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RAPORT FINAL DE CERCETARE
5 Decembrie 2024

Proiect de cercetare:
”Facilitarea accesului la educație prin realitatea augmentată şi stimularea învățării dinamice în afaceri prin microlearning”

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REZUMATUL CERCETĂRII

FACILITAREA ACCESULUI LA EDUCAŢ IE PRIN REALITATEA AUGMENTATĂ ŞI STIMULAREA ÎNVĂŢĂRII DINAMICE ÎN AFACERI PRIN MICROLEARNING

Cuvinte cheie: realitate augmentată, digitalizare, robotizare, machine learning, mediu de afaceri, mediu academic, TSA tulburare de spectru autist, microlearning

OBIECTIV GENERAL: Elaborarea de soluţii digitale bazate pe tehnologii avansate pentru facilitarea accesului la educaţie pe tot parcursul vieţii.

OBIECTIVE SECUNDARE

OS1: Realizarea unei aplicaţii bazată pe RA (Realitatea Augmentată) pentru facilitatea orientării în campus a tinerilor cu TSA (tulburare de spectru autist).

OS2: Analiza privind dezvoltarea unei platforme de Microlearning utilizând BPM (Business Process Modeling) și RPA (Robotic Process Automation) pentru perfecţionarea salariaţilor din mediul de afaceri.

IMPORTANŢA ŞI IMPACTUL OBIECTIVELOR PROPUSE

(OS1) Facilitarea accesului la educaţie avansată şi cercetare este misiunea unei universităţi pro active şi orientate către viitor. În acest sens interesul trebuie focalizat şi către categoriile de beneficiari cu nevoi speciale care trebuie integraţi în cele mai bune condiţii în mediul academic. Universitatea trebuie să ofere soluţii şi pentru categoriile cu dizabiliăţi cum ar fi studenţii cu TSA. Pentru dezvoltarea acestor soluţii se poate apela la Realitatea Augmentată (RA) prin aplicatii care să ofere diferite tipuri de suport, precum şi la procese de robotizare a învăţării. Multe universități folosesc aplicații AR ca o modalitate alternativă pentru ca studenții să exploreze campusul, economisind astfel resurse universitare, cum ar fi timp și bani, deoarece această metodă nu necesită personal pentru efectuarea tururilor campusului.

(OS2) Implementarea de soluții de microlearning este răspândită într-o gamă largă de domenii de afaceri, dar există câteva domenii care au adoptat mai intens această tehnologie datorită nevoii lor de instruire rapidă și eficientă a personalului. Business Process Modeling (BPM) este o tehnică utilizată pentru a reprezenta și analiza activitățile, procesele și fluxurile de lucru ale unei organizații în scopul îmbunătățirii eficienței, eficacității și performanței generale. Business Process Modeling (BPM) este o tehnică utilizată pentru a reprezenta și analiza activitățile, procesele și fluxurile de lucru ale unei organizații în scopul îmbunătățirii eficienței, eficacității și performanței generale.

CONTRIBUȚIILE CERCETARII (OS1)

Facilitarea Accesului la Educație Avansată și Cercetare pentru Studenții cu TSA prin Aplicații de Realitate Augmentată

O universitate proactivă și orientată spre viitor are misiunea de a facilita accesul la educație avansată și cercetare pentru toți studenții, inclusiv pentru cei cu dizabilități. Printre aceştia, studenții cu Tulburări din Spectrul Autismului (TSA) reprezintă o categorie cu un potențial intelectual semnificativ, capabilă să contribuie la progresul științific atunci când beneficiază de sprijin adecvat. Recunoscând acest lucru, universitățile trebuie să asigure accesibilitate și resurse personalizate pentru a permite acestor studenți să-și dezvolte abilitățile și să exceleze academic.

Evoluția Conceptuală și Practică: Acest studiu explorează utilizarea Realității Augmentate (AR) ca instrument inovator pentru îmbunătățirea accesibilității și incluziunii în mediile academice. Aplicațiile AR pot oferi suport personalizat și pot facilita procesele de învățare robotizată, răspunzând nevoilor specifice, cum ar fi orientarea în spații necunoscute – o provocare frecventă pentru persoanele cu TSA. Prin îmbinarea progreselor tehnologice cu incluziunea educațională, universitățile pot acomoda mai bine acești studenți, valorificându-le potențialul intelectual și contribuția la cercetare și societate.

Metodologia Cercetării: Cercetarea îmbină o revizuire calitativă a literaturii de specialitate cu o analiză empirică, pentru a explora aspectele critice privind utilizarea AR pentru studenții cu TSA.

Impactul Cercetării este triplu: -științific: îmbogățește literatura de specialitate oferind o bază solidă pentru explorări ulterioare în domeniul AR și al incluziunii pentru studenții cu TSA; *-aplicativ:* promovează potențialul implementării soluțiilor inovatoare AR, reducând decalajele dintre progresele teoretice și aplicațiile practice; *-informativ:* Crește gradul de conștientizare în rândul publicului larg și consolidează înțelegerea comunității asupra eforturilor și realizărilor din acest domeniu revoluționar, întărind rolul universității ca lider în educația și cercetarea incluzivă.

Rezumatul Concluziilor: Realitatea augmentată (AR) are un potențial semnificativ, evidențiat atât de cercetători, cât și de tendințele statistice privind adoptarea acestei tehnologii. Aplicația propusă se așteaptă să fie un real succes datorită unor avantaje evidente, precum utilizarea unui dispozitiv mobil deja deținut de majoritatea tinerilor (smartphone), rularea directă într-un browser web fără a necesita instalare (eliminând consumul de resurse) și furnizarea de informații valoroase prin simpla orientare a camerei spre diverse ținte.

Orientarea în spații noi, precum campusurile universitare, poate fi dificilă atât pentru persoanele cu dezvoltare neurologică normală, cât și pentru cele cu nevoi speciale, cum ar fi persoanele cu tulburări din spectrul autismului (TSA). O soluție de ghidare poate aduce un sprijin considerabil. Analiza studiilor și aplicațiilor existente evidențiază necesitatea unei astfel de soluții, iar rezultatele obținute din cercetările anterioare indică faptul că aplicația propusă poate aduce o contribuție reală.

O universitate orientată spre viitor trebuie să fie incluzivă și flexibilă pentru toți studenții, indiferent de nevoile lor speciale. Oferind suport individualizat și creând un mediu academic incluziv, universitățile pot contribui la dezvoltarea și succesul tuturor studenților, inclusiv a celor cu TSA.

În concluzie, lucrarea propune un model pilot de cercetare adaptat, realizat printr-un experiment original, bazat pe o aplicație mobilă inteligentă cu tehnologie AR. Relevanța introducerii tehnologiei AR pentru a aborda problema specifică a accesului la educație avansată pentru studenții cu TSA este argumentată solid.

Augmented Reality App Solution For Smart Campus Navigation

Aplicația prezentată în articol demonstrează potențialul realității augmentate (AR) de a transforma semnificativ experiența utilizatorilor în medii complexe, oferind o alternativă dinamică și interactivă la soluțiile tradiționale, precum semnele fizice sau hărțile statice. Prin intermediul ARway SDK, aplicația utilizează tehnologii avansate, precum SLAM, viziunea computerizată și capacitățile hardware ale dispozitivelor mobile, pentru a crea o hartă digitală a campusului, accesibilă direct de pe dispozitivul utilizatorului.

Avantaje și contribuții: Orientare intuitivă și eficientă, Adaptabilitate și scalabilitate, Reduce dependența de sisteme fizice complexe, oferind în schimb un instrument digital modern, care poate fi actualizat rapid.

CONTRIBUȚIILE CERCETARII (OS2)

„Îmbunătățirea Operațiunilor de Afaceri prin Microlearning, BPM și RPA”

Acest articol investighează impactul tehnologiilor emergente precum microlearning, Business Process Modelling (BPM) și Robotic Process Automation (RPA) asupra operațiunilor de afaceri. Articolul subliniază importanța integrării acestor tehnologii pentru a adresa nevoile afacerilor moderne, oferind soluții adaptate dinamicii actuale.

Sinergia între microlearning, BPM și RPA:

Integrarea microlearning-ului cu Business Process Modeling (BPM) și Robotic Process Automation (RPA) oferă o abordare inovatoare pentru optimizarea

operațiunilor de afaceri, combinând învățarea eficientă și personalizată cu tehnologii avansate pentru îmbunătățirea proceselor administrative și educaționale.
Această strategie este ideală pentru medii de afaceri care prioritizează agilitatea, eficiența și învățarea continuă.

Rolul BPM în educație și afaceri:

Business Process Modeling este esențial în curriculum-ul educațional pentru dezvoltarea competențelor de afaceri prin integrarea teoriei cu aplicații practice ale instrumentelor BPM, colaborare cu industria și dezvoltarea abilităților tehnice și interpersonale.

Analiza bibliometrică poziționează BPM ca un punct central al cercetării, evidențiind conexiunile sale cu proces mining și simulare, subliniind creșterea utilizării analizei de date în proiectarea fluxurilor de lucru și sistemelor informaționale.

Impactul RPA asupra automatizării:

Robotic Process Automation (RPA) revoluționează automatizarea sarcinilor prin integrarea tehnologiilor avansate precum inteligența artificială (AI), învățarea automată (ML), procesarea limbajului natural (NLP) și recunoașterea optică a caracterelor (OCR). RPA permite automatizarea sarcinilor complexe care implică luarea de decizii, sporind eficiența operațională și satisfacția clienților, contribuind și la personalizarea experiențelor educaționale. Analiza bibliometrică subliniază rolul crucial al "automatizării inteligente" și sugerează direcții de cercetare pentru dezvoltarea algoritmilor avansați de optimizare a proceselor.

Microlearning și educația modernă:

Microlearning, susținut de BPM și RPA, transformă educația în afaceri, oferind soluții de învățare personalizate, eficiente și accesibile, adaptate nevoilor profesioniștilor moderni. Corelat cu tendințe precum învățarea mobilă, e-learning și blended learning, microlearning îmbunătățește metodele educaționale tradiționale, având aplicații importante în educația superioară și medicală.

Legătura cu social media, gamificarea și adaptările la provocările pandemiei COVID-19 arată rolul său în soluții de învățare inovatoare, la distanță.

Viziune pentru viitor:

Integrarea acestor tehnologii conturează o cultură a învățării și îmbunătățirii continue, relevându-se ca o strategie semnificativă și adaptată provocărilor mediului de afaceri modern. Această abordare oferă o combinație puternică de inovație, tehnologie și eficiență, remodelând peisajul formării profesionale și al educației corporative.

Acest Proiect, derulat sub egida AOSR, a fost un suport motivațional de continuare a cercetării, un real sprijin financiar și un cadru stimulativ al dezvoltării personale. Vă mulțumim!

LIVRABILELE cercetării:

ARTICOLE in reviste x 2

1. Şoldan, B. R. S., & Bejinaru, R. (2023). **Investigating sustainable business ecosystems and the university role: a cluster analysis**. *Management Dynamics in the Knowledge Economy*, 11(3), 251-266.

2. TOMA, M.V. & BEJINARU, R. (2024, xxx). **Augmented Reality App Solution For Smart Campus Navigation**, ***SYSTEMS***, in curs de evaluare

ARTICOLE in volume ale conferintelor indexate ISI proceedings x 2

1. Bejinaru, R., & Toma, M. V. (2024). **AR Technology Potential for Facilitating Access to Advanced Education for Students with ASD.** In *Proceedings of the International Conference on Business Excellence* (Vol. 18, No. 1, pp. 1848-1856). Sciendo. LINK: https://sciendo.com/article/10.2478/picbe-2024-0155

2. BEJINARU, R. & TOMA, M.V. (2024). **Enhancing Business Operations Through Microlearning, BPM and RPA**, Proceedings of the International Conference on Business Excellence, Sciendo, VOLUME 18 (2024): ISSUE 1 (JUNE 2024). LINK: https://sciendo.com/article/10.2478/picbe-2024-0154

PARTICIPARI CONFERINTE x 9

1. Bejinaru, R., & Toma, M. V. (2024). **AR Technology Potential for Facilitating Access to Advanced Education for Students with ASD.** *In Proceedings of the International Conference on Business Excellence* (Vol. 18, No. 1, pp. 1848-1856). Sciendo. LINK: https://sciendo.com/article/10.2478/picbe-2024-0155 - participare fizica

2. BEJINARU, R. & TOMA, M.V. (2024). **Enhancing Business Operations Through Microlearning, BPM and RPA**, Proceedings of the International Conference on Business Excellence, Sciendo, VOLUME 18 (2024): ISSUE 1 (JUNE 2024). LINK: https://sciendo.com/article/10.2478/picbe-2024-0154 - participare fizica

3. Sesiunea Ştiinfica AOSR Tineri Cercetători Etapa 1, din data de 7 iulie 2023 – prezentarea rezultatelor cercetării proiectului.

4. TOMA, M.V. & BEJINARU, R. (2023). **Embracing diversity: Augmented Reality application for inclusive university campus navigation**, *Strategica International Conference*, 11th edition, 26-27.10.2023. - participare fizica , in curs de indexare WOS

5. TOMA, M.V. & BEJINARU, R. (2023). **Îmbrățișarea diversității: aplicație de realitate augmentată pentru navigarea incluzivă în campusul universitar**, *Sesiunea Ştiinţifică AOSR tineri cercetători - Etapa 2, 27 Noiembrie 2023.* - participare fizica

6. TOMA, M.V. & BEJINARU, R. (2023). **Augmenting the university campus: digital approach**, *VI International Scientific Congress - Society of Ambient Intelligence 20-25 Noiembrie 2023;* Panel Discussion "Regional business ecosystem involvement to digitalization and green transition and university's role", https://drive.google.com/file/d/1XI4FbJSE59wrtKAbbhOQnt8PB87DMQED/view

7. Sesiunea Ştiinfica AOSR Tineri Cercetători Etapa 3, din data de 5 iulie 2024 – prezentarea rezultatelor cercetării proiectului, - participare fizica

8. BEJINARU, R. & TOMA, M.V. (2024). **Increasing the efficiency of business operations through microlearning, BPM and RPA**, ***The 6th International Conference "Competitiveness and sustainable development"***, Technical University of Moldova, Chisinau, 7-8 November 2024.

9. Sesiunea Ştiinfica AOSR Tineri Cercetători Etapa 4, din 4 decembrie 2023 – prezentarea rezultatelor cercetării proiectului, - participare fizica

ANEXA 1_RAPORT FINAL INTEGRAL

RAPORT INTERMEDIAR DE CERCETARE_Nr.1
25 Iulie 2023

Conținutul acestui document prezintă sub forma unui raport intermediar rezultatele cercetărilor pe tema proiectului cu titlul *”Facilitarea accesului la educație prin realitatea augmentată şi stimularea învățării dinamice în afaceri prin microlearning”* pe durata celor 3 luni ale proiectului postdoctoral sub egida Academiei Oamenilor de Știință, din România, Filiala București.

Raportul intermediar conţine:
(A) un studiu introductiv al temei ce face obiectul prezentului contract, împreună cu dovada publicării în programul şi volumul conferinței;
(B) un studiu corelat cu tema proiectului din perspectiva trans disciplinară, împreună cu dovada acceptării spre publicare de către editura unei reviste stiintifice de specialitate cu afilierea la AOSR şi
(C) susţinerea unei prezentări cu rezultatele cercetării proiectului în cadrul Sesiunii Ştiinfice AOSR Tineri Cercetători Etapa 1, din data de 7 iulie 2023.

(A)

The 6th International Conference on Economics and Social Sciences

Geopolitical perspectives and technological challenges for sustainable growth in the 21st century

June 15-16, 2023
Bucharest University of Economic Studies, Romania

AR Technology Potential for Facilitating Access to Advanced Education for Students with ASD

Ruxandra BEJINARU[1]*, Marian-Vlăduț TOMA[2]

Abstract

Facilitating access to advanced education and research is the mission of a proactive and future-oriented university. The university must also direct its attention to categories with disabilities such as students with ASD (Autism Spectrum Disorders). For this purpose, Augmented Reality (AR) can be used through applications that offer different types of support, as well as learning robotization processes. Students with ASD have diverse intellectual potential and can significantly contribute to scientific progress. It is important that universities recognize the intellectual potential and talent of students with ASD and provide appropriate support and accessibility to develop their skills and achieve their academic and research performance. Throughout this paper, we aimed to point out aspects of critical importance from these categories: conceptual and practical evolution, influencing factors, advantages and difficulties, perspectives but also risks regarding the lack of action in this direction. This work integrates qualitative literature review research with empirical research. The literature analysis section highlights the extent to which universities provide adaptation and orientation facilities in new spaces, taking into account the difficulty of people with ASD to adjust to unfamiliar spaces. We will present, both based on the literature and from the practice of the field at a global level, the technologies and platforms used in the development of AR applications for orientation in space. The research conclusions have an impact towards at least three directions: 1. Scientific impact, respectively enriching the specialized literature with new perspectives transmitted in a clear, concise and targeted manner; 2. Applicative impact, increasing the potential of implementing innovations in this field; as well as 3. Informative impact on the general public, which contributes to broadening the spectrum of knowledge but also to strengthening the image in the local community of the efforts made by researchers in this revolutionary field of AR.

Keywords: AR technology, Autism Spectrum Disorder (ASD), advanced education, students' abilities, AR application, future-oriented university.

JEL Classification: I23, Q55, O32.

1. Introduction and problem statement

A forward-looking university should adopt a number of long-term strategic development directions to maintain its leading position in the field of education and to fulfil its mission of creating educational opportunities for students and the community (Bejinaru et al., 2018; Bratianu & Bejinaru, 2019; Neamtu et al., 2020). In tandem with global evolution, universities are forced to adapt to new technologies and integrate them into their learning and research processes (Bejinaru, 2019). For example, the use of Augmented Reality (AR) and Virtual Reality (VR) in the teaching and learning processes can improve the efficiency and quality of education. The university of the future will be described by attributes such as: inclusive, integrated, innovative, based on advanced technology, digital, accessible, flexible, and especially global (Friedman, 2008; Linton, 2018; Kapetanaki et al., 2022).

We consider that for the educational system in Romania, advanced technology is a bold purpose that is difficult to achieve on a large scale and research on the issue of increasing access to education for vulnerable categories (such as people with disabilities, or ASD) through AR is almost non-existent, as we have not identified specific publications carried out in our country.

