strategies and conducting electronic monitoring of student work, with advice if necessary [16, 17].

Researchers whose academic work is related to foreign language teaching point out that special attention should be paid to the development of students' responsibility; otherwise, the learning process will not be successful [17]. Ivan Moore even points out that student autonomy begins with students taking responsibility for both the process and the results of their learning: "In doing this: They can identify their learning goals (what they need to learn), their learning processes (how they will learn it), how they will evaluate and use their learning; they have well-founded conceptions of learning, they have a range of learning approaches and skills, they can organize their learning, they have good information processing skills, they are well motivated to learn" [18].

David Little considers it likely that in the next few years much of the research on student autonomy will focus on the impact of autonomous learning, particularly when learning a foreign language, on everyone involved – students, teachers and educational systems in general. According to the researcher, the role of the teacher is to create and support a learning environment in which students can be autonomous. The development of their learning skills cannot be completely separated from the learning content, since learning how to learn a foreign language differs from learning other courses in some important respects [19].

At the same time, as the above list of issues examined by scholars from various countries shows, autonomous learning, in particular the learning of foreign languages, is associated by many with the using information technologies and the search for new approaches, not the least of which are nowadays augmented, virtual and mixed reality [20, 21]. Ozlem Yagcioglu, focusing his research on new approaches to student autonomy in language learning [22], relies on UNESCO's declared role of information and communication technologies in learning: "Information and communication technology (ICT) can complement, enrich and transform education for the better" [23]. Some academics, while extremely appreciative of the potential of augmented and virtual reality in learning, have expressed concerns about whether the education system is ready for the fundamental changes in the educational process that arise from these technologies, or even their elements. Carlos J. Ochoa Fernandez sees augmented and virtual reality as a new challenge for education [24].

Given the importance of the factors for organising offline foreign language learning identified in the reviewed studies (students' motivation, choice and access to learning material, skills and strategies for offline learning, use of information technology, AR-technology), we consider it advisable to introduce the use of augmented reality elements in this process, which can provide the above aspects. In previous studies to determine the possibilities of using AR technology in the process of learning a foreign language, a number of advantages of using elements of this technology have been identified: the involvement of different channels of information perception, the integrity of the representation of the studied object, faster and better memorization of new vocabulary, etc. [25]. The study of a certain section of a foreign language's vocabulary – domain-specific terminology – is relevant both for specialists studying a foreign language and for translators who plan to translate the field. Therefore, continuing our research, we will focus on autonomous learning activities using AR technology in terminology work, which is the initial phase for several possible directions of further development of the educational process – language learning, scientific and technical translation, mastering automated translation systems [26].

The purpose of this paper is to consider the possibility of using interactive semantic networks as elements of augmented reality in the process of autonomous learning to improve the technological training of translators in the aspect of creating domain-specific terminology bases for their further use in foreign language learning and mastering automated translation systems.

3. Result and discussion

Translation education at the current stage necessarily involves technological training of translators, which aims to develop competencies in the use of modern tools and techniques of translation, based on the use of information technologies. An important part of this training is for translators to acquire skills in working with electronic terminology resources, such as searching, structuring, storing, using terminology in computer-assisted translation (CAT) systems, computer-assisted interpreting (CAI) systems, interactive foreign language learning systems and the like. The search for effective technological training for translators is becoming increasingly urgent, but is complicated by the emergence of new tools and the rapid growth of their number. At the same time, there is a trend towards the increasing use of cloud services and online resources. All this makes it necessary to constantly update the content of the educational programme components. One of the ways of solving this problem could be the implementation of augmented reality elements into the educational process [27–29]. The application of augmented reality (AR) technology will allow students to find and obtain the necessary information more quickly, which can be presented in symbolic, audio, graphic or animated form [30, 31]. The use of such technology will be particularly effective in off-line learning, as its peculiarity is the absence of constant direct contact with the teacher and, consequently, the possible complications of acquiring certain knowledge [32–37]. This necessitates a search for augmented reality technologies that were primarily aimed at building professional skills [38–41], particularly in the case of autonomous learning for translators in their technological training.

3.1. Technology for selecting and structuring domain-specific terminology based on interactive semantic networks

One of the options for using augmented reality elements in the technological training of translators can be developed by us the technology of selecting and structuring domain-specific terminology based on interactive semantic networks for their further use in the study of foreign languages and mastering automated translation systems. A schema of this technology based on interactive semantic networks is shown in figure 1. This technology is designed to be used in the learning process by undergraduate students who have already acquired the skills of working with CAT and CAI [42]. In developing it, we used existing interactive semantic networks, which are new online services and have only become available for use in the last few years. In particular, one such service has been developed in the framework of the EU Terminology as a Service (TaaS) project. The goal of the TaaS project was to provide operational access to up-to-date terms based on the exchange of multilingual terminology data and to create effective mechanisms for the reuse of terminology resources.

According to the developed technology (figure 1), the initial step is to use interactive semantic networks for the selection and structuring of domain terminology, which consists in the possibility of defining a semantic field within a certain domain to identify terminological entities for integration in the terminological database of the respective domain. In this case, to initialise the algorithm for the student's construction of his/her individual semantic network, he/she only needs to decide on any source term that relates to the domain with which he/she plans to work on the basis of the created terminological base. This term is entered into the relevant elements of the interface and a hierarchical structure of the semantic field with multi-level relationships between its elements is formed around it by means of the search engine of the interactive semantic network. In this way, the student is at the outset provided with a defined set of directions, each of which opens up a separate terminology pathway. At the same time, the system provides easy and clear visual identification of the elements in their hierarchical order and the different types of links between them. Figure 2 shows the initial phase of building a personalised interactive semantic network based on the original term 'vegetable growing'.

Further action should be taken by the student to develop the semantic network in one or

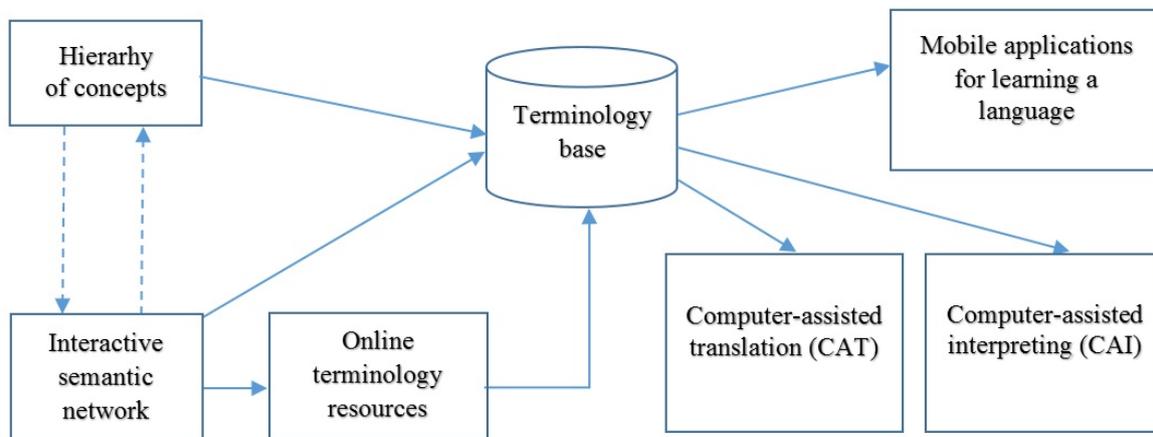


Figure 1. The scheme of technology for selecting and structuring domain-specific terminology based on interactive semantic networks for further use in foreign language learning and mastering computer assisted translation systems.