2. Concept and evolution of Augmented Reality (AR) technology

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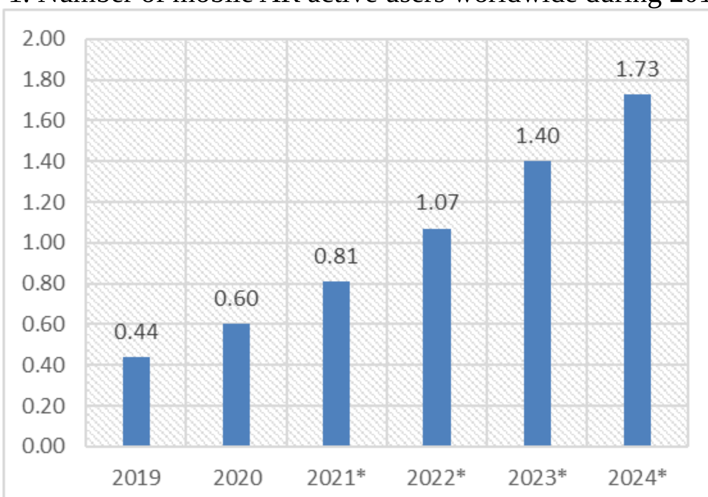
Augmented Reality (AR) is a technology that combines real-world elements with computer-generated virtual elements to create an enriched and interactive user experience. It superimposes layers of digital information, such as images, text, sound or video, over the real environment and allows interaction with these elements in real time (Azuma, 1997). The concept of AR was first introduced in the 1960s, but has gained popularity in recent years due to the development of mobile technologies and wearable devices such as smart phones and tablets. As seen in figure 1, the number of mobile AR active user devices worldwide increased considerably from 2019 and is expected to reach 1.73 billions in 2024, according to statista.com (2022) (https://www.statista.com/statistics/1098630/global-mobile-augmented-reality-ar-users/). These devices have sufficient cameras, sensors and processing power to facilitate AR experiences (Carmigniani et al., 2011).
AR can be classified into several types depending on how virtual information is superimposed on the real environment. The two main categories are position-based AR and recognition-based AR. Position-based AR uses sensors and the Global Positioning System (GPS) to determine the user's location and overlay relevant information based on this location. Recognition-based AR uses image and object recognition technologies to identify objects and overlay relevant virtual information on top of them (Van Krevelen & Poelman, 2010).

At the moment, AR has a wide range of applications in various fields such as medicine, engineering, architecture, entertainment and education. In education, AR has been explored as a tool to enhance student learning, motivation and engagement, as well as to support the development of collaboration and communication skills.

Figure 1. Number of mobile AR active users worldwide during 2019-2024



Source: Adapted from statista.com (2022)

2.1 Using Augmented Reality in Higher Education

Augmented Reality (AR) has undergone significant advancements in recent years, providing novel and stimulating learning opportunities in higher education. Its early experiments and applications in education were initiated in the 1990s and early 2000s, primarily in fields such as architecture, medicine, and engineering (Botden et al., 2007). However, the implementation of AR in higher education was restricted by the high costs and limited technology available at the time.
With the advent of accessible and affordable technology, mobile devices such as smartphones and tablets has played a pivotal role in enabling AR to be integrated into a broader range of educational settings. Concurrently, there has been a surge in the number and diversity of research and case studies on the incorporation of AR in higher education (Santos et al., 2014).

Augmented reality (AR) is also a promising technology that can be integrated into distance learning and online environments, offering innovative solutions to facilitate access to education and meet the needs of a diverse student population. One notable application of AR technology is the development of virtual laboratories, which enable students to engage in experimental activities and refine their skills in a secure and controlled setting (Ibanez et al., 2014). Additionally, AR has the potential to promote collaboration and communication among students and educators in virtual learning environments (Dunleavy & Dede, 2014).

2.2 Using Augmented Reality in education for students with ASD

In recent years, a considerable number of studies investigated the potential of AR technology to support the education of students with autism. Prior studies have primarily focused on examining how AR can be used to enhance the social and communication skills of students with autism, as well as to facilitate their academic learning (Kandalaft et al., 2013; Lahiri et al., 2013). While these studies have provided valuable insights, they have predominantly been conducted within the context of primary and secondary education. Consequently, research on the application of AR in higher education settings for students with autism is still limited.

Given that students with autism frequently encounter difficulties with communication and social interaction (American Psychiatric Association, 2013), AR offers a controlled and structured environment in which they can explore and learn at their own pace without feeling overwhelmed by real-world stimuli (Escobedo et al., 2012). Previous research has demonstrated that incorporating AR into interventions for students with autism can significantly improve their social skills, attention, and communication (Cheng et al., 2015).

Furthermore, AR can facilitate collaboration and communication between students with autism and their peers, thereby supporting the development of social skills that are essential for success in higher education (Wainer et al., 2017). For instance, AR-based applications can create social scenarios and provide real-time feedback on the user's social behaviours, enabling them to improve their social interaction skills (Parsons et al., 2013). Chang et al. (2010) developed an AR-based instructional system that aimed to help students with autism learn complex tasks and enhance their communication and collaboration skills. The system was tested in a university-level engineering course and demonstrated promising results in improving the conceptual understanding and academic performance of students with autism. Parsons et al. (2013) examined the use of virtual and augmented reality environments to facilitate science learning for adolescents and young adults with autism. The study found that participants with autism were able to successfully navigate and interact in AR-based learning environments and that these environments can be used to support learning in higher education.

Radu (2014) also conducted a review of studies on the use of AR in education and identified several examples where AR has been used to support students with special needs, including those with ASD. Although not all research were specific to students with ASD, the review highlights the potential of AR to provide adaptations and personalised support for students with different learning needs.

3. Benefits and challenges of AR in educational context

The advantages and disadvantages of using AR in an educational context, particularly for students with ASD, may vary depending on the specific implementation and context. According to existing research, we extracted several advantages that include the following: -AR can *boost the interest and motivation* of students with ASD by providing them with engaging and interactive learning experiences; -AR provides opportunities for visual and contextual learning, which can be particularly effective for students with ASD, who often have strong visual abilities (Escobedo et al., 2012); -AR supports the development of social skills by helping students with ASD practice interactions and understand social behaviours (Kandalaft et al., 2013); -AR allows learning experiences to be tailored and personalised to the individual needs, enabling them to work at their own pace and focus on areas where they need more support (Akçayır & Akçayır, 2017); -AR can help students with ASD become familiar with new situations and develop self-confidence by giving them the opportunity to explore and experiment in a controlled and safe environment without the pressures and fears associated with new situations (Lorenzo et al., 2016).

Even if the list of benefits can go on, a series of difficulties, barriers, risks or limitations that are inevitable in a process of such scope should not be omitted. The implementation of such a strategy exposes the university to a series of risks and difficulties such as high costs, lack of material endowments and equipment, lack of highly specialized human resources, confidentiality and security issues, mentality and social culture in the sense of a possible negative perception of students without ASD (Merchant et al., 2020).

The costs associated with developing and purchasing AR apps and equipment can be high, which may limit access to this technology for some universities or students with ASD. Implementing AR in higher education can be difficult due to technical issues and the need to adapt content and teaching strategies to this technology (Bower et al., 2014). Another important challenge for some students with ASD, is that the use of AR can lead to sensory overload and increased anxiety. It is important that AR applications are appropriately tailored to take into account the individual needs and sensitivities of students with autism (Zydney & Warner, 2016). In order to effectively use AR in higher education for students with ASD, teachers may need additional training and support to become familiar with the technology and adapt teaching strategies to this new environment. Integrating AR into the university curriculum can be difficult, as it may require revising and adapting course materials and teaching strategies to accommodate this technology. This may require additional time, effort and resources from teaching staff and higher education institutions (Johnson et al., 2011). The use of AR in higher education involves the collection and storage of personal data and information about student performance, which can raise privacy and data security concerns. Educational institutions and AR app developers must implement appropriate security measures to protect this information (Villagran-Vizcarra et al., 2023).

The use of AR in higher education for students with ASD has both advantages and disadvantages. In order to benefit from the potential of this technology and mitigate the disadvantages, careful planning, adaptation of content and teaching strategies, and continuous monitoring and evaluation of the impact on students are essential within a future-oriented university (Prelipcean & Bejinaru, 2018).

4. Research methodology

4.1 Aim of research

Through this paper, we launch a detailed analysis of the subject regarding the facilitation of access to advanced education for students with ASD through AR technology in a higher education organization such as a university in Romania. The research methodology is mixed, which combines the qualitative methods of analysis and synthesis, with the empirical methods of developing and testing an AR application in a particular setting such as the "Stefan cel Mare" University in Suceava.

More systematically, the purpose of the research is to map the overall picture of the theme and to formulate solutions for realistic progress. There are several specific objectives, such as: -to identify the conceptual and practical evolution of the topic addressed, -to identify the influencing factors on the analysed topic, -to identify advantages and disadvantages arising in relation to the analysed topic, -to argue the positive perspectives as well as the risks that may arise for such a practical approach. As we mentioned, qualitative and empirical research methods complement each other. Regarding the results and impact of the research, we will present them in the following section while describing the research methods.

4.2 Research methods

The scientific literature analysis reveals lack of development of AR applications that can be tested and used in higher education, both for people with normal development and even more so, for people with ASD. Thus, we aim to develop an app for mobile devices (smartphone, tablet) using AR technology to support orientation on a school or university campus. Using GPS technology, built-in optical sensor and screen, the app will display complementary content in the form of graphic/text/audio & video creations when the camera is pointed at a specific target. This way, people with special needs such as those with ASD can be supported to orient themselves and get comfortable with new spaces, especially if they have a social skills deficit. The app can also be used to deliver guidance and additional information for people with normal development.

The app to be developed will run on a web server for easy access and use. Thus, the app does not require installation from a specialised app store such as the Play Store (Android) or Apple Store (iPhone) and does not take up local storage space. Because it's cross-platform, it means that can be accessed from any device that has a browser installed. The app is accessed by simply scanning a QR code that links to the web server hosting it. The application flow chart is described in figure 2.

The application will be tested during the admissions process at "Stefan cel Mare" University in Suceava, both with potential students visiting the campus for the first time for the registration process and with voluntary people with ASD from the Help Autism Suceava Centre. To access the application, QR codes will be placed on a panel containing the name of each faculty, so that the student can scan the QR code for the faculty concerned and be directed to the web application, receiving guidance. On the first run, the users will be prompted to choose between standard assistance for orientation and special assistance (for people with ASD). The delivered content will be personalised depending on the chosen option.

Both during the university admissions period and in the first weeks of the semester, students can be disoriented and confused about the location of registration rooms for each faculty and later about the location of lecture halls and seminar lab rooms. Some find it difficult to socialise and ask for directions, especially because in a university study people from many different locations across the country and beyond.

The major limitations of the research methodology we can specify are lack of generalization and representativity, as the experiment will be developed in a specific framework, namely "Stefan cel Mare" University campus. Although this type of approach provides a certain control and predictiveness on the experiment and this could lead to further improvements.

5. Conclusions and expected results

Considering the potential of AR highlighted by both researchers and statistics on the trend of this technology adoption, it is expected that the proposed application will be a real success, with obvious advantages such as the use of a mobile device, as a smartphone, that most young people already own, running directly on a web browser without the need to install the application (thus eliminating resource consumption) and the valuable information it can provide by simply pointing the camera to various targets. Settling in and orienting to new spaces, especially those such as university campuses, can be difficult for both people with normal neurological development and people with special needs, such as those with autism spectrum disorders. Therefore, guidance can be very helpful. Based on the existing studies and applications that have been developed and tested, the need for a solution in terms of orientation on campus and by analysing the results obtained from previous research, it can be expected that the proposed application can make a real contribution.

In general, a future-oriented university must be inclusive and flexible towards all students, regardless of their special needs. By providing individualized support and creating an inclusive academic environment, universities can contribute to the development and success of all students, including those with ASD.

In conclusion, the paper proposes an adapted research model, which will be realized in an original (new) experiment through the intelligent mobile application based on AR. The paper argues the relevance of introducing AR technology for a specific problem such as access to advanced education for students with ASD. The implementation of this experiment has the potential to identify - both functionalities and dysfunctionalities and brings to light possible future approaches.

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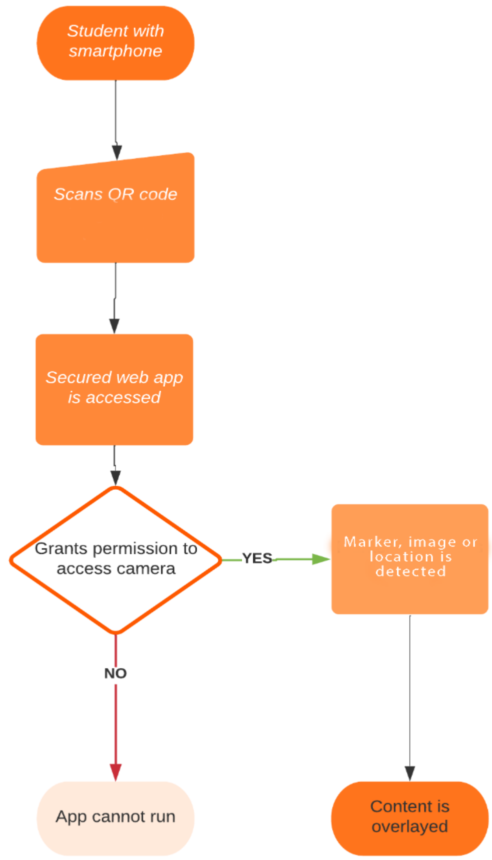
Figure 2. Application flow chart



Source: Authors own elaboration.

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(B)

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Investigating Sustainable Business Ecosystems and the University Role: A Cluster Analysis

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Abstract: This research paper aims to identify the factors, components, and key aspects that significantly contribute to the establishment of a sustainable business ecosystem through a comprehensive bibliometric analysis. By analysing prominent publications, we seek to describe coherent strategies with an expected impact. Our objectives encompass exploring trends from both theoretical perspectives, such as predictions by scientists, and empirical perspectives, including figures derived from studies. We outline several secondary objectives that guide our step-by-step approach. Firstly, we identify defining elements of a sustainable business environment based on insights from specialized literature. Secondly, we categorize ecosystems into different types, such as economic, digital, ecological, and entrepreneurial, providing further elaboration later in the paper. Thirdly, we present an updated understanding of the dynamic evolution of ecosystems and their components. This includes examining the influence of digital advancements and digitalization on the business environment, as well as the opportunities and threats they generate. Of particular importance is the role of universities as a significant landmark within the business ecosystem. We discuss the university's involvement in technological and informational transfer to ensure sustainability, focusing on the levers through which universities consolidate and stimulate the business ecosystem. To achieve our objectives, we employ bibliometric analysis, utilizing the VOSviewer software, which offers valuable insights for constructing diagnostic schemes and development models tailored to specific business environment challenges. The research methodology relies on the VOSviewer software for processing academic publication databases. To align with the theme and purpose of this study, we selected the SCOPUS database for its implicit certification of superior academic quality in the publications it contains.

Keywords: business ecosystem, entrepreneurship, digital ecosystem, digitalization, sustainability, university.

Introduction

A business ecosystem can be understood as a network of interconnected organizations, individuals, and resources that collaborate and depend on each other to create value and thrive within the global context. It is similar to how different species in a natural ecosystem rely on each other for survival. In a business ecosystem, companies, entrepreneurs, suppliers, customers, investors, and other stakeholders interact and form relationships to exchange goods, services, knowledge, and resources. They work together, sometimes even with competitors, to create innovative products or services, develop new markets, and meet customer needs (Schmidt et al., 2020).

The concept of a business ecosystem emphasizes the interdependence and symbiotic relationships among participants. It recognizes that no single company or entity operates in isolation but is part of a larger interconnected system. The ecosystem can include traditional companies, startups, industry associations, educational institutions, government bodies, and other entities that contribute to the overall growth and success of the ecosystem. By collaborating and leveraging each other's strengths, businesses within the ecosystem can achieve collective goals, drive innovation, and create a thriving economic environment. The concept of a business ecosystem highlights the importance of collaboration, shared value creation, and adapting to changes in the external environment to ensure long-term sustainability and competitiveness (Cobben et al., 2022).

Today, the university is an active and important player on all levels of economic, social, ecological, and cultural life, etc. The university is advancing in terms of material, technological and informational resources, but especially its intellectual capital (Bratianu, 2007; Bratianu, Prelipcean, & Bejinaru, 2020). Teaching staff, researchers and students are enhancing - with each generation. More advanced, better performing, smarter resources facilitate the work of individuals and thus the results increase exponentially. This system, which produces a considerable advance in the academic environment, has the potential to be extended to the business environment and produce similar effects. However, these two environments differ in the influence exerted by competition, risks and vulnerabilities (Bejinaru, 2022; Bratianu, 2002, 2018). Business collaboration is different from academic collaboration. That's why the university can play the role of mediator, facilitator, or guide for the business environment in order to offer fair support to any entrepreneur in order to ensure a sustainable business ecosystem (Jarvi et al., 2018; Neamtu, Hapenciuc, & Bejinaru, 2019).

We consider important to emphasize that university's role for supporting a sustainable business ecosystem implies that universities have a responsibility to promote and support sustainable business practices by providing education and research opportunities, fostering partnerships with businesses, and creating a culture of sustainability on campus
(Clarysse et al., 2014; Jarvi et al., 2018; Lupan & Bejinaru, 2019; Van der Borgh et al., 2012). This can involve integrating sustainability concepts into curricula, conducting research on sustainable business models, and working with local businesses to develop and implement sustainable practices. Universities can also play a role in developing future business leaders who understand the importance of sustainability and are equipped to drive positive change in the business world (Bratianu & Bejinaru, 2016; Schaeffer & Matt, 2016).

In line with the previous arguments, we pose the following *Research Question*: *"What are the key contributions of universities to different types of business ecosystems and how do universities play a crucial role in supporting for entrepreneurship, and driving sustainable business growth within these ecosystems?"* This research question aims to explore the diverse roles of universities in various business ecosystems and how they contribute to each ecosystem's development and sustainability. It also seeks to understand the specific ways in which universities foster innovation, support entrepreneurship, and facilitate sustainable practices within these ecosystems. By addressing this research question, we intend to provide valuable insights into the multifaceted role of universities in shaping and nurturing different business environments, helping policymakers, business leaders, and academics understand the strategic significance of universities in promoting economic growth, innovation, and sustainability.

Literature Review

Types of business ecosystems

Universities can be involved in various types of business ecosystems depending on their expertise, resources, and strategic goals. Taking action into the business sector is assigned through the third mission of the university (Bejinaru & Baesu, 2013). We have identified some relevant types of business ecosystems where universities often play a significant role (Faber et al., 2019; Li et al., 2023; Scaringella & Radziwon, 2018).
Technology and Innovation Ecosystems: Universities are often at the forefront of research and development, making them key players in technology-driven ecosystems. They collaborate with industry partners, startups, and research institutions to advance technological innovation, foster entrepreneurship, and drive economic growth (Alves-Scaliza et al., 2022; Appio et al., 2019; Cai et al., 2020).
Entrepreneurial Ecosystems: Universities actively contribute to entrepreneurial ecosystems by providing incubation programs, startup support, mentorship, and access to funding. They cultivate a culture of innovation and entrepreneurship, encouraging students, faculty, and alumni to create new ventures and contribute to the startup ecosystem (Cho, et al., 2022; Padilla-Meléndez & del-Aguila-Obra, 2022; Prokop, 2022).
Industry-Specific Ecosystems: Universities can be involved in business ecosystems specific to certain industries, such as healthcare, renewable energy, or biotechnology. They collaborate with industry partners, conduct industry-focused research, and provide specialized education and training to support the growth and development of these sectors (Landoni, 2020; Kolomytseva & Pavlovska, 2020).
Regional Development Ecosystems: Universities play a vital role in driving regional economic development by engaging with local businesses, government entities, and community organizations. They contribute to workforce development, knowledge transfer, and technology commercialization, creating a conducive environment for sustainable business growth within the region (Birkner et al., 2017; Markkula & Kune, 2015; Thomas et al., 2021).
Sustainability and Environmental Ecosystems: As sustainability becomes increasingly important, universities contribute to ecosystems focused on environmental conservation, clean technologies, and sustainable practices. They conduct research, provide expertise, and collaborate with industry and government stakeholders to promote sustainable business models and address environmental challenges (Oh et al., 2016; Zmiyak et al., 2020). It's important to note that the relevance of these ecosystems may vary based on the university's strengths, research priorities, geographical location and other factors. Universities often tailor their involvement to align with their core competencies and make a meaningful impact in specific areas of expertise. The university agenda is dynamic and proactivity makes it possible to generate exponential effects for society and business.

Mapping the University entrepreneurial role

The university has become a major component in the entrepreneurial ecosystem by providing resources and support for students who want to start their own businesses or enter the entrepreneurial world (Bejinaru & Prelipcean, 2017). In this sense we bring some arguments that can support this point of view. The basic mission of the university is to educate. Many universities offer specialized programs in entrepreneurship and business management that prepare students with the skills and knowledge to start their own businesses or work within an existing business. Business performance and competitive advantage can be achieved with the necessary resources and funding. Universities struggle to offer access to resources and funding for students who want to start their own businesses. These may include mentoring programs, consulting services, access to investor networks and grant funds. Another critical issue in the entrepreneurial ecosystems, especially for start-ups, are partnerships with local companies. Universities can create partnerships with local companies to provide students with opportunities to learn directly from experienced entrepreneurs and business leaders. These partnerships can provide students with access to resources such as internships and employment opportunities, as well as access to valuable networks of contacts (Bejinaru et al., 2023).

The second mission of the university is research & development, thus contribution to innovation is another area of supporting the business ecosystem. Universities are also an important source of innovation in terms of developing new and innovative technologies and services. In this context, research and innovation centers that work on developing new technologies and products that can be used in the business world. An important dimension that the universities can influence and model is the entrepreneurial culture. By encouraging entrepreneurship among students and the university community, universities can help create an entrepreneurial culture in their region and stimulate local economic development. This can attract investors and entrepreneurs, which will help create a strong and sustainable business ecosystem (Bejinaru et al., 2018).

We target to point out several arguments that can be used to support the fact that the university has become a major component in the entrepreneurial ecosystem.

Research methodology

Purpose and methodology

In order to fulfil the proposed objectives, we used a bibliometric analysis at this stage, as this can provide us with a series of guiding information. The processing of databases with the VOSviewer software provides results on the basis of which diagnostic schemes can be built as well as development models for the business environment, depending on the analysed problem. The methodology used in this research is based on the VOSviewer software for processing academic publications databases. Corroborating the theme and purpose of the work, we chose the SCOPUS database because, implicitly, it offers a certification that the publications have a superior academic quality (Agostini et al., 2020).

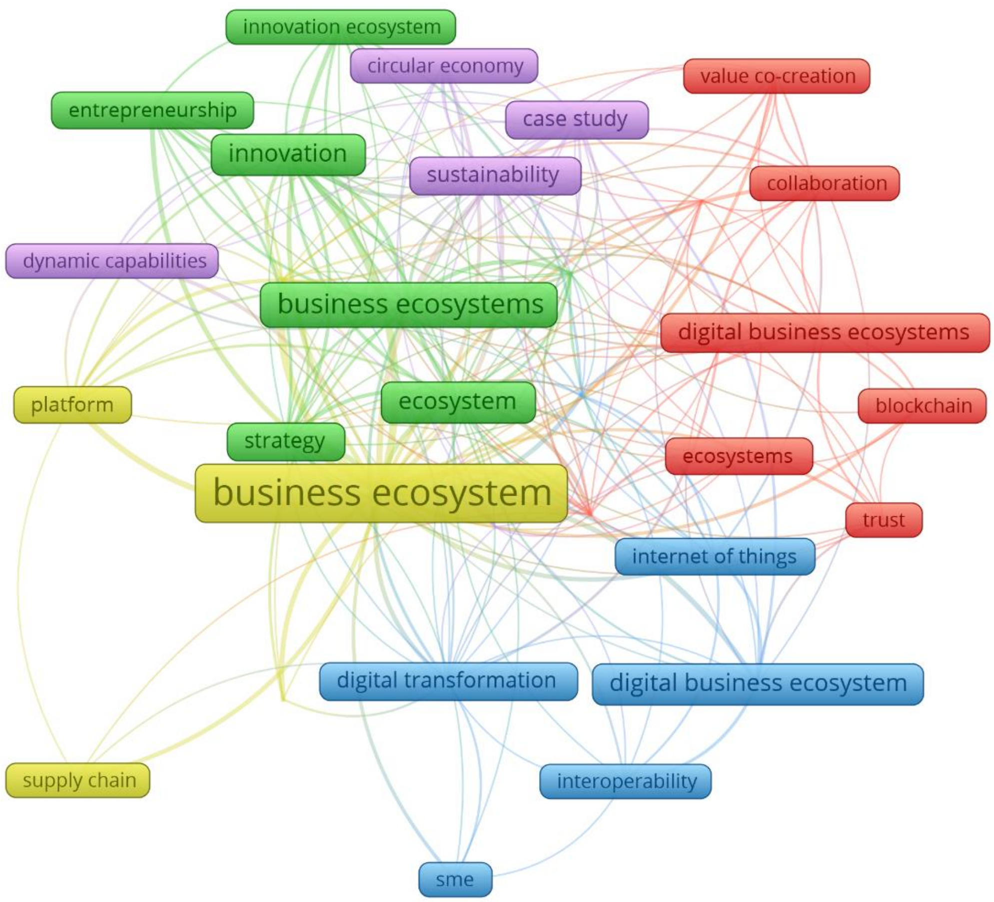

Figure 1. Cluster network of keywords co-occurrence
Source: authors elaboration in VOSviewer

Results and discussions

Cluster network of keywords co-occurrence

In order to implement the analyse we launched the search for the key phrase "business ecosystem*" and obtained 1823 papers. We extracted them from the SCOPUS database and analysed them with all the details available in the bibliometric analysis program. First of all, we were interested in the network output of keywords calculated based on the number of co-occurrences and their cross-occurrence. This type of analysis offers both visual results such as maps: co-occurrence map, overlay map and density map as well as numerical results by associating indexes to each keyword according to its number of occurrences in the analysed articles (Ellegaard & Wallin, 2015). More concretely, the formation of clusters can be easily observed based on the colours on the map and can be interpreted based on the indices in the table provided by the program. For an overview, we specify that we have five clusters, which we will detail and discuss in the following. From the analysis of the specialized literature, we extracted a series of edifying findings regarding the essential components of an ecosystem. In the same way, we identified different typologies of economic, digital, social or ecological ecosystems. The purpose of the research was also related to highlighting the role that the university, as a player, has in the process of consolidating a sustainable business ecosystem. The results of the bibliometric analysis gave us significant evidence about these aspects. It can be easily observed based on figure 1 that the following types of ecosystems are discussed in the specialized literature, in various fields: business ecosystem, digital ecosystem, innovation ecosystem. All these being connected at the same time with sustainability and digitalization.

Co-occurrence keyword analysis is a method of analysing the relationship between keywords or phrases in a given text or set of texts. It involves identifying the frequency and proximity of keywords or phrases to one another in the text, and using this information to infer the relationship between them. For example, if two keywords or phrases are found to frequently appear near one another in a set of texts, it can be inferred that they have a strong relationship. Co-occurrence keyword analysis (illustrated in figure 1) can be used in a variety of fields, such as natural language processing, information retrieval, and marketing research. It can help identify patterns in large sets of unstructured data, such as social media posts, customer reviews, or news articles (Zupic and Cater, 2015).

Clusters' composition

The concept of business ecosystems encompasses interconnected networks of organizations, individuals, and resources that collaborate and coexist to create value. In relation to the clusters mentioned, each cluster addresses different aspects relevant to business ecosystems, emphasizing various elements and perspectives. Following we shall explore the composition and connectivity of these clusters within the context of business ecosystems.

The first cluster, as the most powerful in visual and numeric aspects, is the RED one. This cluster is called: Digital business ecosystems, after the keyword with the highest value of occurrences. To extract a meaning from this picture we must understand the links and interconnectivity between all the keywords, starting with, "collaboration" and "digital business ecosystems". Collaboration is a core aspect of digital business ecosystems, enabling businesses to work together to create new products, services, and business models. Collaboration between businesses, customers, and suppliers can lead to more efficient and effective value creation -thus it is undoubtedly necessary that researchers discuss them. Artificial Intelligence (AI) and blockchain are key technologies that enable digital business ecosystems to operate more efficiently, securely, and transparently. AI enables businesses to analyse large amounts of data to gain insights, while blockchain provides a secure and transparent platform for transactions and data exchange (Dwivedi et al., 2023). Ecosystems can provide SMEs with the resources, networks, and support they need to succeed, while SMEs can help ecosystems to grow and evolve (Bejinaru et al., 2023). Trust is a critical factor in digital business ecosystems, as it enables businesses to work together effectively and to share data and information securely. Value co-creation refers to the process of creating value together with customers, suppliers, and other stakeholders, which can help to build trust and foster collaboration in the ecosystem (Martinez-Martinez et al., 2022). Overall, these keywords are interrelated and play important roles in the development and growth of digital business ecosystems, as they enable businesses to collaborate effectively, create new value, and drive progress towards a more sustainable future. In this context, we could assume that the university role facilitating knowledge exchange and research collaboration within the red cluster.

The GREEN cluster is named Innovation, after the most representative item in the group. Innovation plays a crucial role in the sustainable business ecosystem as it helps businesses create and implement new, more sustainable products, services, and business models (Burciu, et al., 2023). "Business ecosystems" are critical for companies to thrive in today's rapidly changing and interconnected business environment. This refers to a network of businesses, customers, suppliers, and other stakeholders that are interconnected and interdependent. "Business Models" refer to the way a company creates, delivers, and captures value from its products and services. Following ”entrepreneurship", "innovation" and "strategy" refer to a plan of action that a company takes to achieve its goals. Companies must develop a strategy that enables them to compete effectively in the marketplace, deliver value to their customers, and achieve their goals (Bejinaru, 2018; Mazzei, Ketchen & Shook, 2017). In essence, these words are significant as they describe the critical components of a thriving and sustainable business environment. Companies that understand the importance of business ecosystems, business models, entrepreneurship, innovation, and strategy will be well-positioned to succeed in today's rapidly changing business environment. Business ecosystems provide an environment where innovation can flourish through collaboration and knowledge sharing. Business models and entrepreneurship are essential for leveraging opportunities within ecosystems, while strategic thinking guides decision-making and orchestrates ecosystem activities. In brief, we can appreciate that the university's role in the GREEN cluster refers to fostering innovation, supporting entrepreneurship, and providing strategic guidance for sustainable business ecosystems.

The BLUE cluster is comprising the following keywords "digital business ecosystems", "digital transformation", "Internet of Things (IoT)", "interoperability", "open innovation", and "SME" which are all interconnected and related to each other in several ways. A digital business ecosystem refers to a network of businesses, customers, suppliers, and other stakeholders who are interconnected through digital technologies and platforms. The digital Transformation is the process of using digital technologies to fundamentally change the way businesses operate and interact with their customers, suppliers, and other stakeholders. A more recent concept like "Internet of Things (IoT)" has emerged and refers to the growing network of connected devices, including sensors and other types of devices, that collect and exchange data in real-time. IoT technologies play a key role in the digital business ecosystem by enabling businesses to collect and analyse data to make more informed decisions (Sestino et al., 2020). Open innovation is an important aspect of the digital business ecosystem because it enables businesses to leverage the collective knowledge and resources of their network to drive growth and competitiveness. Open innovation is different than the traditional innovation and can take various forms, including crowdsourcing, collaborative research and development, licensing, joint ventures, and spin-offs. The key to open innovation is creating a culture of collaboration, trust, and openness that allows for the free flow of ideas and knowledge between different organizations and individuals (Bigliardi et al., 2021; Saura et al., 2023). This cluster shows what issues play important roles in the development and growth of digital business ecosystems, enabling businesses to operate more effectively and efficiently and to drive progress towards a more sustainable future. Synthetically, digital transformation is a catalyst for adapting business processes and operations within ecosystems. Open innovation encourages collaboration and knowledge sharing across ecosystem boundaries, while SMEs continue to play a significant role in driving digital innovation within ecosystems. At this point we can observe that, when referring again to the university's role, the conclusions are partially repeatable in terms of its role for driving digital transformation, fostering open innovation, and supporting SMEs in leveraging digital technologies within digital business ecosystems.

The YELLOW cluster includes the concepts of "business ecosystems", "business model", "collaborative networks", "platform", and "supply chain" which are often put together because they are all critical components of a modern, connected, and sustainable business environment. Further we consider several reasons why these concepts are put together. A business ecosystem refers to a network of businesses, customers, suppliers, and other stakeholders that are interconnected and interdependent. In a business ecosystem, companies collaborate and share resources to create new products, services, and business models that drive progress and create value (Zbuchea et al., 2023). As we previously mentioned, companies need to have a well-defined business model that enables them to compete effectively in the marketplace and deliver value to their customers. Collaborative networks are a critical component of business ecosystems, as they enable companies to work together effectively to create new products, services, and business models. Also, collaborative networks and platforms provide companies with the resources, networks, and support they need to succeed and grow (Graça & Camarinha-Matos, 2017; Gupta, Mejia & Kajikawa, 2019). The supply chain refers to the network of businesses, suppliers, and other stakeholders that are involved in the production and delivery of products and services and is critical for companies to compete effectively. The yellow cluster includes keywords that are critical components of a modern, connected, and sustainable business environment. The papers comprised within this cluster consider that companies that understand the importance of business ecosystems, business models, collaborative networks, platforms, and supply chains will be well-positioned to succeed in today's rapidly changing business environment. The interconnectivity of keywords in the yellow cluster is revealing the fact that collaborative networks and platforms provide the infrastructure for ecosystem participants to interact, collaborate, and exchange resources a framework within which the university has a key role. Business models define how value is created and captured within ecosystems, while supply chains ensure efficient and effective flow of goods and services among ecosystem partners.

Table 1. Composition of co-occurrence keywords clusters

Cluster	ITEMS	Occurrences	Link strength
[red cluster] **Digital business ecosystems**	Artificial intelligence	15	15
	Blockchain	19	12
	Collaboration	19	23
	Digital business ecosystems	**43**	23
	Ecosystems	20	12
	SMES	24	23
	Trust	16	15
	Value co-creation	15	18
	Value creation	24	36
[green cluster] **Innovation**	Business ecosystems	128	61
	Business models	30	30
	Ecosystem	71	61
	Entrepreneurship	27	36
	Innovation	64	**79**
	Innovation ecosystem	17	25
	Strategy	30	43
[blue cluster] **Digital transformation**	Digital business ecosystems	60	32
	Digital transformation	**34**	**33**
	Internet of things	23	32
	Interoperability	15	13
	Open innovation	29	27
	SME	17	10
[yellow cluster] **Business ecosystems**	**Business ecosystems**	**393**	239
	Business model	47	64
	Collaborative networks	20	17
	Platform	21	36
	Supply chain	16	11
[purple cluster]	Case study	31	39
	Circular economy	15	19
	Digitalization	15	14

Sustainability	Dynamic capabilities	16	17
	Sustainability	**32**	**39**

Source: (elaboration based on VOSviewer)

The following keywords: “case study”, “circular economy”, “digitalization”, ”dynamic capabilities” and “sustainability” form the PURPLE cluster and provide insight into the current state and future of business and the economy, thus we called it after the core term which is “sustainability”. Sustainability is a critical consideration within business ecosystems, as it encompasses environmental, social, and economic dimensions. Sustainable practices and goals are integrated into the strategies, operations, and decision-making processes of ecosystem participants to create long-term value while minimizing negative impacts on the environment and society. Discussing the keywords according to their order, a “case study” is a research method used to examine a specific real-life situation or issue in detail. By examining case studies of businesses that have adopted circular economies or digitalization, we can gain insight into the challenges and benefits of these approaches (Campos et al., 2020). The circular economy is a model of production and consumption that aims to reduce waste and minimize negative environmental impacts. In a circular economy, resources are kept in use for as long as possible, extracting the maximum value from them before recovering and regenerating them (Ghisellini, Cialani, & Ulgiati, 2016). In this context, digitalization refers to the increasing use of digital technologies and digital data in all aspects of life, including business and the economy. Digitalization is transforming the way businesses operate and interact with their customers, suppliers, and other stakeholders (Hagberg, Sundstrom & Egels-Zandén, 2016; Van Veldhoven & Vanthienen, 2022).

Dynamic capabilities are an emerging concept that refer to a company's ability to adapt and respond to changes in its environment (Bejinaru & Baesu, 2017). In the context of a circular economy and digitalization, dynamic capabilities are critical for companies to respond to the changing needs and demands of customers and to remain competitive (Cegarra-Navarro et al., 2021; Cepeda-Carrion, Cegarra-Navarro, & Jimenez-Jimenez, 2012). In this picture we consider that sustainability refers to the ability of a system, such as a business or an economy, to remain viable and productive over the long term. In the context of a circular economy or digitalization, sustainability is critical for businesses to meet the needs of their customers and to reduce their negative impact on the environment. Overall, the keywords of this purple cluster (presented in table 1) provide insight into the current state and future of business and the economy. According to the keywords in the purple cluster, the university’s role, is critical in advancing research and knowledge on sustainable practices, circular economy, digitalization, dynamic capabilities, and their integration into business ecosystems.

In summary, these clusters contribute to the understanding and connectivity of various elements within business ecosystems. They highlight the importance of collaboration, digital technologies, innovation, business models, entrepreneurship, sustainability, and other key factors that shape the dynamics and success of business ecosystems. By considering these interconnected elements, organizations can navigate and thrive within complex and evolving business ecosystems.