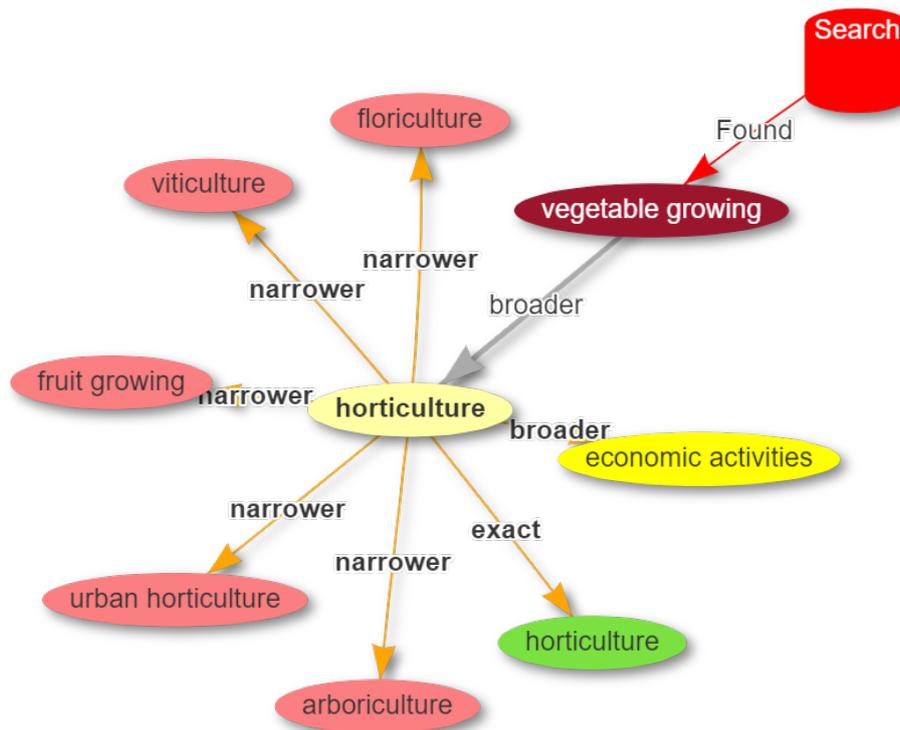


Figure 2. Initial phase of creating a personalised interactive semantic network based on the source term “vegetable growing”.

more directions that are appropriate for his or her individual task. The types of links between the elements of the network, which indicate the hierarchical relationship between them, can help the student to decide on the appropriate direction. In particular, the system can automatically establish four types of such links: exact, broader, narrower, related. The exact type of link means that it is an exact match or synonymy. In terms of moving along the development of

a network with such a link, the system can provide additional opportunities to obtain search results in the form of related terms. Using the network development direction of the broader link, the student will be able to further search for terms at a higher hierarchical level of concepts and move to related domains, which will contribute to his/her understanding of the integrity of a particular domain. A ‘narrower’ link will allow the student to build a network in the narrower direction of the field and access a list of terms that under other circumstances he/she might have obtained after a lengthy search in the relevant reference books. This is an important aspect of using such online networks, given that the translator is usually not an expert in a particular domain and therefore cannot have a detailed understanding of the terminological vocabulary of that domain. Given the development of the network to cover a wider terminological spectrum, it is advisable to move along the related type links. The results of the development of the individual interactive semantic network in different directions depending on the type of linkage are shown in figure 3.