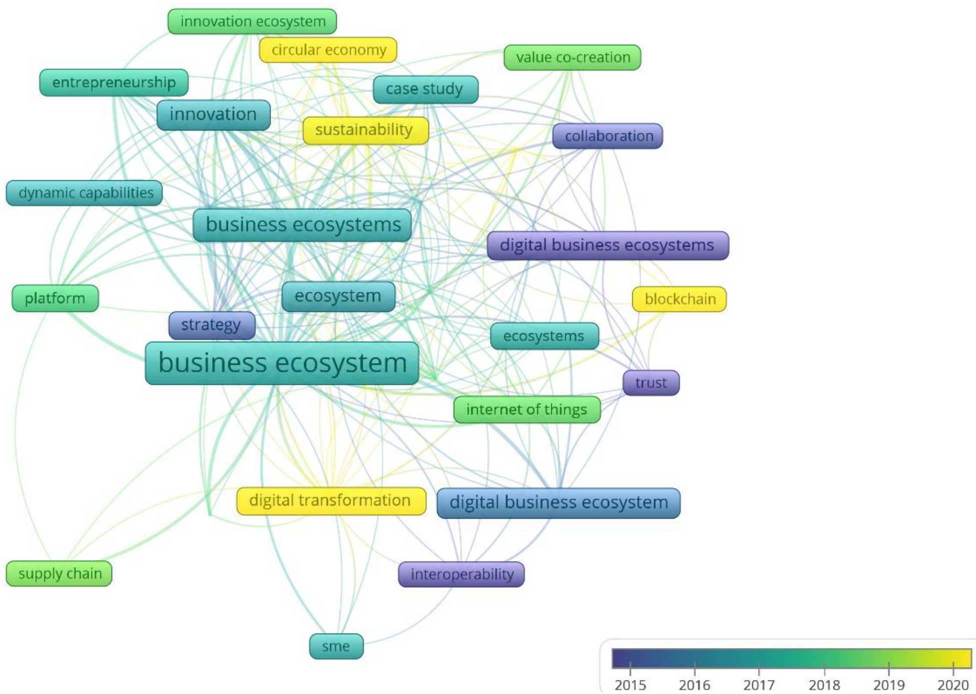

Figure 2. Overlay map of keywords co-occurrence

Source: authors elaboration in VOSviewer

Overlay map of keywords co-occurrence

Another type of cluster analysis is represented in Figure 2 as the Overlay map of keywords co-occurrence. This gradient colour visualization shows the evolution in time of literature theory and research associated to the key concept of "business ecosystems". Chronologically, since 2015, first links, are between keywords in dark purple colour like: "collaboration", "strategy", "trust" and "interoperability" which belong to the business and management domains. The next couple of years 2016-2017, reveal the items in nuances of blue and turquoise, like: "innovation", "case studies" and "business ecosystem". The display on the overlay map is the same as on the network visualisation of clusters but here the significance is based on the colours distribution and time-line. The concepts may belong to the same cluster but they might correspond to different years. The green colour items, associated to years 2018-2019, are: "innovation", "value-co-creation", "internet of things". Corresponding to the recent period we have keywords in yellow colour like: "digital transformation", "blockchain", "sustainability" and "circular economy". This combination of keywords is both confusing and challenging in terms of anticipating what the perspectives are. In this regard, we can appreciate that the publications in the field (as visualised in figure 2) shall evolve and intensify research towards a digital & mobile technology approach (Han et al., 2023; Piscicelli, 2023).

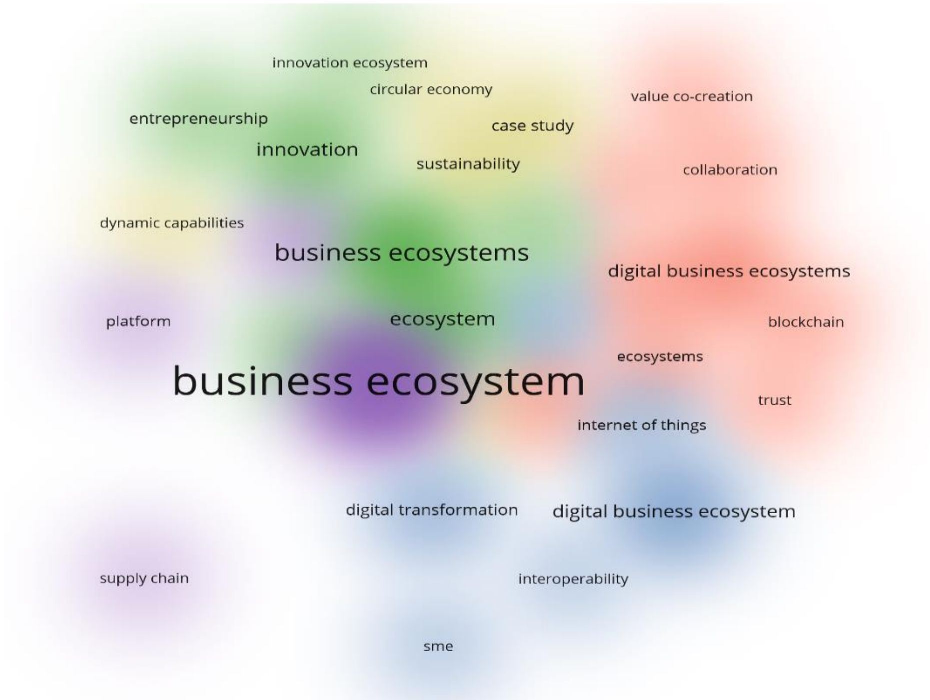

Figure 3. Density map of cluster keywords

Source: authors elaboration in VOSviewer

Density map of keywords co-occurrence

Through the bibliometric analysis, the density map of keywords co-occurrence provides information about the frequency and the way keywords (terms) appear together in scientific publications from a certain field or subfield. This analysis (represented in figure 3) can provide a visual and detailed picture of research trends and models in the respective field. Within a density map, keywords are represented as nodes, and the links between nodes indicate the frequency with which these keywords appear together in scientific publications. Thus, the areas with a high density of nodes indicate the keywords that are more closely related and that are more frequently used together in a certain scientific area (Vargas et al., 2022). The information provided through the density map of keywords co-occurrence is useful as it reveals: the main research topics in the respective field; the degree of interconnection and interdependence between the various research topics; the evolution and changes in research themes over time; identifying gaps in research in the field and identification of potential collaborators in research. In general, the density map of keywords co-occurrence can provide a general vision of the research field and help orient researchers towards relevant and innovative research topics within the respective field (Zupic & Cater, 2015).

From figure 3, we can clearly observe that purple and green clusters are closely connected while the blue and the red ones are somehow distant. We can conclude that digitalization is not yet so much approached in relation to the business ecosystem until now. This density map shows that the core elements related are business ecosystems, innovation, sustainability and digital transformation. It will be interesting to discover more on this issue in the next couple of years.

Analyses conclusions

In the last years, the economic and management literature has largely stressed the importance of knowledge assets for company's competitiveness. As we previously argued throughout the sections, the university has an important role to play in various aspects of life, including economic, social, ecological, and cultural. The university is constantly advancing in terms of material, technological, and informational resources, and especially human resources. The university's academic environment has the potential to be extended to the business environment and produce similar effects. However, the two environments differ in terms of the influence exerted by competition, which implies that the university can play the role of mediator, facilitator, or guide for the business environment to ensure a sustainable business ecosystem.

From another perspective, the university's basic mission of educating students includes specialized programs in entrepreneurship and business management that prepare students with the skills and knowledge to start their own businesses or work within an existing business. Universities can also offer access to resources and funding for students who want to start their own businesses, including mentoring programs, consulting services, access to investor networks, and grant funds. Additionally, universities can create partnerships with local companies to provide students with opportunities to learn directly from experienced entrepreneurs and business leaders. Universities are also an important source of innovation and can encourage entrepreneurship among students and the university community, creating an entrepreneurial culture in their region and stimulating local economic development.

Throughout the bibliometric analysis we extracted several perspectives on the topic and thus we resume the following ideas. We discussed the interconnectivity and importance of different concepts in the development and growth of digital business ecosystems. The RED cluster focuses on collaboration, digital business ecosystems, AI, blockchain, SMEs, trust, and value co-creation. The GREEN cluster emphasizes innovation, business ecosystems, business models, entrepreneurship, and strategy. The BLUE cluster discusses digital business ecosystems, digital transformation, IoT, interoperability, open innovation, and SMEs. The YELLOW cluster highlights business ecosystems, business models, collaborative networks, platforms, and supply chain. The PURPLE cluster is focusing on sustainability issues.

The overall analysis suggests that businesses need to understand and utilize these concepts to succeed in today's rapidly changing business environment. Collaboration, innovation, well-defined business models, and supply chain are crucial for companies to create new products, services, and business models that drive progress and create value. Meanwhile, digital technologies, such as AI, blockchain, IoT, and interoperability, provide secure and transparent platforms for transactions and data exchange that enable businesses to operate more efficiently and effectively. In the sense of what we previously analysed and according to the bibliometric analysis, we propose a series of possible ways to develop the university's contribution to business ecosystems: -*Collaboration and Networking:* Partnership between business leaders, employees, and universities can provide opportunities for collaboration, networking, and knowledge sharing. This can help businesses stay informed about the latest trends and developments in their industry, and identify new opportunities for growth and innovation. -*Access to Talent:* Universities can provide access to talented individuals, including students and alumni, who can bring new skills, perspectives, and ideas to businesses. -*Access to Research and Development*: Universities often have research and development capabilities that businesses can tap into to develop new products, services, and technologies. -*Promoting Sustainability*: Universities can help promote sustainability by engaging businesses in sustainable business practices, supporting sustainable business initiatives, and promoting sustainability research and development. -*Knowledge Transfer*: Universities can facilitate the transfer of knowledge and technology between academia and industry, which can help businesses stay ahead of the curve and compete in a rapidly changing business environment. -*Continuous Learning*: Universities can provide opportunities for employees to continue learning and developing their skills, which can help businesses stay competitive and innovative. -*Social Impact*: By partnering with universities, businesses can contribute to the creation of a more sustainable and equitable society, and demonstrate their commitment to social responsibility and sustainability. By establishing partnerships between business leaders, employees, and universities, all parties can work together to create a more sustainable and innovative business ecosystem. Finally, the article highlights the main role of SMEs in driving innovation and growth in digital business ecosystems and the secondary role of universities in this equation.

Conclusions

In conclusion, the university plays a crucial role in supporting the business ecosystems. By providing a platform for researchers, students, and industry professionals to come together, the university fosters an environment of learning and innovation. The university integrates collaborative efforts and promotes the exchange of ideas, encourages interdisciplinary research, and drives the advancement of knowledge in various fields. This knowledge exchange and research collaboration form the foundation for the development of sustainable business ecosystems. Throughout the paper we emphasize that the university's role extends beyond knowledge exchange to encompass fostering innovation, supporting entrepreneurship, and providing strategic guidance for sustainable business ecosystems. By nurturing a culture of innovation, it inspires creativity and encourages the development of new ideas and solutions. The clusters' analysis revealed the sustainability dimension of the university through strategic guidance to businesses, helping them navigate the complexities of the rapidly changing business environment and align their strategies with sustainability goals. This holistic approach contributes to the growth and success of businesses within the ecosystem, while also promoting sustainability and responsible business practices.

The literature and cluster analysis clearly frame the university's role in driving digital transformation, fostering open innovation, and supporting SMEs in leveraging digital technologies within digital business ecosystems, thus it becomes evident that these conclusions align with the university's overarching responsibilities. The university serves as a catalyst for digital transformation by providing education and training on emerging technologies, conducting research on their applications, and collaborating with industry partners to drive innovation. Additionally, the university plays a crucial role in supporting SMEs in adopting and leveraging digital technologies, providing them with the necessary guidance, resources, and networks to thrive in the digital era. These efforts contribute to the overall development and sustainability of digital business ecosystems.

Concerning the limitations of the research we shall point out the following: limited scope of data sources – due to the fact that the research relies primarily on bibliometric analysis using the VOSviewer software and the SCOPUS database. While this approach provided valuable insights from academic publications, it might not have captured all relevant data sources, such as industry reports, surveys, or data from non-academic sources. In this regard, certain perspectives or emerging trends from the business ecosystem might be missed, limiting the comprehensiveness of the findings. Another obvious limitation is the lack of in-depth qualitative analysis. The research mainly focused on quantitative analysis and identifying interconnections between keywords in the clusters. However, a more in-depth qualitative analysis, such as interviews or case studies with key stakeholders, could provide deeper insights into the practical implications of the university's role in supporting business ecosystems. Qualitative methods can offer a better understanding of real-world practices, challenges, and opportunities related to the university's involvement in fostering innovation, driving digital transformation, and supporting SMEs in digital business ecosystems. We shall consider to overcome these limitations for future studies to enrich the understanding of the subject.

Summing up the previous analyses, we come to the conclusion that the university's role in supporting business ecosystems is a multidimensional one, which encompasses a series of actions such as: facilitating knowledge exchange and research collaboration, fostering innovation and entrepreneurship, providing strategic guidance, driving digital transformation, promoting open innovation, supporting SMEs, and advancing research on sustainable practices. This multifaceted role highlights the university's significance in shaping and nurturing business ecosystems, driving progress, and addressing the challenges of the modern business landscape. By actively engaging in these activities, the university plays a pivotal role in creating an environment conducive to growth, innovation, and sustainability.

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(C)

Conţinutul integral al prezentării se regăseşte în documentul C.

RAPORT INTERMEDIAR DE CERCETARE_Nr.2
4 Decembrie 2023

Conținutul acestui document prezintă sub forma unui raport intermediar rezultatele cercetărilor pe tema proiectului cu titlul *”Facilitarea accesului la educație prin realitatea augmentată și stimularea învățării dinamice în afaceri prin microlearning”* pe durata lunilor 4, 5, 6 ale proiectului postdoctoral sub egida Academiei Oamenilor de Știință, din România, Filiala București.

Raportul intermediar (2) conţine detalii despre rezultatele proiectului de cercetare:

(A) O lucrare de cercetare ce explorează potențialul tehnologiei Realității Augmentate (AR) pentru îmbunătățirea experiențelor de navigare în campusul universitar, cu un accent deosebit pe satisfacerea nevoilor studenților cu tulburări de spectru autist (ASD), ceea ce face obiectul prezentului contract, împreună cu dovada publicării în programul şi volumul conferinței;

TOMA, M.V. & BEJINARU, R. (2023). **Embracing diversity: Augmented Reality application for inclusive university campus navigation**, ***Strategica International Conference***, 11th edition, 26-27.10.2023.

(B) Participarea fizică şi prezentarea rezultatelor cercetării - la Sesiunea Ştiinţifică AOSR tineri cercetători - Etapa 2, 27 Noiembrie 2023, sediul Academiei Oamenilor de Știință din România, din strada Ilfov, nr. 3, sector 5, București, în Sala de Consiliu, parter;

TOMA, M.V. & BEJINARU, R. (2023). **Îmbrățișarea diversității: aplicație de realitate augmentată pentru navigarea incluzivă în campusul universitar**, ***Sesiunea Ştiinţifică AOSR tineri cercetători - Etapa 2, 27 Noiembrie 2023.***

(C) Participare şi prezentare online la Conferinţa Internaţională - VI International Scientific Congress - Society of Ambient Intelligence 20-25 Noiembrie 2023; Panel Discussion “Regional business ecosystem involvement to digitalization and green transition and university’s role” - Titlul Prezentării: *Augmenting the university campus: digital approach, Vlad Toma, Bejinaru Ruxandra.*

TOMA, M.V. & BEJINARU, R. (2023). **Augmenting the university campus: digital approach**, ***VI International Scientific Congress - Society of Ambient Intelligence 20-25 Noiembrie 2023;*** Panel Discussion “Regional business ecosystem involvement to digitalization and green transition and university’s role”, https://drive.google.com/file/d/1XI4FbJSE59wrtKAbbhOQnt8PB87DMQED/view

(A)

STRATEGICA INTERNATIONAL CONFERENCE
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EMBRACING DIVERSITY: AUGMENTED REALITY APPLICATION FOR INCLUSIVE UNIVERSITY CAMPUS NAVIGATION

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Abstract. *This academic paper explores the potential of Augmented Reality (AR) technology in enhancing university campus navigation experiences, with a particular focus on catering to the needs of students with autism spectrum disorder (ASD). We address the limitations of traditional campus navigation methods and introduce AR as a promising solution. We consider that the mission of a future-oriented university is to enable and facilitate access to higher education and advanced research opportunities focusing on becoming more inclusive. Throughout the literature review, we delve into the interactive nature of AR, its multisensory capabilities, and the importance of spatial registration. We also highlight the complexity of AR system architecture, emphasizing the role of hardware and software components, rendering engines, and tracking algorithms. The paper then explores the utility of AR in campus navigation, emphasizing its potential in improving spatial awareness and enriching educational experiences. The methodology section outlines the objectives of the research, including understanding the adoption of AR in universities for orientation, exploring AR technologies and platforms, and defining key characteristics of an AR application. Within the results and discussion section we present findings related to the use of AR applications in future-oriented universities for campus navigation. While specific university-based implementations are limited, pioneers like MIT, Stanford, and Harvard are to be watched for their potential adoption of AR technology as core stream of their long-term academic leadership strategy. We focused on exploring technologies and platforms for developing AR applications, encompassing modeling and computer vision, geospatial technologies, sensor technologies, machine learning, cloud computing, network technologies, and frameworks in order to argue their positive impact. Within the section dedicated to developing AR applications for students with ASD we emphasize stakeholder engagement, technological selection, application development, user feedback, and continuous improvement. The paper concludes by proposing a sequence diagram illustrating the interaction between parties involved in developing and using an AR campus navigation application.*

Keywords: *academic leadership strategy; application; Augmented Reality (AR); autism spectrum disorder (ASD); campus navigation; future-oriented university; students.*

Introduction

Due to the global evolution, universities are compelled to adjust to emerging technologies and incorporate them into their educational and research methodologies (Bejinaru & Prelipcean, 2017). Navigating through expansive university campuses can be a challenging experience, particularly for newcomers, international students, or those with accessibility needs. Traditional methods of campus navigation—like static maps, signages, and GPS-based mobile applications—often fall short in offering a comprehensive, interactive, and inclusive navigation solution (Liao et al., 2015).

Augmented Reality (AR)-based campus navigation systems have the potential to fill this gap by providing interactive, context-sensitive, and real-time orientation assistance. By superimposing directions, annotations, and other relevant information directly over the physical world, AR applications can create a more intuitive and engaging navigation experience. Furthermore, these systems can be customized to cater to diverse user needs, offering features like voice guidance for visually impaired users or sign language avatars for those who are hearing-impaired.

Augmented Reality is an interactive paradigm where digital elements are superimposed onto the real world, thereby augmenting the user's perception and interaction with their environment (Milgram & Kishino, 1994). AR differs from Virtual Reality (VR) in that it does not create an entirely simulated environment but integrates digital information with the existing environment in real-time (Billinghurst & Kato, 2002). Using a variety of technologies, including computer vision algorithms, machine learning and sensor data, AR applications have been developed for diverse domains like healthcare, industrial maintenance, education, business administration and other fields (Bejinaru, 2019). From a technical perspective, AR systems often consist of multiple components: a camera for capturing the real-world environment, a display mechanism (which can range from smartphone screens to AR glasses), tracking systems for spatial and object recognition, and a computational backend for data processing (Carmigniani et al., 2011; Wagner & Schmalstieg, 2007). These systems may use various tracking technologies such as marker-based, marker-less, and simultaneous localization and mapping (SLAM) for the precise placement of virtual objects in the real world.

Literature review

The essence of Augmented Reality lies in its real-time interaction capabilities, allowing a seamless blend of computer-generated information with the physical world. This dynamism in the interaction is not just a technological marvel but also a fundamental shift in how we perceive and interact with digital data (Azuma et al., 2001). It challenges the passivity of traditional interfaces by engaging users directly with contextual information. Unlike many other digital technologies that isolate the user from the physical environment, AR thrives on context-awareness. The system actively uses sensorial data—captured through accelerometers, gyroscopes, and GPS—to adapt and provide relevant information, making each AR experience highly personalized (Kretzenbacher et al., 2020). Besides the major benefits, future-oriented universities must carefully plan and invest in the technology, considering both its short-term benefits and long-term viability to ensure its sustainability (Neamtu et al., 2020).