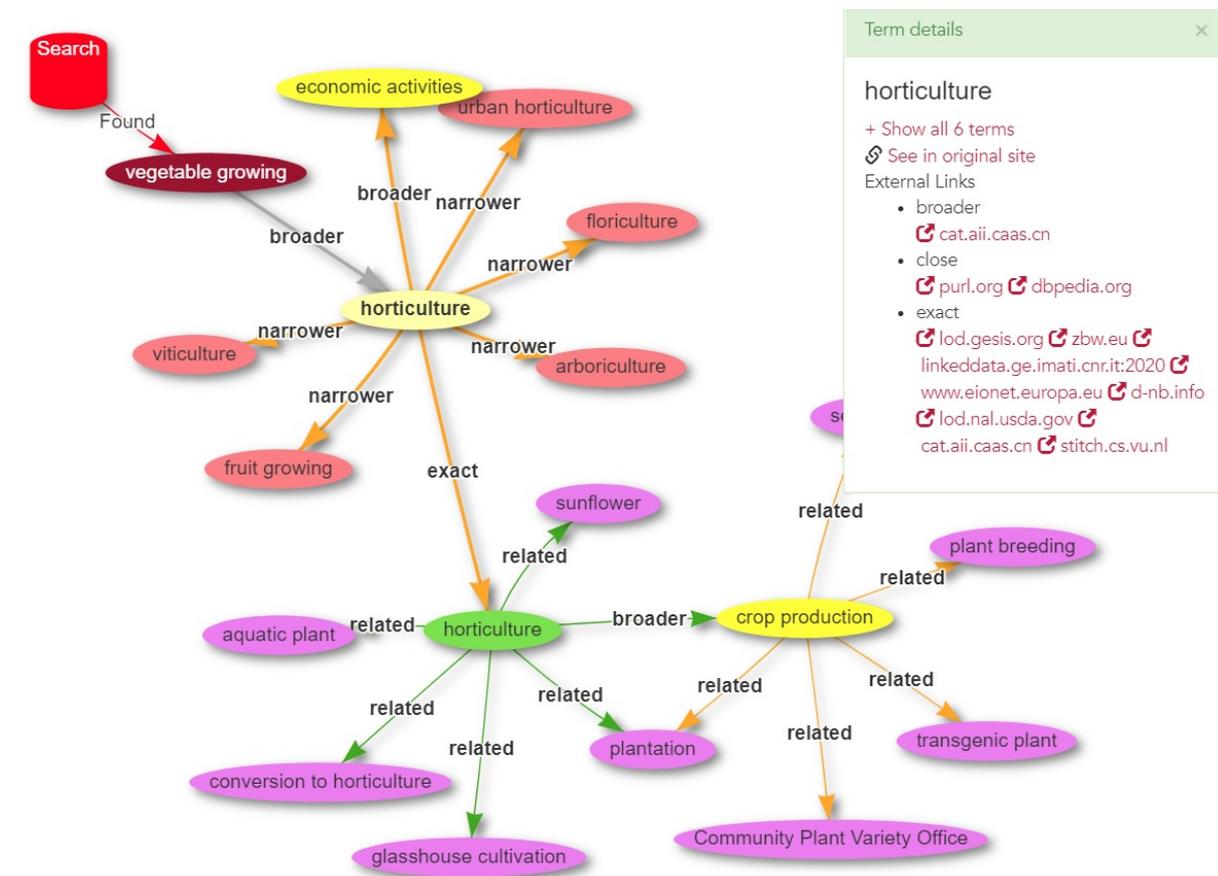


Figure 3. A individual interactive semantic network, developed along different lines depending on the type of relationship.

At this stage in the implementation of the technology for selecting and structuring sector-specific terminology based on interactive semantic networks, students can already begin to extract selected terms from the constructed network and place them into the terminology database. In doing so, the students must be made familiar with the criteria we have defined for creating and completing terminology bases in which it is appropriate to structure domain-specific terminology derived from interactive semantic networks. In defining the criteria, we were guided primarily by the possibility of further use of terminology bases for such purposes

as: learning foreign languages using mobile applications, mastering Computer Aided Translation (CAT) systems, mastering Computer Aided Interpretation (CAI) systems, which corresponds to the logic of the developed technology. To such criteria, we have classified:

- universality (ability to meet the need for terminological support for different processes directly or with minimal modification),
- structurability (possibility of placing terms), synonyms, matches and other additional information to the term in compliance with generally accepted principles,
- convertibility (the ability to convert to other formats for the needs of other systems without changing the structure and content),
- extensibility (the possibility of changing the structure of the database to accommodate additional information in the entry at any stage of its completion, without loss of data).

After being introduced to these criteria, the students had to decide on their own about the software to create the terminology database, the format of the database and its initial structure. The autonomy given to the students to make such decisions was due to their experience with CAT and CAI and therefore with the terminology bases used in such systems.

However, using the specialised functions of the interactive semantic networks, the students were able to obtain extended information about the terms defined for entry into the terminology base, if necessary. This toolkit is based on the interactive use of online resources that can be accessed via external links and which concentrate a considerable amount of terminology indicating its affiliation to a domain, its interpretation, definitions of terms, their matching, etc. (see figure 3). The online resources used include powerful bases such as: Interactive Terminology for Europe (IATE), General Multilingual Environmental Thesaurus (GEMET), National Agricultural Library's Agricultural Thesaurus and Glossary, LusTRE (multilingual Thesaurus Framework), TAUS (The language data Network) etc.

Using the resources of such databases makes it possible to extend the content of terminology bases beyond the simple structure, containing only terms and their matches, to the use of extended information. In particular, the extension of each terminology entry with additional information such as domain, definition, synonyms, etc. (figure 4) contribute to increasing their informative value. They can be useful when such databases are used with automated translation systems. In this case, the terminology databases should be structured with appropriate fields for structuring such information.

In the list of links to external online resources generated by the interactive semantic network, there can also be resources containing additional information in the form of multimedia documents, electronic documents, videos, books, images (figure 5). The value of such resources in autonomous learning lies not only in the selection of terminology for terminology bases, but more in the opportunity to understand in detail the nature of the term, the context of its use, and to form an idea of defining the object. With this technology of using semantic networks, students are able to learn more about the objects of a particular domain through a terminological apparatus without being overloaded with redundant information.

It is important to note that a developed interactive semantic network can be automatically converted into another format for displaying its elements, namely by hierarchical structure (figure 6). This format of presenting the network allows students to enhance their ability to explore the constructed network in terms of the interrelationship of its elements, in particular in the aspect of distinguishing more general concepts from highly specialised vocabulary.

According to the scheme of technology for selecting and structuring sector-specific terminology (figure 1), working in the Hierarchy of concepts representation of the interactive semantic network, students can also extract terms from it and add them to the terminology base, but without the possibility of obtaining additional information from the online resources.