While most people attribute AR to visual overlays, it's worth noting that it is not restricted to the visual modality. AR can offer a multisensory experience that can also include audio and haptic feedback (Steinicke et al., 2010). This multi-modal approach opens up numerous opportunities for more immersive and engaging interactions. The concept of spatial registration is another cornerstone in AR systems. This involves the accurate alignment of virtual and physical elements, which ensures that the digital overlays are correctly positioned relative to real-world objects (Klein & Murray, 2009).

On the technical side, the system architecture of AR can be quite complex. Hardware and software components work together to create this immersive experience. The hardware often comprises of various sensors for tracking movement and orientation, display devices that range from smartphones to specialized AR glasses, and cameras for capturing real-world data (Carmigniani et al., 2011; Lee & Tuceryan, 2004). From a software perspective, the rendering engine plays a crucial role in creating the virtual elements. Frameworks and platforms such as ARCore, ARKit, Unity3D and Unreal Engine are widely used for developing AR applications. Additionally, sophisticated tracking algorithms, such as Simultaneous Localization and Mapping (SLAM), are employed for real-time location and orientation tracking (Klein & Murray, 2009).

Using augmented reality for campus navigation

The utility of augmented reality in navigating new spaces, particularly in the context of university campuses, represents an innovative intersection of spatial cognition, human-computer interaction, and educational technology. One of the most significant advantages of employing AR in university campus navigation is the augmentation of spatial awareness. AR can facilitate the internalization of spatial relationships by overlaying digital information, such as directional arrows or point-of-interest markers, directly onto the real world. This real-time augmentation alleviates the cognitive load involved in spatial reasoning (Sweller, 2011), thus aiding the user in quickly becoming familiar with unfamiliar spaces. Beyond navigation, the AR system can serve educational goals by contextualizing information relevant to specific campus locations. For instance, when a user approaches a science building, the application could display historical facts, ongoing research projects, and other educational material (Dunleavy et al., 2009). This enhanced engagement not only enriches the user’s experience but also contributes to a deeper learning outcome, incorporating elements of situated learning theory (Lave & Wenger, 1991).

Campus navigation applications for students with autism spectrum disorders (ASD)

Autism spectrum disorder (ASD) is a complex neurodevelopmental disorder characterized by deficits in social communication and interaction, alongside restricted, repetitive patterns of behavior, interests, or activities (American Psychiatric Association, 2013). The term "spectrum" is used to denote the wide range of symptoms and individual differences in severity and functioning that can occur in individuals with ASD (Baio et al., 2018). While ASD is characterized by significant challenges, it is noteworthy that individuals with ASD may also exhibit remarkable strengths such as enhanced perceptual skills and attention to detail (Mottron, Dawson, & Soulières, 2009).
Augmented Reality has a significant potential for creating more inclusive educational environments, especially for students with autism spectrum disorder. Campus navigation is a critical stage of university life that can be overwhelming for many students, and even more so for those with ASD, who may face challenges with social interaction, spatial navigation and coping with new routines (Kasari et al., 2019). Integrating AR technology into campus orientation activities for ASD students could create a tailored experience that better suits their individual needs (Escobedo et al., 2012).

One of the critical elements in AR applications for ASD students is the adaptability of the user interface. It is crucial for these applications to be highly customizable, allowing for adjustments such as the simplification of visual elements or modification of audio prompts. This conforms with the principles of Universal Design for Learning (UDL) and can accommodate the sensory sensitivities often associated with ASD (Rose et al., 2006). Students with ASD can also benefit significantly from immediate feedback that AR applications deliver. Real-time tracking and feedback mechanisms are integrated within the applications to adjust the orientation process dynamically according to the students' immediate needs (Zhou et al., 2018). When triggered, AR delivers clues that can range from simple, unimodal cues such as visual markers indicating directions, to more complex multi-modal cues incorporating sound and haptic feedback. Based on the tenets of Applied Behavioral Analysis (ABA), AR can deliver conditioned stimuli at regular intervals to elicit desired behavioral responses, such as maintaining a certain walking pace or staying within demarcated safe zones on the campus. While campus navigation is the primary goal, these AR applications can also promote the development of other cognitive skills such as spatial awareness and problem-solving. Cognitive load theory suggests that these additional skills can be incrementally integrated without overwhelming the user (Sweller, 2011).

Methodology

In order to be able to future develop an augmented reality application for navigation in new spaces by students with autism but also by those with normal development, we proposed the following objectives:

O1. To have an overall understanding of the level of adoption of augmented reality by future-oriented universities for navigation in new spaces and how the problem of students with autism is approached.

O2. To study the main technologies and platforms available for the development of an augmented reality application.

O3. To establish the key characteristics that the application must have.

Considering the fact that each university has certain peculiarities regarding the location of buildings, access roads and other campus objectives, the following research questions were formulated to fulfill the mentioned objectives:

RQ1. How do universities implement campus navigation solutions based on augmented reality?

RQ2. What technologies and platforms are available to develop augmented reality applications for campus navigation?

RQ3. What should be taken into account for the development of an augmented reality application for campus navigation for students with autism spectrum disorder?

Results and discussion

Objective 1: The use of augmented reality applications by universities for campus navigation

Going through the scientific literature, it can be stated that there has been a proliferation of AR applications for the broader student demographic, but information on specific universities using such applications is quite scant. However, various universities have been at the forefront of incorporating AR technology to foster a more inclusive educational environment. Universities such as MIT, Stanford, and Harvard have been pioneers in adopting AR and VR technologies in education and it wouldn't be far-fetched to anticipate the inclusion of features accommodating the needs of students with ASD in their AR-oriented initiatives in the near future, given their history of innovation and inclusivity (Papagiannis, 2017). Moreover, there has been a broader interest in the potential applications of AR technology for individuals with autism. For instance, researchers have been exploring how AR can be used to assist individuals with ASD in learning new skills and achieving greater independence (Kuriakose & Lahiri, 2015). In their research, the authors scrutinized how AR can be an enabler in enhancing the learning experiences and fostering greater autonomy for individuals with ASD. Their pioneering work paves the way for universities globally to conceptualize and implement AR applications that are addressing the unique needs of individuals with autism.

Future-oriented universities have a tradition in applying strategic university governance and took upon themselves the development of customized AR applications specifically tailored for their campuses (Lupan & Bejinaru, 2019). These applications generally offer features such as AR guided tours, interactive campus maps, and information pop-ups about different facilities on the campus. Although it is possible that some information is not publicly available and the applications are not entirely dedicated to orientation in new spaces, we found that some examples of notable universities and institutions where AR has been used or piloted for campus navigation or related applications are:

University of Arizona – Developed an AR application that offers a 3D map visualization of the campus, information pop-ups about different facilities, and real-time event information.

Harvard University – While not a fully-fledged AR campus tour, Harvard has utilized AR in various exhibitions and set-ups across the campus to offer enriched experiences.

MIT (Massachusetts Institute of Technology) – Used AR in multiple projects including campus tours that include AR-enhanced experiences of the facilities.

Stanford University – Though it predominantly uses AR for research and academic purposes, there have been instances of AR being used for campus navigations and tours, predominantly during exhibitions and special events.

University of Cambridge – Has leveraged AR technology in public engagements and outreach programs, including interactive AR-enhanced maps of certain facilities.

Yale University – Yale has employed AR in various exhibitions and public engagements, though detailed AR campus tours are yet to be instituted.

University of British Columbia – Engaged in the development of AR initiatives, including the pilot testing of AR-enhanced campus tours to facilitate better campus navigation and information dissemination.

University of Tokyo – Involved in AR research projects and has employed AR in public engagements and tours, offering a glimpse into the campus's facilities through AR lenses.

ETH Zurich – The university has employed AR in various projects, including offering AR-enhanced experiences during campus tours, particularly focused on architecture and facility demonstrations.

Though not exclusively for campus navigation, there are applications developed to assist individuals with ASD in navigation and understanding space:

Autism2Ability: This platform offers applications with visual support and AR technology to help students with ASD in various capacities including understanding new environments which can be harnessed for navigating throughout the campus.

Wayfinding Project: A specific endeavor undertaken by the University of Minnesota to assist individuals with ASD in navigation through spaces using AR technology.

The landscape of AR applications specifically tailored for campus navigation, including the needs of students with ASD, is still developing. Many of the existing solutions are general-purpose AR platforms that require substantial customization to meet the specific requirements of college campuses and the diverse needs of their students. This suggests that this field of research has significant potential for innovation and exploration. Given the trajectory of advancements in AR technology, it is plausible to anticipate a surge in universities incorporating AR applications in their campuses that are tailored to the needs of students with ASD, presenting an optimistic future.

Objective 2: Technologies and platforms for developing augmented reality applications for campus navigation

Developing an augmented reality (AR) application for campus navigation involves the use of a variety of technologies and platforms, including AR development frameworks, cloud computing platforms for backend support, and tools for creating 3D models and assets (Bejinaru & Balan, 2020). In the following section we break down the prominent technologies and platforms that can be leveraged to build a comprehensive AR application.

Technologies: Augmented reality platforms are usually used alongside a suite of advanced technologies that redefine the interaction between the digital and physical worlds. At the forefront are modeling and computer vision technologies like 3D reconstruction, which uses methods such as LiDAR (Light Detection and Ranging) and photogrammetry, and SLAM (Simultaneous Localization and Mapping) which facilitates the precise overlay of digital objects over the physical spaces. Geospatial technologies with GIS (Geographic Information Systems) integration providing enhanced navigation experiences on campuses are complemented by GPS and Beacon technology for precise localization, especially indoors. The dynamism of AR is represented by a multitude of sensor technologies, including accelerometers, gyroscopes, and magnetometers, which are essential in detecting device movements and orientation, thus facilitating a more immersive AR experience. Machine and deep learning technologies amplify AR's capabilities in identifying and interpreting real-world objects and contexts. The scalability and performance of AR applications is based on cloud computing's ability to handle voluminous datasets and intricate computations. Network technologies, especially 5G and edge computing, are ensuring real-time AR interaction by guaranteeing faster data transmission and low latency. Collectively, these technologies stand as the basis for ensuring AR's seamless, immersive, and responsive experiences.

Platforms and software development kit (SDKs): Table 1 provides a summary of the most popular frameworks and SDK's for developing augmented reality applications. These platforms are at the forefront of AR development, offering a broad array of tools and functionalities to develop state-of-the-art AR applications for campus navigation. Leveraging these platforms can significantly enhance the campus orientation experience, offering students an engaging, tailored and immersive introduction to the campus environment.

Table 1. AR Development Platforms and SDKs (Source: authors' own contribution)

Platform	Description
Google ARCore	Enables developers to create AR applications for Android devices.
Apple ARKit	Enables developers to create AR applications for iOS devices
Vuforia Engine	A platform that provides an SDK for creating AR applications that use image recognition and tracking. It supports Android, iOS, Windows, Unity, and Unreal Engine.
Hololink	A web-based platform that enables creation of AR through a visual no-code solution.
Unity	Cross-platform game engine for developing 2D and 3D games, simulations, and interactive experiences. It supports various platforms.
Unreal Engine	Game engine for developing high-quality games, simulations, and interactive experiences. It supports various platforms.
Wikitude	A platform that provides an SDK for creating AR applications that use image recognition and tracking. It supports various platforms, such as Android, iOS, Windows, Unity, and Unreal Engine.
8th Wall	A web-based platform that enables creation of AR through a visual no-code solution. AR created in 8th Wall is served directly in the mobile browser without the use of an app.

Objective 3: Developing AR applications for campus navigation for students with ASD

Developing an augmented reality application for campus navigation customized for students with autism spectrum disorder requires a multidisciplinary approach that intertwines knowledge from computer science, psychology, education, and design. It is crucial to adopt evidence-based practices to create an AR application that is effective and beneficial for students with ASD. Following the research, a number of 9 steps necessary to develop such an application were identified. Here we outline some pivotal considerations and methodologies:

Identifying the goals and objectives: The initial phase begins with a nuanced understanding of the goals and objectives that the AR application aspires to achieve. At this point, it becomes essential to envision an app that can act as an inclusive tool, facilitating easy navigation and decipherable information about various campus facilities for students with ASD. A strong focus on sensory preferences and cognitive styles of these studies can influence the development of user-centric features.

Stakeholder engagement: As we move forward, stakeholder engagement emerges as a critical endeavor, where the collaboration with students, including those with autism, faculty, and administrative personnel translates into valuable insights. Here, emphasis should be placed on creating a support system that encourages feedback and suggestions from autistic students, ensuring their unique perspectives are integrated into the app, a strategy that promotes inclusivity and user-centered design (Bower et al., 2014).

Technological selection: The technological substrate forms the next layer, where choices made in selecting platforms and tools resonate with the aspirations of inclusivity. Leveraging platforms such as Unity for the overarching development and integrating AR functionalities through ARKit or ARCore stand as viable strategies. A focus here should be on technologies that enable the creation of features like simplified navigation and intuitive interfaces which would cater specifically to students with ASD, facilitating their comfortable interaction with the app (Craig, 2013).

Content development: In the center of this developmental blueprint lies content creation and crafting of media elements and graphical overlays tailored to foster an enriching experience for all users, including those with ASD. The development team must infuse the content with an understanding of the cognitive and sensory preferences of autistic students, orchestrating an environment within the app that is both supportive and understanding of their needs (Wojciechowski & Cellary, 2013).

Application development: During the application development phase, the technical blueprints emerge into a tangible entity. Here, the developers use the power of programming languages and AR technologies to architect an app with rich features, responsive designs, and user-friendly interfaces. Essential in this stage is the integration of ASD-friendly features, which could encompass simplified layouts, calming color schemes, and the provision of clear instructions to guide the students efficaciously. Furthermore, the integration of the AR application with the existing campus infrastructure stands as a critical determinant in the successful implementation and operational fluidity of the system.

Testing: As the structure receives its substantial form, a rigorous testing phase initiates to identify potential glitches. It is in this phase where the app undergoes several tests, potentially including usability testing with a diverse group of students, encompassing those with ASD. Tailored testing protocols for autistic students could be utilized to ensure that the app caters to their unique needs effectively and sensitively (Dunleavy, Dede, & Mitchell, 2009).

User feedback and iterations: Post the initial deployment in a controlled environment, it is prudent to foster a feedback-rich ecosystem where users, including those with ASD, can articulate their experiences and pinpoint areas necessitating refinement. The feedback should be meticulously analyzed to derive actionable insights, promoting a cyclical process of refinement through various iterations.

Deployment: Following the iterative refinements based on holistic feedback, the deployment phase marks the inaugural launch of the application to the wider public. It would be pivotal to establish a support system, perhaps a helpline or a digital manual, to aid all students, including those with ASD, in seamlessly adapting to the new technological improvement. Engaging the university community in a comprehensive understanding about the app’s functionalities would be a strategic move, ensuring smooth integration into the daily routines of all students (Bower et al., 2014).

Continuous improvement: After the deployment, the application enters a phase of dynamic evolution characterized by continuous improvements. Here, a sustained engagement with the user base, paying attention to the feedback received from the ASD community can guide the trajectory of further developments. The constant concern on technological advancements and user preferences would need periodic updates, guaranteeing that the app remains a reliable, inclusive, and innovative tool in the educational landscape. Considering the data gathered for answering the research questions, we proposed a sequence diagram that illustrates the functioning and interaction between the parties involved in developing and using an augmented reality campus navigation application (Figure 1).

Conclusions

The major scope was that throughout this paper to explore the potential of Augmented Reality (AR) technology in improving campus orientation experiences, with a particular emphasis on catering to the needs of students with autism spectrum disorder (ASD). We approached various aspects related to AR technology, its applications in campus navigation, and its relevance for students with ASD and we reiterate the key findings: -Augmented Reality has significant potential in enhancing campus navigation experiences; -We documented the complexity of AR system architecture, including hardware components like cameras and displays, as well as software components like rendering engines and tracking algorithms; -AR is not limited to visual overlays and can offer a multisensory experience, including audio and haptic feedback particularly relevant for students with ASD; -Proper spatial registration ensures that digital overlays are correctly positioned relative to real-world objects.

We highlight the potential of AR technology in addressing the unique challenges faced by students with ASD during campus navigation. We emphasize the need for highly customizable interfaces, immediate feedback mechanisms, and features that accommodate sensory sensitivities. As part of our research, we outline a comprehensive methodology for developing AR applications for campus navigation. It includes steps such as stakeholder engagement, technological selection, content development, testing, user feedback, deployment, and continuous improvement. We conclude that the field of AR applications for campus navigation, particularly for students with ASD, is still evolving. Many existing solutions are general-purpose and require customization for specific campuses. We stress the importance of user-centered design, adaptability, and continuous improvement in the development of AR applications for this purpose and suggest that universities and institutions are increasingly recognizing the value of AR technology in education and campus navigation.