The screenshot shows the USDA NAL Agricultural Thesaurus and Glossary interface. On the left, there is a search sidebar with fields for 'Search term or text to match', 'Language' (set to English), 'Search method' (set to 'Terms which contain this character'), and 'Number of terms to display' (set to 200). A 'Search the Thesaurus' button is at the bottom of the sidebar. The main content area is titled 'Thesaurus Search Results' and features the term 'horticulture' in a large font. Below the term, there are sections for 'Subject Category' (Plant Science and Plant Products), 'Definition' (Horticulture is defined as that branch of agriculture concerned with growing plants that are used by people for food, for medicinal purposes, and for aesthetic gratification.), 'Definition Source' (Agricultural Marketing Service, USDA), 'RDF/XML Format' (http://lod.nal.usda.gov/nalt/18.rdf), 'Persistent URI' (http://lod.nal.usda.gov/nalt/18), 'Broader Term' (Plant Science and Plant Products), and 'Narrower Term' (arboriculture, bonsai, citrusiculture). On the right side, there is a 'Change Display' section with a 'Show Term Hierarchy' link, and a 'Search for this Term' section with links to 'Google Scholar', 'AGRICOLA Articles', and 'AGRICOLA Books'.

Figure 4. Structure of the presenting additional information on the term “horticulture” in the online resource “National Agricultural Library’s Agricultural Thesaurus and Glossary”.

3.2. Experimental testing of the use of interactive semantic networks in translator training

In order to identify the possibilities and ways of using interactive semantic networks in the process of technological training of translators, we conducted a survey of students who were asked to experience them while they were in distance learning, which created a situation of autonomous learning. 38 students took part in this type of experiential learning, learning how to create terminology bases with a view to their future use in foreign language learning using mobile applications and mastering the use of computer-assisted translation systems. The questionnaire used for the survey contained 11 questions and provided two alternative answers to each question – “Yes” or “No”. The content of the questionnaire, as well as summarised quantitative data on the responses, are shown in table 1.

The responses to the first question show a positive effect on the learning of domain-specific terminology bases precisely in the aspect of term identification and selection technology in the lack of an in-depth understanding of the domain. This was made possible precisely using interactive semantic networks, as indicated by 78.9% of the students. A convincing proof of the effectiveness of interactive semantic networks was the responses to the second question of the questionnaire, as 84.2% of the students owe it to them to be able to identify related concepts and terms related to a certain source term. In other words, only 15.8% of the students could identify the lexical field of certain terms based on their own prior knowledge in a certain field.

The high number of affirmative responses to the third question (81.6%) is most likely due to the easier perception of information presented in visual form, which is generally an effective support for autonomous learning. In particular, the functionality of the interactive network to visually reproduce the terms of a particular area and the relationships between them contributed to an understanding of its integrity, even at an early stage of familiarity with it.

In addition, the use of an interactive semantic network to highlight terms of a particular domain allowed the students to detail the elements of the terminological system in the right

The screenshot shows the BnF Data interface for the term "Horticulture". At the top, there is a search bar with the text "search data.bnf.fr" and a magnifying glass icon. Below the search bar, the word "Horticulture" is displayed in a large font, followed by a small icon of a pencil. Underneath, there is a small image of a garden. To the right of the image, the following metadata is listed:

- Topic: Horticulture
- Source file: RAMEAU
- Field: Agriculture, Pêche
- Variant subject headings: Orticoltura (italien), Plantes cultivées - Cultures, Plantes - Cultures

 Below this, there are three sections of related resources:

- related to this theme** (11 resources in data.bnf.fr): This section contains three sub-lists: "Broader concept (1)" with "Agriculture", "Narrower concept (3)", and "Related Terms (7)".
- Documents on this topic** (256 resources in data.bnf.fr): This section contains five sub-lists: "Multimedia documents (1)", "Videos, films (7)", "Electronic documents (7)", "Books (217)", and "Pictures (24)".

Figure 5. Structure of presentation of additional information about the term “horticulture” in online resources in the form of multimedia and electronic documents, videos, books, images.

direction quite effectively, as reported by 73.7%. This kind of activity is directly related to the filling of terminology bases and would have required significantly more time if done by other means.

The availability of an automated function in the interactive semantic network to generate relationships between terms across the four hierarchical levels proved to be an effective tool for 76.3% of the students, who indicated that it allowed them to identify the right set of terminology data to add to the terminology database aimed at solving a specific problem.