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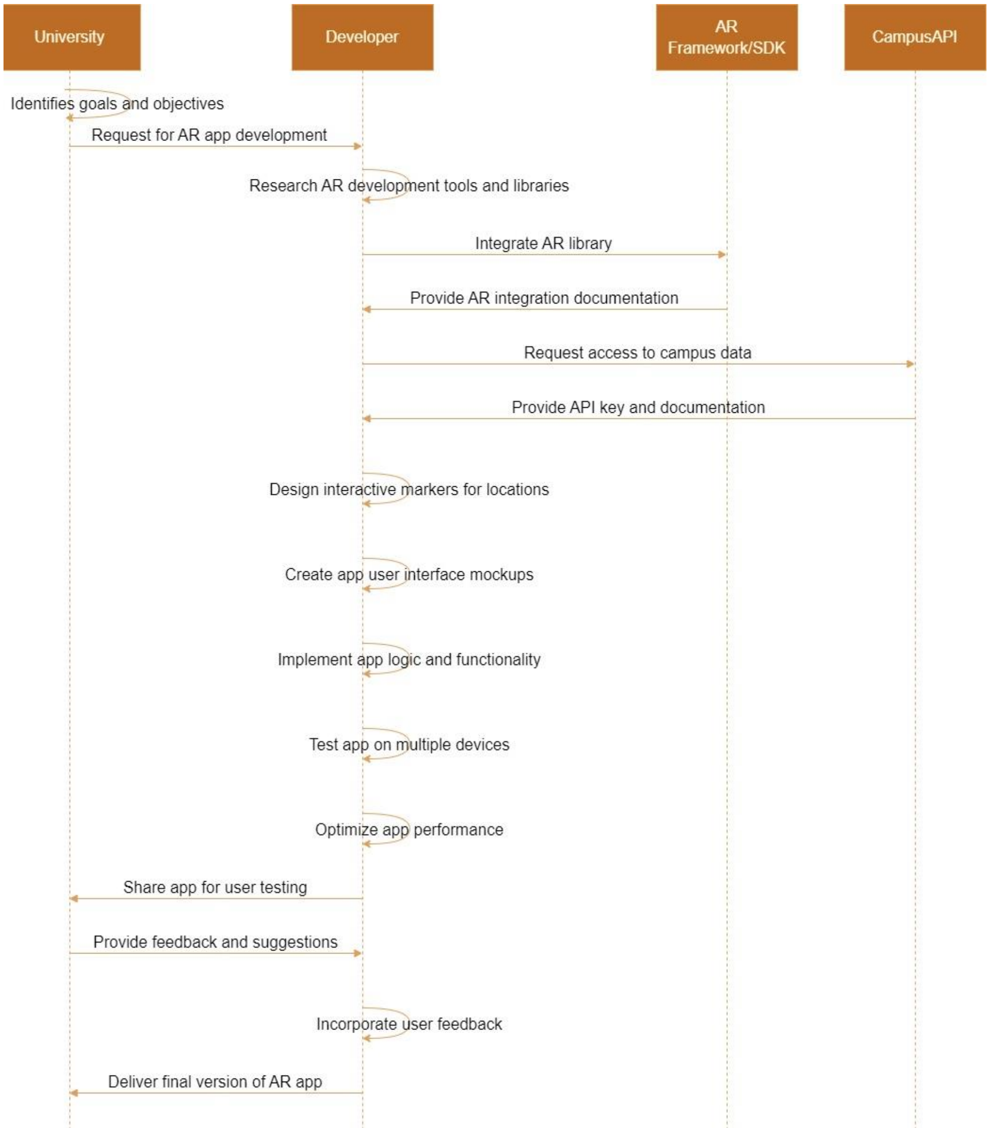

***Figure 1*. Augmented reality sequence diagram**
Source: (authors' own contribution)

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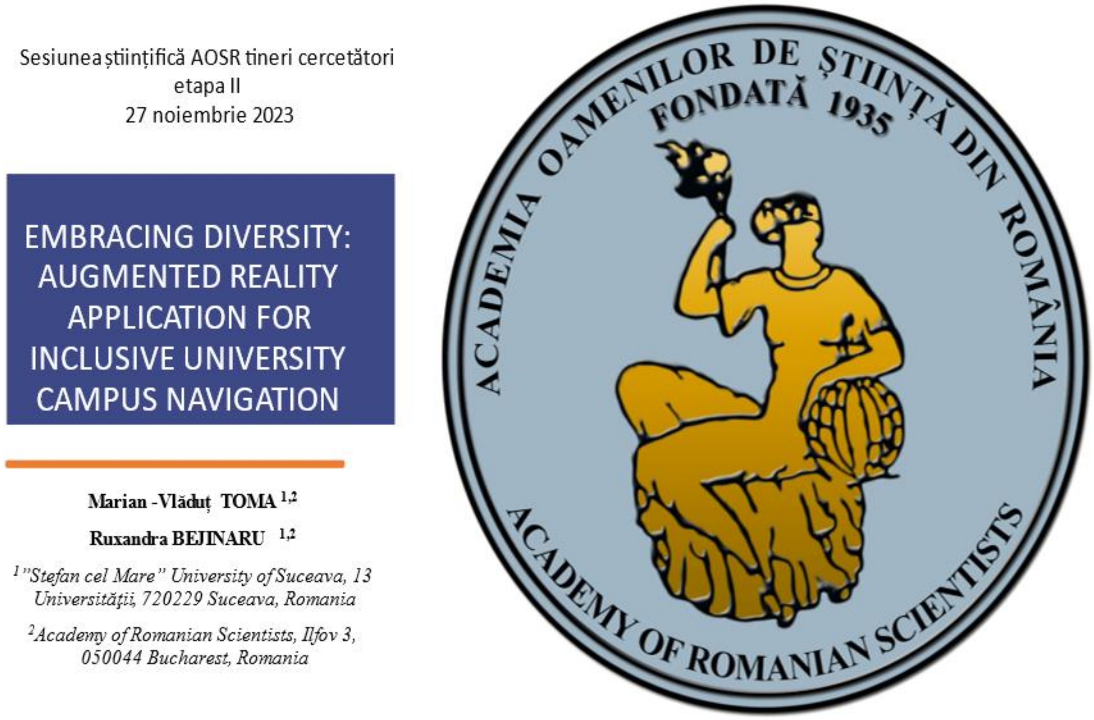
(B)

TOMA, M.V. & BEJINARU, R. (2023). **Îmbrățișarea diversității: aplicație de realitate augmentată pentru navigarea incluzivă în campusul universitar**, Sesiunea Ştiinţifică AOSR tineri cercetători - Etapa 2, 27 Noiembrie 2023.



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TOMA, M.V. & BEJINARU, R. (2023). **Augmenting the university campus: digital approach**, VI International Scientific Congress - Society of Ambient Intelligence 20-25 Noiembrie 2023; Panel Discussion “Regional business ecosystem involvement to digitalization and green transition and university’s role”, https://drive.google.com/file/d/1XI4FbJSE59wrtKAbbhOQnt8PB87DMQED/view

VI INTERNATIONAL SCIENTIFIC CONGRESS
SOCIETY OF AMBIENT INTELLIGENCE
NOVEMBER 20-25, 2023

PROGRAM ISC SAI 2023 –
PANEL DISCUSSION “REGIONAL BUSINESS ECOSYSTEM INVOLVEMENT TO DIGITALIZATION AND GREEN TRANSITION AND UNIVERSITY’S ROLE”

November 23 (Thursday)

10:00 – 14:00	Panel Discussion “Regional business ecosystem involvement to digitalization and green transition and university’s role” (ISCSAI_2023_ID.15) *Moderators:* *Carmen NASTASE, Prof. PhD, Stefan cel Mare University of Suceava (Romania)*

Join Zoom Meeting
https://us02web.zoom.us/j/88640343007?pwd=aXltS05lazRKcDZaaGJSMzZhQ2RXQT09
Meeting ID: 886 4034 3007
Passcode: 879616

09.45 – 10.00 **Registration**

10.00 - 10.20 **Opening and presentation**

Chair: Carmen Chasovschi, Stefan cel Mare University of Suceava, Romania

10.20 - 10.40 – **Innovation Laboratories for Climate Actions - Project presentation**, Consortium from Finland, Lithuania, Bulgaria, Romania, Ukraine
10.40 - 11.00 - **Lithuanian Innovation Laboratory for Climate Actions as facilitator of ecosystem actors' involvement**, Ana Aleknavičienė, Vilnius College of Technologies and Design, Lithuania 11.00 - 11.40 - **The perception of tourism businesses in Romania regarding the European Green Agend**a, Carmen Chasovschi, Mihaela State, Ștefan cel Mare University of Suceava, Romania
11.40 - 12.00 - **Ukraine`s path to climate neutrality according to EU framework**, Irina Maksymova, State University of Economics and Technology Ukraine

12.00 - 12.20 - Coffee break

Chair: Ruxandra Bejinaru Stefan cel Mare University of Suceava, Romania

12.20 - 12.40 - **The university role in developing components of the green economy**, Ruxandra Bejinaru, Ștefan cel Mare University of Suceava, Romania
12.40 - 13.00 - **Chernivtsi Business System**, Viktoria Kyfyak, Olena Vinnychuk, Yevhen Tkach, Yuriy Fedkovych Chernivtsi National University, Ukraine
13.00 - 13.20 - **Augmenting the university campus: digital approach**, Vlad Toma, Ștefan cel Mare University of Suceava, Romania
13.30 - 13.40 - **University keyrole in fostering the green entrepreneurial mindset**, Otilia Bordeianu, Lucia Moroșan Dănila, Ștefan cel Mare University of Suceava, Romania
13.40 - 14.00 – **Aspects regarding the role of tourism in sustainable socio-economic development**, Adrian Liviu Scutariu, Ștefan cel Mare University of Suceava, Romania

Final conclusions and closing

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ISC SAI 2023

RAPORT INTERMEDIAR DE CERCETARE_ Nr.3
IULIE 2024

Conținutul acestui document prezintă sub forma unui raport intermediar rezultatele cercetărilor pe tema proiectului cu titlul *”Facilitarea accesului la educație prin realitatea augmentată și stimularea învățării dinamice în afaceri prin microlearning”* aferent etapei 3 a proiectului postdoctoral sub egida Academiei Oamenilor de Știință, din România, Filiala București.

Raportul intermediar (3) conţine detalii despre rezultatele proiectului de cercetare:

(A) Participarea fizică și prezentarea rezultatelor cercetării ce explorează potențialul tehnologiei Realității Augmentate (AR) pentru îmbunătățirea experiențelor de navigare în campusul universitar, cu un accent deosebit pe satisfacerea nevoilor studenților cu tulburări de spectru autist (ASD), ceea ce face obiectul prezentului contract, împreună cu dovada publicării în programul și volumul conferinței: ICBE-2024, *International Conference on Business Excellence*, organizată de Academia de Studii Economice din București.

BEJINARU, R. & TOMA, M.V. (2024). **AR Technology Potential for Facilitating Access to Advanced Education for Students with ASD**, Proceedings of the International Conference on Business Excellence, Sciendo, VOLUME 18 (2024): ISSUE 1 (JUNE 2024). LINK: https://sciendo.com/article/10.2478/picbe-2024-0155

(B) Participarea fizică și prezentarea rezultatelor cercetării ce explorează impactul tehnologiilor emergente, cum ar fi microlearning-ul, modelarea proceselor de afaceri (BPM) și automatizarea proceselor robotizate (RPA) în operațiunile de afaceri, ceea ce face obiectul prezentului contract, împreună cu dovada publicării în programul și volumul conferinței: ICBE-2024, *International Conference on Business Excellence*, organizată de Academia de Studii Economice din București.

BEJINARU, R. & TOMA, M.V. (2024). **Enhancing Business Operations Through Microlearning, BPM and RPA**, Proceedings of the International Conference on Business Excellence, Sciendo, VOLUME 18 (2024): ISSUE 1 (JUNE 2024). LINK: https://sciendo.com/article/10.2478/picbe-2024-0154

(C) Participarea fizică şi prezentarea rezultatelor cercetării - la Sesiunea Ştiinţifică AOSR tineri cercetători - Etapa 3, 5 Iulie 2024, sediul Academiei Oamenilor de Știință din România, din strada Ilfov, nr. 3, sector 5, București, în Sala de Consiliu, parter;

*BEJINARU, R. & TOMA, M.V. (2024). **Enhancing Business Operations Through Microlearning, BPM and RPA**.*

(A)

International Conference on Business Excellence – ICBE 2024
Smart Solutions for a Sustainable Future
18th edition, 21-23 Martie 2024

AR Technology Potential for Facilitating Access to Advanced Education for Students with ASD

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Abstract: Facilitating access to advanced education and research is the mission of a proactive and future-oriented university. The university must also direct its attention to categories with disabilities such as students with ASD (Autism Spectrum Disorders). For this purpose, Augmented Reality (AR) can be used through applications that offer different types of support, as well as learning robotization processes. Students with ASD have diverse intellectual potential and can significantly contribute to scientific progress. It is important that universities recognize the intellectual potential and talent of students with ASD and provide appropriate support and accessibility to develop their skills and achieve their academic and research performance. Throughout this paper, we aimed to point out aspects of critical importance from these categories: conceptual and practical evolution, influencing factors, advantages and difficulties, perspectives but also risks regarding the lack of action in this direction. This work integrates qualitative literature review research with empirical research. The literature analysis section highlights the extent to which universities provide adaptation and orientation facilities in new spaces, taking into account the difficulty of people with ASD to adjust to unfamiliar spaces. We will present, both based on the literature and from the practice of the field at a global level, the technologies and platforms used in the development of AR applications for orientation in space. The research conclusions have an impact towards at least three directions: 1. Scientific impact, respectively enriching the specialized literature with new perspectives transmitted in a clear, concise and targeted manner; 2. Applicative impact, increasing the potential of implementing

innovations in this field; as well as 3. Informative impact on the general public, which contributes to broadening the spectrum of knowledge but also to strengthening the image in the local community of the efforts made by researchers in this revolutionary field of AR.

Keywords: AR technology, Autism Spectrum Disorder (ASD), advanced education, students' abilities, AR application, future-oriented university.

JEL Classification: I23, Q55, O32.

Introduction and problem statement

A forward-looking university should adopt a number of long-term strategic development directions to maintain its leading position in the field of education and to fulfil its mission of creating educational opportunities for students and the community (Bejinaru et al., 2018; Bratianu & Bejinaru, 2019; Neamtu et al., 2020). In tandem with global evolution, universities are forced to adapt to new technologies and integrate them into their learning and research processes (Bejinaru, 2019). For example, the use of Augmented Reality (AR) and Virtual Reality (VR) in the teaching and learning processes can improve the efficiency and quality of education. The university of the future will be described by attributes such as: inclusive, integrated, innovative, based on advanced technology, digital, accessible, flexible, and especially global (Friedman, 2008; Linton, 2018; Kapetanaki et al., 2022).

We consider that for the educational system in Romania, advanced technology is a bold purpose that is difficult to achieve on a large scale and research on the issue of increasing access to education for vulnerable categories (such as people with disabilities, or ASD) through AR is almost non-existent, as we have not identified specific publications carried out in our country.

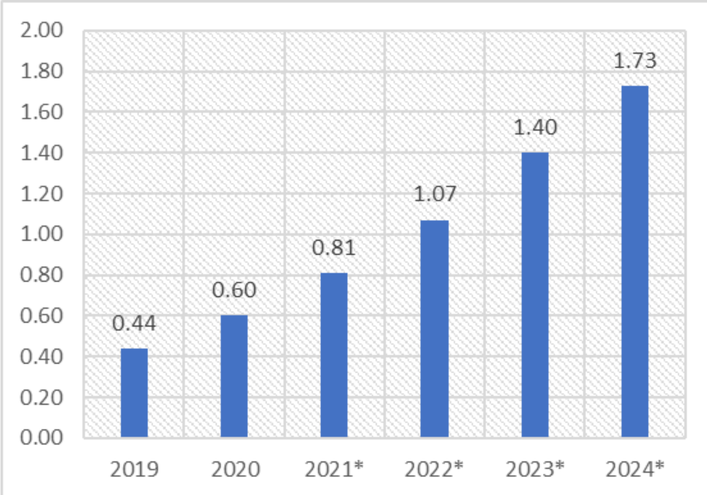
Concept and evolution of Augmented Reality (AR) technology

Augmented Reality (AR) is a technology that combines real-world elements with computer-generated virtual elements to create an enriched and interactive user experience. It superimposes layers of digital information, such as images, text, sound or video, over the real environment and allows interaction with these elements in real time (Azuma, 1997). The concept of AR was first introduced in the 1960s, but has gained popularity in recent years due to the development of mobile technologies and wearable devices such as smart phones and tablets. As seen in figure 1, the number of mobile AR active user devices worldwide increased considerably from 2019 and is expected to reach 1.73 billions in 2024, according to statista.com (2022) (https://www.statista.com/statistics/1098630/global-mobile-augmented-reality-ar-users/). These devices have sufficient cameras, sensors and processing power to facilitate AR experiences (Carmigniani et al., 2011).

AR can be classified into several types depending on how virtual information is superimposed on the real environment. The two main categories are position-based AR and recognition-based AR. Position-based AR uses sensors and the Global Positioning System (GPS) to determine the user's location and overlay relevant information based on this location. Recognition-based AR uses image and object recognition technologies to identify objects and overlay relevant virtual information on top of them (Van Krevelen & Poelman, 2010).

At the moment, AR has a wide range of applications in various fields such as medicine, engineering, architecture, entertainment and education. In education, AR has been explored as a tool to enhance student learning, motivation and engagement, as well as to support the development of collaboration and communication skills.

Figure 1. Number of mobile AR active users worldwide during 2019-2024



Source: Adapted from statista.com (2022)

Using Augmented Reality in Higher Education

Augmented Reality (AR) has undergone significant advancements in recent years, providing novel and stimulating learning opportunities in higher education. Its early experiments and applications in education were initiated in the 1990s and early 2000s, primarily in fields such as architecture, medicine, and engineering (Botden et al., 2007). However, the implementation of AR in higher education was restricted by the high costs and limited technology available at the time.

With the advent of accessible and affordable technology, mobile devices such as smartphones and tablets has played a pivotal role in enabling AR to be integrated into a broader range of educational settings. Concurrently, there has been a surge in the number and diversity of research and case studies on the incorporation of AR in higher education (Santos et al., 2014).

Augmented reality (AR) is also a promising technology that can be integrated into distance learning and online environments, offering innovative solutions to facilitate access to education and meet the needs of a diverse student population. One notable application of AR technology is the development of virtual laboratories, which enable students to engage in experimental activities and refine their skills in a secure and controlled setting (Ibanez et al., 2014). Additionally, AR has the potential to promote collaboration and communication among students and educators in virtual learning environments (Dunleavy & Dede, 2014).

Using Augmented Reality in education for students with ASD

In recent years, a considerable number of studies investigated the potential of AR technology to support the education of students with autism. Prior studies have primarily focused on examining how AR can be used to enhance the social and communication skills of students with autism, as well as to facilitate their academic learning (Kandalaft et al., 2013; Lahiri et al., 2013). While these studies have provided valuable insights, they have predominantly been conducted within the context of primary and secondary education. Consequently, research on the application of AR in higher education settings for students with autism is still limited.

Given that students with autism frequently encounter difficulties with communication and social interaction (American Psychiatric Association, 2013), AR offers a controlled and structured environment in which they can explore and learn at their own pace without feeling overwhelmed by real-world stimuli (Escobedo et al., 2012). Previous research has demonstrated that incorporating AR into interventions for students with autism can significantly improve their social skills, attention, and communication (Cheng et al., 2015).

Furthermore, AR can facilitate collaboration and communication between students with autism and their peers, thereby supporting the development of social skills that are essential for success in higher education (Wainer et al., 2017). For instance, AR-based applications can create social scenarios and provide real-time feedback on the user's social behaviours, enabling them to improve their social interaction skills (Parsons et al., 2013). Chang et al. (2010) developed an AR-based instructional system that aimed to help students with autism learn complex tasks and enhance their communication and collaboration skills. The system was tested in a university-level engineering course and demonstrated promising results in improving the conceptual understanding and academic performance of students with autism. Parsons et al. (2013) examined the use of virtual and augmented reality environments to facilitate science learning for adolescents and young adults with autism. The study found that participants with autism were able to successfully navigate and interact in AR-based learning environments and that these environments can be used to support learning in higher education.

Radu (2014) also conducted a review of studies on the use of AR in education and identified several examples where AR has been used to support students with special needs, including those with ASD. Although not all research were specific to students with ASD, the review highlights the potential of AR to provide adaptations and personalised support for students with different learning needs.

Benefits and challenges of AR in educational context

The advantages and disadvantages of using AR in an educational context, particularly for students with ASD, may vary depending on the specific implementation and context. According to existing research, we extracted several advantages that include the following: -AR can *boost the interest and motivation* of students with ASD by providing them with engaging and interactive learning experiences; -AR provides opportunities for visual and contextual learning, which can be particularly effective for students with ASD, who often have strong visual abilities (Escobedo et al., 2012); -AR supports the development of social skills by helping students with ASD practice interactions and understand social behaviours (Kandalaft et al., 2013); -AR allows learning experiences to be tailored and personalised to the individual needs, enabling them to work at their own pace and focus on areas where they need more support (Akçayır & Akçayır, 2017); -AR can help students with ASD become familiar with new situations and develop self-confidence by giving them the opportunity to explore and experiment in a controlled and safe environment without the pressures and fears associated with new situations (Lorenzo et al., 2016).

Even if the list of benefits can go on, a series of difficulties, barriers, risks or limitations that are inevitable in a process of such scope should not be omitted. The implementation of such a strategy exposes the university to a series of risks and difficulties such as high costs, lack of material endowments and equipment, lack of highly specialized human resources, confidentiality and security issues, mentality and social culture in the sense of a possible negative perception of students without ASD (Merchant et al., 2020).

The costs associated with developing and purchasing AR apps and equipment can be high, which may limit access to this technology for some universities or students with ASD. Implementing AR in higher education can be difficult due to technical issues and the need to adapt content and teaching strategies to this technology (Bower et al., 2014). Another important challenge for some students with ASD, is that the use of AR can lead to sensory overload and increased anxiety. It is important that AR applications are appropriately tailored to take into account the individual needs and sensitivities of students with autism (Zydney & Warner, 2016). In order to effectively use AR in higher education for students with ASD, teachers may need additional training and support to become familiar with the technology and adapt teaching strategies to this new environment. Integrating AR into the university curriculum can be difficult, as it may require revising and adapting course materials and teaching strategies to accommodate this technology. This may require additional time, effort and resources from teaching staff and higher education institutions (Johnson et al., 2011). The use of AR in higher education involves the collection and storage of personal data and information about student performance, which can raise privacy and data security concerns. Educational institutions and AR app developers must implement appropriate security measures to protect this information (Villagran-Vizcarra et al., 2023).

The use of AR in higher education for students with ASD has both advantages and disadvantages. In order to benefit from the potential of this technology and mitigate the disadvantages, careful planning, adaptation of content and teaching strategies, and continuous monitoring and evaluation of the impact on students are essential within a future-oriented university (Prelipcean & Bejinaru, 2018).

Research methodology

Aim of research

Through this paper, we launch a detailed analysis of the subject regarding the facilitation of access to advanced education for students with ASD through AR technology in a higher education organization such as a university in Romania. The research methodology is mixed, which combines the qualitative methods of analysis and synthesis, with the empirical methods of developing and testing an AR application in a particular setting such as the "Stefan cel Mare" University in Suceava.

More systematically, the purpose of the research is to map the overall picture of the theme and to formulate solutions for realistic progress. There are several specific objectives, such as: -to identify the conceptual and practical evolution of the topic addressed, -to identify the influencing factors on the analysed topic, -to identify advantages and disadvantages arising in relation to the analysed topic, -to argue the positive perspectives as well as the risks that may arise for such a practical approach. As we mentioned, qualitative and empirical research methods complement each other. Regarding the results and impact of the research, we will present them in the following section while describing the research methods.

Research methods

The scientific literature analysis reveals lack of development of AR applications that can be tested and used in higher education, both for people with normal development and even more so, for people with ASD. Thus, we aim to develop an app for mobile devices (smartphone, tablet) using AR technology to support orientation on a school or university campus. Using GPS technology, built-in optical sensor and screen, the app will display complementary content in the form of graphic/text/audio & video creations when the camera is pointed at a specific target. This way, people with special needs such as those with ASD can be supported to orient themselves and get comfortable with new spaces, especially if they have a social skills deficit. The app can also be used to deliver guidance and additional information for people with normal development.

The app to be developed will run on a web server for easy access and use. Thus, the app does not require installation from a specialised app store such as the Play Store (Android) or Apple Store (iPhone) and does not take up local storage space. Because it's cross-platform, it means that can be accessed from any device that has a browser installed. The app is accessed by simply scanning a QR code that links to the web server hosting it. The application flow chart is described in figure 2.

The application will be tested during the admissions process at "Stefan cel Mare" University in Suceava, both with potential students visiting the campus for the first time for the registration process and with voluntary people with ASD from the Help Autism Suceava Centre. To access the application, QR codes will be placed on a panel containing the name of each faculty, so that the student can scan the QR code for the faculty concerned and be directed to the web application, receiving guidance. On the first run, the users will be prompted to choose between standard assistance for orientation and special assistance (for people with ASD). The delivered content will be personalised depending on the chosen option.

Both during the university admissions period and in the first weeks of the semester, students can be disoriented and confused about the location of registration rooms for each faculty and later about the location of lecture halls and seminar lab rooms. Some find it difficult to socialise and ask for directions, especially because in a university study people from many different locations across the country and beyond.

The major limitations of the research methodology we can specify are lack of generalization and representativity, as the experiment will be developed in a specific framework, namely "Stefan cel Mare" University campus. Although this type of approach provides a certain control and predictiveness on the experiment and this could lead to further improvements.

Conclusions and expected results

Considering the potential of AR highlighted by both researchers and statistics on the trend of this technology adoption, it is expected that the proposed application will be a real success, with obvious advantages such as the use of a mobile device, as a smartphone, that most young people already own, running directly on a web browser without the need to install the application (thus eliminating resource consumption) and the valuable information it can provide by simply pointing the camera to various targets. Settling in and orienting to new spaces, especially those such as university campuses, can be difficult for both people with normal neurological development and people with special needs, such as those with autism spectrum disorders. Therefore, guidance can be very helpful. Based on the existing studies and applications that have been developed and tested, the need for a solution in terms of orientation on campus and by analysing the results obtained from previous research, it can be expected that the proposed application can make a real contribution.

In general, a future-oriented university must be inclusive and flexible towards all students, regardless of their special needs. By providing individualized support and creating an inclusive academic environment, universities can contribute to the development and success of all students, including those with ASD.

In conclusion, the paper proposes an adapted research model, which will be realized in an original (new) experiment through the intelligent mobile application based on AR. The paper argues the relevance of introducing AR technology for a specific problem such as access to advanced education for students with ASD. The implementation of this experiment has the potential to identify - both functionalities and dysfunctionalities and brings to light possible future approaches.

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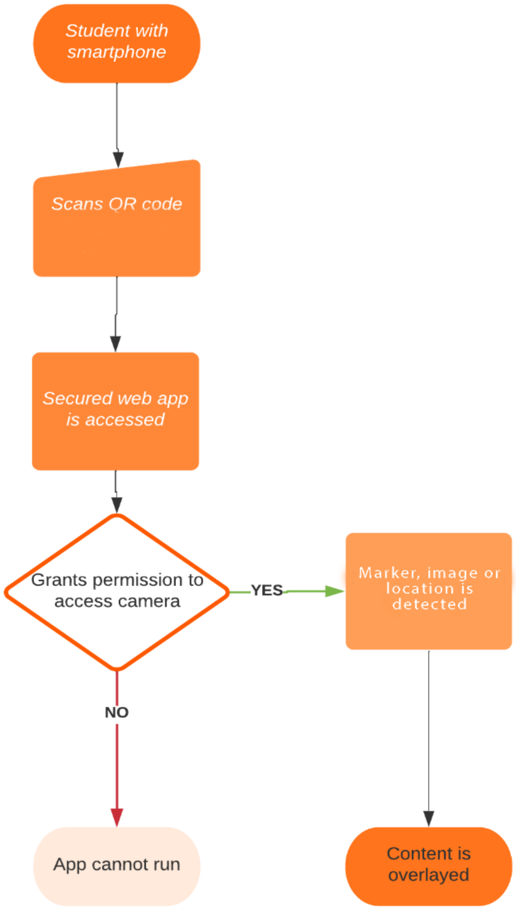
Figure 2. Application flow chart



Source: Authors own elaboration.

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AR Technology Potential for Facilitating Access to Advanced Education for Students with ASD
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ENHANCING BUSINESS OPERATIONS THROUGH MICROLEARNING, BPM AND RPA

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Abstract: This paper aims to investigate the impact of emerging technologies such as microlearning, Business Process Modelling (BPM) and Robotic Process Automation on business operations. In the first part, we did a literature review and defined the key concepts underlying these technologies. Microlearning caters to the modern learner by offering short, effective learning bursts that align well with the fast pace of today's work environments. BPM accelerates the process of delivering learning content specific to microlearning modules by optimizing specific workflow. RPA contributes by automating routine tasks using bots, improving the learning experience by providing instant materials, support and feedback. In the second part, we conducted a bibliometric research with the help of VOSViewer, focusing on an analysis of the co-occurrence of keywords specific to the 3 technologies, highlighting research trends and patterns, the impact of research in terms of citation analysis, but also research gaps on a topic. A future perspective was outlined for the implementation of these technologies in business environments, analyzing their impact and presented a section with case studies, highlighting common challenges and offering possible solutions. Summarizing all this, it can be said that the synergy between these 3 technologies has obvious advantages such as increasing productivity, optimizing administrative processes, reducing costs, and improving learning experiences, but it can also pose implementation problems specific to adopting new technologies in a constantly changing environment.

Keywords: Bibliometric Analysis, Business Development, Business Process Modeling (BPM), Microlearning, Robot Process Automation (RPA)

Introduction

The scope of the paper is to offer a forward-looking perspective on employee training and organizational efficiency in the business context of integrating modern technology in professional development. The aim is to identify what impact might have enhancing business operations using BPM (Business Process Modeling) and RPA (Robotic Process Automation). We shall briefly argue the relevance of each concept involved in the process.

Firstly, the concept of "*microlearning*", represents a method that delivers content in small, specific bursts, that aligns perfectly with the contemporary workforce's preferences and learning behaviors (Díaz Redondo et al., 2021; Leong et al., 2021; Samala et al., 2023). With just minutes at a time, microlearning efficiently perfects skills and locks down new information – an essential tool in navigating through the rush of modern work life. This learning approach caters to the need for quick, accessible learning that can be easily integrated into the daily workflow without overwhelming the learners (Nikkhoo et al., 2023).

Secondly, the inclusion of *Business Process Modeling (BPM) and Robotic Process Automation (RPA)* is necessary as representing the technological backbone of the proposed microlearning platform in a business environment. We can picture BPM as our personal assistant, remodeling learning processes for peak performance, spotlighting key info while speeding up content delivery. This could potentially streamline the creation and distribution of microlearning modules, making the platform highly adaptive to the changing needs and objectives of the business (Li et al., 2014; Reijers, 2021).

Another key role of RPA is that the automation of repetitive tasks can be also applied for learning and development (L&D) activities, by automating the administrative and support tasks associated with training programs. This not only reduces the operational burden on L&D teams but also enhances the learning experience by providing timely support and feedback to learners, thereby increasing engagement and effectiveness (Meidan et al., 2017).

Microlearning and Business Process Modeling (BPM) represent two innovative concepts that, when combined, can bring significant benefits to the business environment Hug (2005). Tech changes in the blink of an eye, pushing us to ensure our team isn't left behind. A versatile development strategy becomes our secret weapon in this race. We will further argue the functioning and utility of integrating microlearning with BPM in the business environment (Guralnick, 2018).

When businesses blend microlearning with BPM and RPA technologies, they're really setting themselves apart. It's all about crafting top-notch skills among employees which paves the way to outshine competitors and dominate the marketplace. This synergy between learning and process optimization opens up new possibilities for the continuous growth and adaptability of organizations (Bejinaru & Iordache, 2010) in the face of the challenges of the dynamic contemporary business environment.

Literature review

Business process modeling

Business Process Modeling (BPM) is a methodology that facilitates the visual representation of an organization's processes, aiding in their comprehension, analysis, and improvement (Dumas, La Rosa, Mendling, & Reijers, 2018). It plays a critical role in identifying, redesigning, and optimizing processes to enhance efficiency and achieve organizational goals (Weske, 2019). By uncovering the trouble areas—whether it's slowdowns or doing more than needed—BPM makes everything run smoother from cutting expenses to boosting how well we serve our customers. The creation of visual diagrams, such as flowcharts and process maps, not only aids in bridging the communication gap among stakeholders but also lays the groundwork for integrating business operations with technological implementations (vom Brocke & Rosemann, 2015). Furthermore, BPM is not a one-time activity but a continuous process that requires ongoing evaluation and refinement to meet new business challenges and opportunities (Weske, 2019).

Across diverse domains, the transformative effect of technology is hard to ignore. These days in education, it's not just about what students can learn but how smoothly everything runs behind the scenes. Thanks to BPM, the educational sector is getting a major upgrade in efficiency across board—from sharpening up admin tasks to delivering better student services.

By introducing BPM into educational settings, students are walking out of class with not just theory but practical skills in making businesses run smoother and more efficiently. For instance, a study by O’Leary (2020) emphasized the integration of BPM tools and methodologies within MBA programs to foster an understanding of digital transformation in business. Thanks to the latest in BPM software, learners now have a playground for testing out business management theories on actual industry scenarios. Students today aren't just reading about business operations; they're actively reshaping them with advanced BPM tools like ARIS and Bizagi right from their desks. According to a research by Harmon and Ramos (2018), getting hands on and being involved with everyday business jobs not only clears up complex ideas about operations but also shows just how much tweaking these processes can propel an organization forward. An example includes the collaboration between universities and corporations to provide students with live projects that require BPM solutions. In a case study by Müller et al. (2019), students worked alongside professionals to redesign the supply chain processes of a manufacturing company, applying BPM principles to enhance efficiency and reduce costs. Students embarking on these joint ventures find themselves applying what was once theoretical knowledge in tangible ways, seamlessly blending study with industry application. The role of BPM education extends beyond technical skills, contributing significantly to the development of soft skills such as leadership, teamwork, and critical thinking (Baesu & Bejinaru, 2020). Engaging students in BPM projects requires them to navigate complex problem-solving scenarios, communicate effectively with team members, and lead process improvement initiatives. According to Van Looy (2021), getting hands-on with such experiences is key for prepping students to excel in the teamwork and mixed-discipline reality of contemporary businesses.

Schools are now teaching BPM, equipping young minds with critical business tools early on. Through a combination of theoretical coursework, experiential learning with BPM tools, collaborative industry projects, and a focus on both hard and soft skills development, students are better prepared to meet the challenges of today’s business world. Graduates come out of these initiatives not just more hireable but equipped with sharp tools for making workplaces run smoother and smarter.

Robotic process automation

Robotic Process Automation offers businesses a chance to automate routine operations and give human workers room for more creative endeavors, employing nifty bots to tackle diverse online chores, interacting with different applications just as humans do (clicking, typing, browsing through pages and other activities). The operational backbone of RPA is formed by software bots, which are specifically programmed to execute predefined tasks (Anagnoste et al., 2021). From fast entering loads of data to unpacking intricate business trends, these bots keep things running smoothly day and night—no rest needed, no room for slip-ups. An RPA platform is like the control center for bots, offering all the necessary tools to create, put to work, and keep an eye on them. The workflow designer is a key component of an RPA platform and is used to orchestrate the tasks without the need of coding. Its user-friendly graphics guide the user through setting up and deploy operations in no time. When examining pharmaceutical organizations Anagnoste (2018) found that the primary challenges include managing large volumes of data, encountering high rates of errors that adversely affect the company's reputation, extensive time dedicated to correcting mistakes, navigating through outdated systems, and facing a high employee turnover rate due to the monotonous nature of the tasks.

When mixing RPA with the powers of Artificial Intelligence (AI) and Machine Learning (ML), bots turn into decision-makers. They start adapting their work using insights provided by the data they crunch. Working with Natural Language Processing (NLP), RPA bots are no longer just automated tools, they now grasp human conversations, streamlining tasks from answering client questions to analyzing stacks of papers effortlessly. Another key technology used by RPA bots is Optical Character Recognition (OCR), reading everything from pictures to hard reading text, digitizing info with ease. The integration capabilities of RPA, achieved through Application Programming Interfaces (APIs) and screen scraping, ensure that these bots can seamlessly interact with a multitude of software systems, enhancing their utility and flexibility across various operational contexts, as shown by Toma (2023) that used RPA to automate the collection and signing of university daily sheets.

The significance of RPA in operational efficiency and innovation is extensively documented in the literature. Lacity and Willcocks (2016) get into the subject as they unwrap the power of RPA to facilitate productivity like never before. Similarly, Syed et al. (2019) explores the theme and reveals that diving into RPA is more than just trendy—it's a smart move filled with benefits for those ready to lead. Aguirre and Rodriguez (2017) really broke new ground by showing us what happens when you mix RPA with AI - giving business operations a boost for the future. Moreover, the research conducted by Wanner and Janiesch (2020) shed light on the transformative role of RPA—turning up process speed and receiving positive feedback from satisfied customers. Learning is improved directly by RPA, enhancing every lesson along the way. According to Johnson et al. (2017), the use of RPA in automating feedback mechanisms allowed for more personalized and detailed feedback, contributing to better learning outcomes. With RPA tools in play, every student gets a learning journey that's personalized just for them.. A case study by Smith and Patel (2020) illustrates how RPA was used to tailor learning paths for students in an online learning platform, resulting in improved engagement and academic performance. By doing so, educational institutions can equip students with the tools necessary for personalized and effective learning, thereby fostering an environment that not only improves engagement and performance but also prepares students for a future where technological adaptability is key (Prelipcean & Bejinaru, 2018).

Another example is a study by Clark et al. (2021), which demonstrated how RPA was utilized to dynamically adjust learning materials and assessments based on student progress and feedback, resulting in improved academic performance and learner satisfaction. For every student's step forward, RPA can recommend the right resource or module they need next based on their current performance. This was illustrated in a project described by Thompson and Lee (2019), where RPA tools analyzed quiz results to recommend additional reading materials and practice exercises for students struggling with certain concepts.

Microlearning

Microlearning is characterized by its delivery of content in small, manageable units, facilitating short-term focused learning activities. This approach, as Hug (2005) initially conceptualized, leverages relatively brief learning units to support skill acquisition, knowledge retention, and the achievement of specific learning objectives, making it particularly suited for ongoing professional development. As shown by Guralnick (2018), it turns out breaking down learning materials into bite-sized pieces really works with the current students. It hooks their short attention spans and makes fitting new info more easily.

Microlearning platforms are digital environments packed with tools for delivering learning content, such as a repository for storage, learning pathways, adaptive algorithms, analytics and reporting. Key references on the topic include works by Hug (2005), who introduces microlearning as a new pedagogical challenge, and Giurgiu (2017), who discusses microlearning as an evolving eLearning trend. Regarding the field of business education, this approach has proven to be a very useful tool, as shown by Jahnke, Lee, Pham, He, and Austin

(2020), that highlight microlearning's role in facilitating just-in-time learning, where learners can immediately apply concepts and skills to real-world business challenges, thereby reinforcing learning through practice.

Using BPM and RPA alongside short learning modules not only changes how we deliver lessons but also customizes them. BPM aligns development with delivery so every lesson increases in relevance and effect. In parallel, RPA is making distributing lessons or assessing learners less of a problem, according to Lacity, Willcocks & Craig (2016) during their findings which highlight benefits including efficiency and scalability. This personalization aspect, explored by Ifenthaler and Yau (2020), enhances the learning experience by ensuring that learners receive content that is most relevant to their needs and learning progress. Moreover, the scalability afforded by RPA's automation capabilities allows educational institutions and corporations to offer microlearning opportunities to a broad audience without a corresponding increase in administrative overhead.

Despite the promising integration of microlearning, BPM, and RPA, challenges such as ensuring data privacy, maintaining content quality, and overcoming technological barriers remain. The study by Schwerer and Mödritscher (2021) points out the need for more advances algorithms and investigation the long term impact on personal and professional development.