The responses to the questions on the software that the students used to create the terminology bases can be explained by the influence of two factors, namely the availability for use of a particular software product and the level of proficiency in it. The fact that 68.4% of students chose MS Excel to create and complete their terminology databases, confirms the fact that the programme is commonly available and the experience of using it is acquired not only in the study of specialised courses, but also in previous phases of mastering information technologies. However, it is important that 21.1% of the students created terminology bases using specialised modules designed to generate such bases when working with CAT systems. This indicates that a fairly large proportion of students have not only mastered these modules to a level which has enabled them to carry out such operations at a higher technological level, but are also aware of possible ways of obtaining and using them. It is important to note that although only 10.5% of students reported using the functionality of CAI systems to create and complete a terminology base, but due to the relatively low prevalence of such systems, this indicates that students valued certain aspects of these systems and gave them preference over

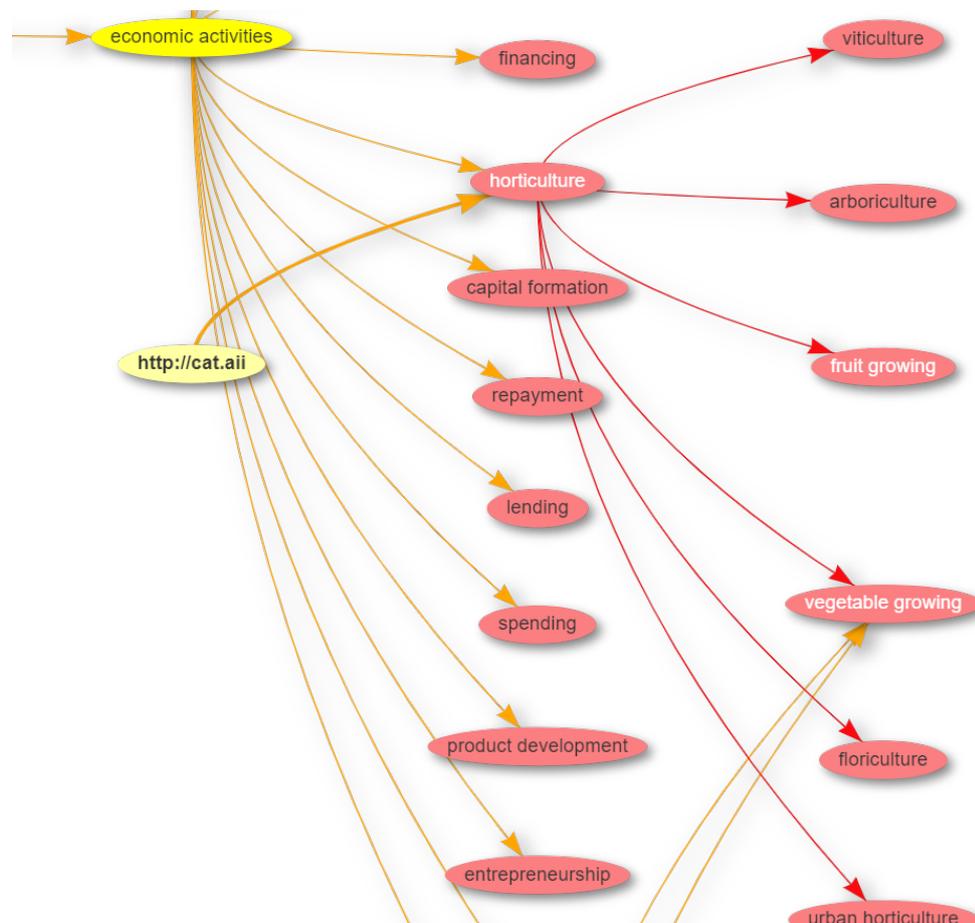


Figure 6. Presentation of the created interactive semantic network with a hierarchical structure.

others.

Judging by the responses to the question about finding and using additional information about terms, more than a third of the students used the available potential of interactive semantic networks for this purpose. This is an indication that some of the students were not only forming terminological bases, but also trying to understand the essence of the industry in more depth. Analysing the high number of “No” responses (86.8%) regarding the need to modify the structure of the database in order to expand it, it can be stated that the students had sufficient experience in designing the structure of the terminology bases during the creation phase. This allowed them to predict the necessary fields for concentrating the information available in the semantic network about the term entered in such a way that, in the vast majority of cases, they met the requirements.

Overall, the results of the survey indicate the potential of interactive semantic networks in the process of technological training of translators, in particular for forming terminological bases for their further use in learning foreign languages and mastering automated translation systems.

4. Conclusions

In the process of technological training of translators, it has been found that it is advisable to implement elements of augmented reality in order to increase its efficiency. One of these elements can be interactive semantic networks, the technology of using which for the selection and structuring of industry terminology we have developed and tested in the conditions of

Table 1. Results of a student questionnaire on the using interactive semantic networks.

Question	Response rate	
	Yes	No
Did the use of interactive semantic networks help you acquire the skills to create domain-specific terminology bases?	78.9	21.1
Has the use of interactive semantic networks contributed to the identification of related concepts and terms associated with a particular source term?	84.2	15.8
Has the visualised representation of the interactive semantic network contributed to an understanding of the integrity of a particular field in which you are not an expert?	81.6	18.4
Has the use of an interactive semantic network enabled you to understand better the range of components of a particular field in order to detail terminology in the right direction?	73.7	26.3
Does the presence of established relationships between the different hierarchical levels in the interactive semantic network help to outline a terminology dataset for input into the terminology database according to a certain logic?	76.3	23.7
Have you used MS Excel to create and complete your terminology database?	68.4	31.6
Have you used specialised CAT system modules to create and complete your terminology base?	21.1	78.9
Have you used the functionality of CAI systems to create and complete your terminology base?	10.5	89.5
Did you fill your terminology database with additional information about the terms entered?	34.2	65.8
Have you used the specialised functions of interactive semantic networks to find more information about terms?	39.5	60.5
Have you needed to change the structure of your base in order to expand it?	13.2	86.8

autonomous learning. This technology allows:

- create a personalised, interactive semantic network to form a domain-specific terminology base,
- to develop a personalised, interactive semantic network along various lines, depending on the need for detailing and structuring domain-specific terminology,
- to select domain-specific terminology on the basis of its detailing, taking into account the types of hierarchical relationships of the interactive semantic network,
- to get more information about terms through the interactive use of external online resources, the links to which are automatically generated by the created semantic networks,
- to investigate the generated semantic networks in the aspect of distinguishing more general concepts from highly specialised vocabulary.

To structure the domain terminology selected on the basis of interactive semantic networks we defined the criteria of creation and filling terminological bases, with possibility of their further use for foreign language learning with mobile applications, mastering computer aided translation (CAT) systems, mastering computer aided interpretation (CAI). These criteria are universality, structurability, convertibility, extensibility.

The experimental use of the developed technology in the process of autonomous training of translators has shown a positive influence on their technological training, in particular in

the aspect of the ability to define and select terms when there is no deep understanding of the domain, to detail elements of the terminological system in the right direction, to create terminological bases on the basis of selection and detailing of terms using interactive semantic networks.

References

- [1] Semerikov S, Chukharev S, Sakhno S, Striuk A, Osadchyi V, Solovieva V, Vakaliuk T, Nechypurenko P, Bondarenko O and Danylchuk H 2020 *E3S Web of Conferences* **166** 00001
- [2] Burov O, Kiv A, Semerikov S, Striuk A, Striuk M, Kolgatina L and Oliinyk I 2020 *CEUR Workshop Proceedings* **2731** 1–46
- [3] Shokaliuk S, Bohunencko Y, Lovianova I and Shyshkina M 2020 *CEUR Workshop Proceedings* **2643** 548–562
- [4] Syvyi M, Mazbayev O, Varakuta O, Panteleeva N and Bondarenko O 2020 *CEUR Workshop Proceedings* **2731** 369–382
- [5] Ponomareva N S 2021 *Journal of Physics: Conference Series* **1840** 012035
- [6] Polhun K, Kramarenko T, Maloivan M and Tomilina A 2021 *Journal of Physics: Conference Series* **1840** 012053
- [7] Bobyliev D Y and Vihrova E V 2021 *Journal of Physics: Conference Series* **1840** 012002
- [8] Velykodna M 2021 *Psychodynamic Practice* **27** 10–28
- [9] Tkachuk V, Yechkalo Y, Semerikov S, Kislova M and Hladyr Y 2021 Using Mobile ICT for Online Learning During COVID-19 Lockdown *Information and Communication Technologies in Education, Research, and Industrial Applications* ed Bollin A, Ermolayev V, Mayr H C, Nikitchenko M, Spivakovsky A, Tkachuk M, Yakovyna V and Zholtkevych G (Cham: Springer International Publishing) pp 46–67 ISBN 978-3-030-77592-6
- [10] Benson P 2004 Autonomy and information technology in the educational discourse of the information age *Information technology and innovation in language education* ed Davison C (Hong Kong: Hong Kong University Press) pp 173–192
- [11] Cotterall S 2000 *ELT Journal* **54** 109–117
- [12] Hurd S, Beaven T and Ortega A 2001 *System* **29** 341–355
- [13] Murphy L 2006 Supporting learner autonomy in a distance learning context *Learner autonomy 10: Integration and support* ed Gardner D (Dublin: Authentik) pp 72–92
- [14] Pemberton R, Li E S, Or W W and Pierson H D (eds) 1996 *Taking Control: Autonomy in Language Learning* (Hong Kong University Press)
- [15] Scrivner O, Madewell J, Buckley C and Perez N 2016 Augmented reality digital technologies (ARDT) for foreign language teaching and learning *2016 Future Technologies Conference (FTC)* pp 395–398
- [16] Lamb T and Reinders H 2006 *Supporting Independent Language Learning* (Bern, Switzerland: Peter Lang)
- [17] Scharle A and Szabó A 2007 *Learner autonomy: A guide to developing learner responsibility* (Cambridge: Cambridge University Press)
- [18] Moore I What is learner autonomy? URL <http://extra.shu.ac.uk/cet1/cpla/whatislearnerautonomy.html>
- [19] Little D 2004 Learner autonomy and second/foreign language learning URL <https://www.llas.ac.uk/resources/gpg/1409>
- [20] Liu D, Dede C, Huang R and Richards J (eds) 2017 *Virtual, Augmented, and Mixed Realities in Education* (Singapore: Springer)
- [21] Schmenk B 2005 *TESOL Quarterly* **39** 107–118
- [22] Yagcioglu O 2015 *Procedia - Social and Behavioral Sciences* **199** 428–435
- [23] UNESCO ICT in education URL <https://en.unesco.org/themes/ict-education>
- [24] Ochoa C 2016 Virtual and augmented reality in education. Are we ready for a disruptive innovation in education? *ICERI2016 Proceedings* 9th annual International Conference of Education, Research and Innovation (IATED) pp 2013–2022 ISBN 978-84-617-5895-1 URL <http://dx.doi.org/10.21125/iceri.2016.1454>
- [25] Tarasenko R, Amelina S, Kazhan Y and Bondarenko O 2020 *CEUR Workshop Proceedings* **2731** 129–142
- [26] Tarasenko R, Amelina S and Azaryan A 2020 *CEUR Workshop Proceedings* **2643** 360–375
- [27] Nechypurenko P, Starova T, Selivanova T, Tomilina A and Uchitel A 2018 *CEUR Workshop Proceedings* **2257** 15–23
- [28] Nechypurenko P, Stoliarenko V, Starova T, Selivanova T, Markova O, Modlo Y and Shmeltser E 2020 *CEUR Workshop Proceedings* **2547** 156–167
- [29] Kiv A, Shyshkina M, Semerikov S, Striuk A and Yechkalo Y 2020 *CEUR Workshop Proceedings* **2547** 1–12
- [30] Zinonos N, Vihrova E and Pikilnyak A 2018 *CEUR Workshop Proceedings* **2257** 87–92
- [31] Striuk A, Rassovytska M and Shokaliuk S 2018 *CEUR Workshop Proceedings* **2104** 412–419
- [32] Kolomoiets T and Kassim D 2018 *CEUR Workshop Proceedings* **2257** 237–246

- [33] Kramarenko T, Pylypenko O and Zaslavskiy V 2020 *CEUR Workshop Proceedings* **2547** 130–144
- [34] Lavrentieva O, Arkhypov I, Kuchma O and Uchitel A 2020 *CEUR Workshop Proceedings* **2547** 201–216
- [35] Lavrentieva O, Arkhypov I, Krupskiy O, Velykodnyi D and Filatov S 2020 *CEUR Workshop Proceedings* **2731** 143–162
- [36] Tkachuk V, Yechkalo Y, Semerikov S, Kislova M and Khotskina V 2020 *CEUR Workshop Proceedings* **2732** 1217–1232
- [37] Shepiliev D S, Semerikov S O, Yechkalo Y V, Tkachuk V V, Markova O M, Modlo Y O, Mintii I S, Mintii M M, Selivanova T V, Maksyshko N K, Vakaliuk T A, Osadchyi V V, Tarasenko R O, Amelina S M and Kiv A E 2021 *Journal of Physics: Conference Series* **1840** 012028
- [38] Mintii I and Soloviev V 2018 *CEUR Workshop Proceedings* **2257** 227–231
- [39] Zelinska S, Azaryan A and Azaryan V 2018 *CEUR Workshop Proceedings* **2257** 204–214
- [40] Rashevskaya N and Soloviev V 2018 *CEUR Workshop Proceedings* **2257** 192–197
- [41] Rashevskaya N, Semerikov S, Zinonos N, Tkachuk V and Shyshkina M 2020 *CEUR Workshop Proceedings* **2731** 79–90
- [42] Tarasenko R and Amelina S 2020 *CEUR Workshop Proceedings* **2732** 1012–1027