Methodology

By puting together information from three complex fields, "microlearning", "business process modelling" and "robotic process automation", we aim to enrich our understanding beyond current horizons and provide valuable insight. To achieve this goal, we have conducted a bibliometric analysis, a methodology that utilizes quantitative approaches to examine and assess academic literature (Vargas et al., 2022). The primary role of bibliometric analysis is to uncover research patterns and trends, such as academic productivity, the significance of contributions, and the interconnections among various academic disciplines (Ellegaard & Wallin, 2015). This type of analysis is versatile, incorporating a range of procedures like citation analysis to evaluate the influence of specific works, authors, or research fields; co-citation analysis to identify seminal works and key researchers; co-occurrence analysis to detect dominant concepts and themes through the examination of frequently occurring words in titles or abstracts; and impact analysis using metrics such as citation counts, the h-index, or journal impact factors (McAllister et al., 2022). These methods provide numerical and visual interpretations but also have limitations, such as the potential misrepresentation of research quality or the selection of inappropriate indicators, which could skew the results of the analysis (Zupic & Cater, 2015; Alayo et al., 2021).

However, the advantages of bibliometric analysis are significant in importance despite certain limitations, such as those mentioned. It facilitates extensive analysis of vast datasets from diverse sources, aiding in the discovery of publication trends and knowledge gaps, thereby guiding future research. Moreover, a suggestive visual representation of the chronological evolution of writings on a specific topic becomes extremely relevant in an in-depth research of it. Identifying a chronology of writings, authors, and journals that have conveyed information about the analyzed theme is useful in shaping the research approach. It is also cost-effective, relying on existing software and online databases. Another advantage that cannot be ignored is the time-saving aspect, which is an essential resource in the research process. The main goal of bibliometric analysis is to assess the research impact in a specific field, over a certain period of time, or according to other criteria (Glinyanova et al., 2021; Hillmann, 2021; Agostini et al., 2020; Diez-Martin et al., 2021). Considering these benefits, we argue that bibliometric analysis is a valuable tool for providing a comprehensive review of the literature in a given field (Dhamija

& Bag, 2020). We will further explore the most active research areas, prominent researchers and institutions, and the most cited articles or journals.

We applied the standard stages of bibliometric analysis using databases of works extracted from Scopus based on the key phrases “Microlearning”, “Business Process Modeling” and “Robot Process Automation”. The query codes used were as basic as follows:

TITLE-ABS-KEY (" Microlearning ")

TITLE-ABS-KEY (" Business Process Modeling ")

TITLE-ABS-KEY ("Robot process Automation")

To conduct a keyword co-occurrence analysis, steps were undertaken to load the database into the specialized software VOSviewer, followed by the selection of desired analysis criteria. For each concept, the threshold limit was incrementally adjusted in order to result an acceptable number of keywords and relevant for subsequent stages of the bibliometric analysis. This procedure is essential for achieving an efficient and focused analysis.

Related to the keywords, there are several analysis options to consider as: Keywords Co-occurrence Network, Keywords Co-occurrence Overlay Map, and Keywords Density Map. The Keywords Co-occurrence Network facilitates the visualization of relationships among keywords within the database. The nodes in this network represent the keywords, while the links between them indicate the frequency of these words appearing together in the same works. This analysis can highlight groups or clusters of closely related keywords, suggesting subdomains of interest or emerging research trends (Shah et al., 2019). The Keywords Co-occurrence Overlay Map adds an additional layer of information to the co-occurrence network by variably coloring the nodes based on supplementary criteria, such as publication year or the impact score of the works featuring the keywords. This enables the observation of temporal evolution in research interest and the identification of domains gaining or losing popularity (Van Eck & Waltman, 2010).

Keyword co-occurrence analysis plays a crucial role in understanding the dynamics of a study field by emphasizing emerging trends and ascending topics through the identification of frequently combined keywords, facilitating thematic grouping of works and providing a clear perspective on the internal structure and relationships between various research subjects. Furthermore, the analysis can reveal existing knowledge gaps, where research could make significant contributions (Van Eck & Waltman, 2017).

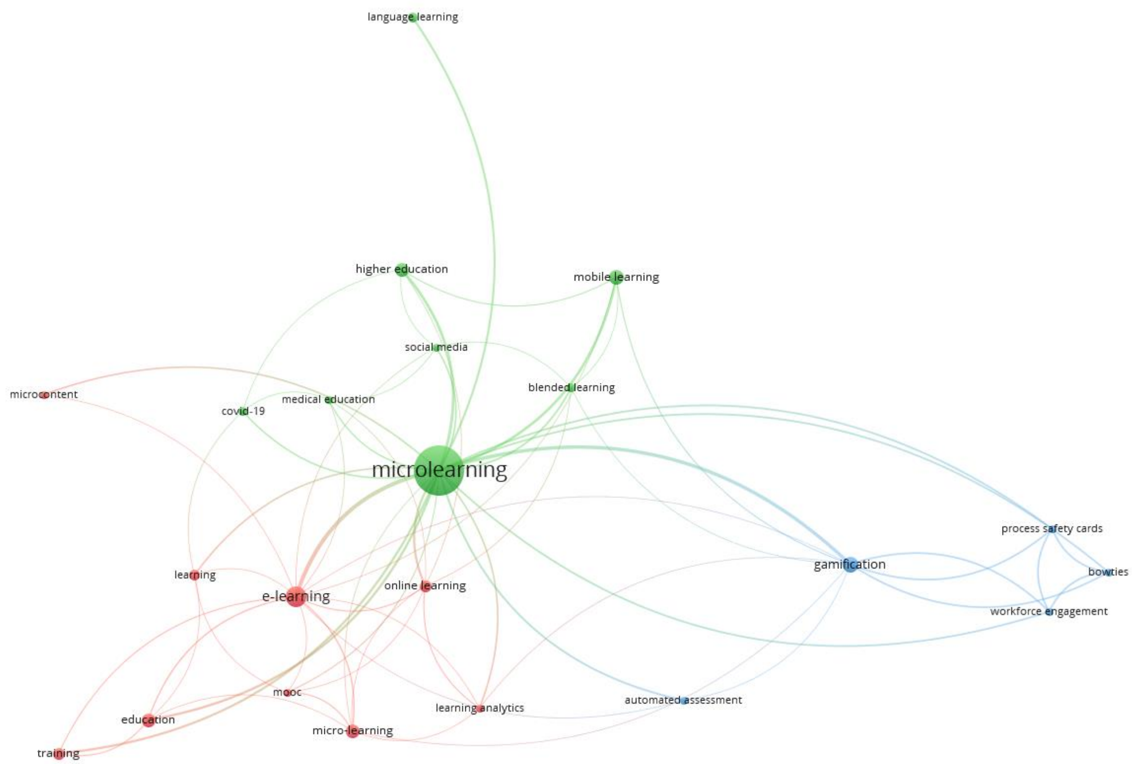

Figure 1. Co-occurrence Network for "microlearning" keyword
Source: authors' elaboration with VOSviewer

Cluster Analysis

"Microlearning" cluster analysis

In brief, the forthcoming figure 1, which will be presented and discussed, comprises 22 keywords that are deemed representative as they fulfill the criterion of appearing (simultaneously) in the content of at least 5 works within the analyzed database, encompassing 376 articles.

As we can observe in Figure 1, adjacent to "microlearning," terms like "mobile learning," "e-learning," and "blended learning" are strongly linked, indicating a significant relationship between microlearning and these modern educational methodologies. The proximity of "mobile learning" and "e-learning" to "microlearning" reflects the trend of utilizing technology to facilitate learning in manageable increments, often through mobile and online platforms which allow for flexible and accessible education.

The association between "microlearning", "higher education" and "medical education" suggests that this approach is of interest and potentially can be applied in these formal education settings, possibly to enhance the traditional learning experience or to provide additional support and resources.

The presence of terms such as "social media" and "gamification" in the vicinity of "microlearning" implies an intersection with more interactive and engagement-focused methods of learning, that could indicate a research interest in how game-like activities and social platforms can be incorporated into microlearning to increase motivation and participation. Also, the connection to "COVID-19" might reveal a recent focus, potentially related to the pandemic's impact on education and the subsequent increase in demand for innovative and remote learning solutions, including microlearning strategies to address the challenges of distance learning and keeping learners engaged outside of the traditional classroom.

"Business Process Modeling" cluster analysis

The VOSviewer protocol is similar for "business process modeling" concept and comprises a total of 7957 keywords for the standard threshold of 5 which generates a total of 485 keywords on the co-occurrence map that makes it impossible to be deciphered. Thus, we raised the threshold to 20 occurrences and obtained a set of 74 keywords that is more relevant and efficient to analyze.

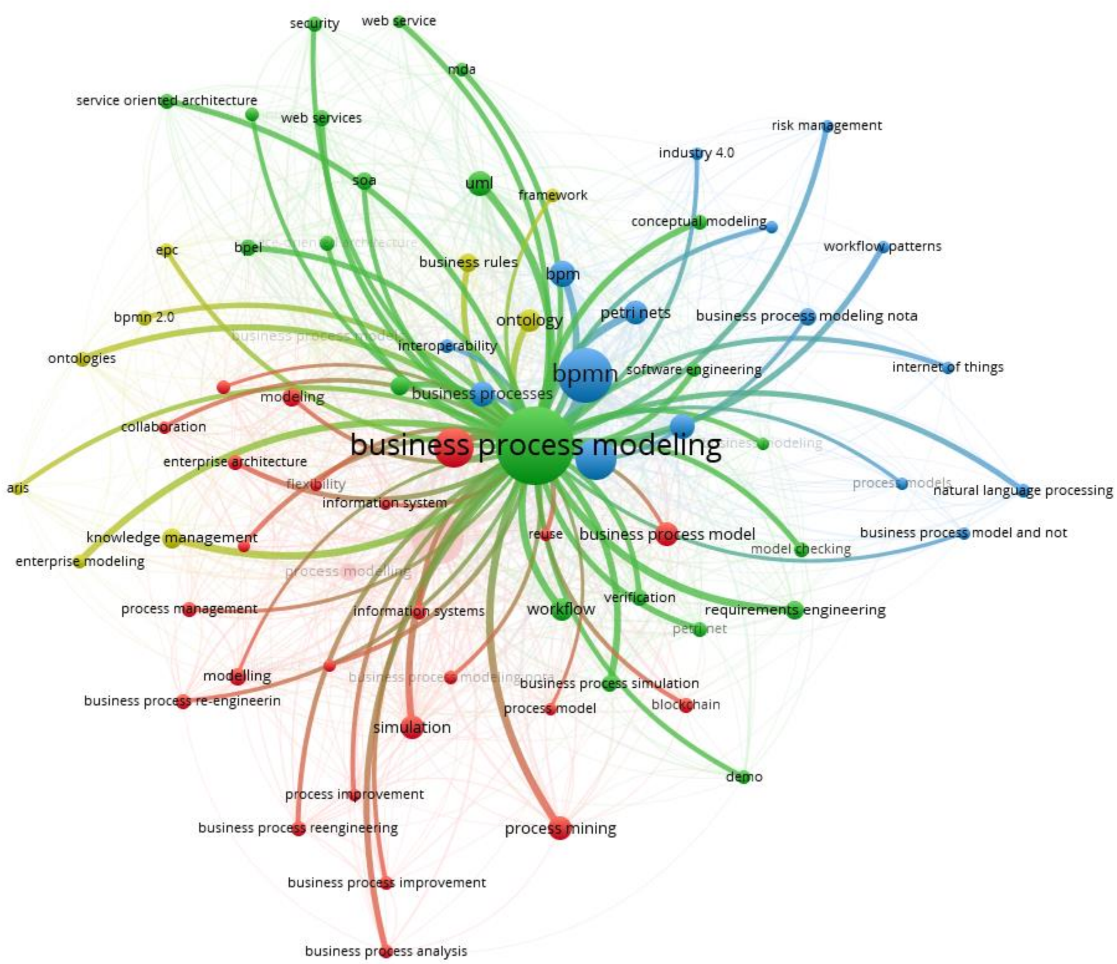

Figure 2. Co-occurrence Network for "Business Process Modeling" keyword

Source: authors' elaboration with VOSviewer

In Figure 2, the central and most prominent cluster is anchored by the term "business process modeling," suggesting it is a primary focus of the research field and frequently associated with other key terms. Terms such as "business process management" (BPM), "process mining," and "simulation" are prominently connected to the central term, indicating that these are well-established and significant sub-areas in the domain of business process modeling. The strong connections between "business process modeling" and "process mining" might indicate a trend in literature that emphasizes the importance of extracting process-related information from event logs to improve business processes. The connection between "business process modeling" and terms like "ontology," "enterprise architecture," and "knowledge management" suggests an interdisciplinary approach, where business process modeling integrates concepts from these related fields to enhance the comprehensiveness and utility of the models. The presence of terms such as "BPMN" (Business Process Model and Notation), "workflow," and "information systems" reflects the technical aspects of the field, pointing towards the practical application of business process models in designing and managing workflows within information systems.

"Robotic Process Automation" cluster analysis

Finally, the upcoming Figure 3, representing the RPA co-occurrence analysis includes 55 keywords identified as representative, out of 2105. The 55 keywords meet the criteria of concurrently appearing in the content of at least 5 works within the examined database, which consists of 940 articles.

The term "intelligent automation" occupies a central position. This signifies its core relevance and frequent co-occurrence with other terms in the literature. In proximity we can see significant terms like "machine learning," "robotic process automation," and "natural language processing, indicating a strong association between intelligent automation and these fields, suggesting that advancements in machine learning and natural language processing are likely influencing the development of intelligent automation technologies.

The term "machine learning" is also closely associated with "deep learning," "neural networks," and "computer vision," reflecting the contribution of these technologies to the progress of intelligent automation. Such connections may imply a trend in the research community towards leveraging deep learning algorithms and neural networks to enhance the capabilities of computer vision systems within the scope of automation. In addition, "robotic process automation" links to "robotics" and "intelligent systems," highlighting the application of robotics in automating structured business processes. This might represent the operational aspect of intelligent automation, where RPA is employed to streamline and improve the efficiency of workflows.

The visualization also shows a connection to broader industrial and technological trends. Terms like "Industry 4.0", "digital transformation," and "internet of things" (IoT) underscore the integration of intelligent automation within the larger context of digital and industrial advancements, reflecting a multidisciplinary approach that combines automation, data exchange, and manufacturing technologies (Bejinaru & Balan, 2020).

Robotic Process Automation (RPA) is increasingly intersecting with emergent concepts such as IoT, blockchain, digital twins, and Industry 5.0, (that can be observed in yellow color) heralding transformative research and application avenues. The integration of RPA with IoT facilitates the automation of both digital and physical tasks, enhancing efficiency and enabling predictive maintenance (Nalgozhina et al., 2023). Coupling RPA with blockchain technology promises secure, automated transactions and smart contract execution, ensuring data integrity and streamlined processes (Moreira et al., 2023). Moreover, RPA's role in Industry 5.0 underscores its capacity to support personalized production and foster human-robot collaboration, aligning automated processes with human ingenuity and customization demands (Dewasiri et al., 2023; Pypłacz & Žukovskis, 2023).

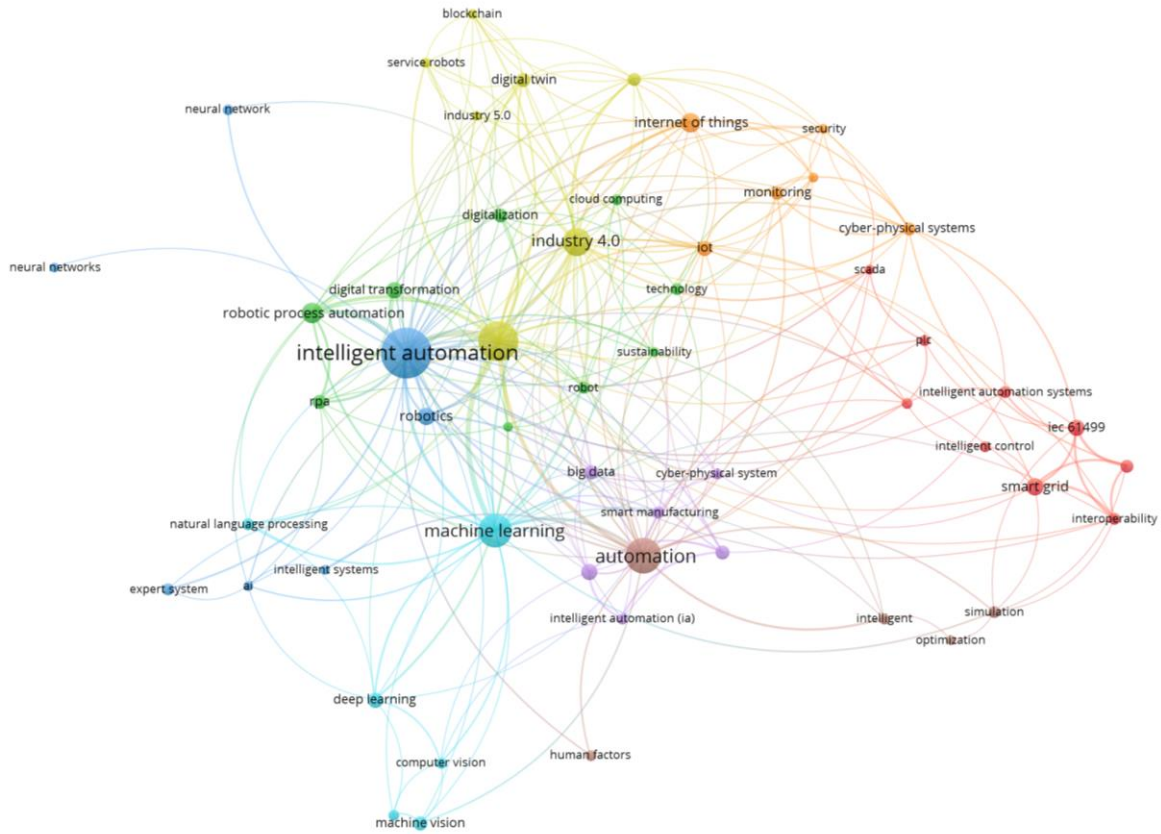

Figure 3. Co-occurrence Network for "Robot Process Automation" keyword

Source: authors' elaboration with VOSviewer

Case studies

Businesses are increasingly integrating innovative technologies such as microlearning, BPM, and RPA to improve corporate training and operational efficiency. This type of implementation has shown clear benefits such as increased employee engagement, productivity gains and cost reductions. However, fully realizing these benefits requires addressing the challenges of technology integration, change management and scalability, as the case studies described below illustrate both the successful application of these technologies and the obstacles encountered, providing valuable lessons for other organizations.

JPMorgan Chase & Co. utilized RPA within its BPM framework to automate routine tasks, thereby enhancing efficiency and allowing employees to focus on more strategic activities. Beside the advantages, fitting cutting-edge technology into all areas of business highlighted that employees need extensive learning programs and efforts in management change. Similarly, AT&T's implementation of microlearning to support continuous employee development demonstrates the approach's effectiveness in enhancing job performance and engagement but in the same time faced challenges such as the selection of relevant content and the integration with the existing technology.

Siemens AG, the tech giant in electronics and electrical engineering, has led the way with BPM and RPA to boost how fast and flexible it operates. The company initiated a comprehensive digital transformation program aimed at automating complex business processes across various departments, from procurement to human resources (Lacity & Willcocks, 2016). Siemens was able to automate repetitive tasks, reduce manual effort and improve process speed, leading to significant cost savings and increased process transparency, but in the same time the company faced challenges in aligning its IT infrastructure with the new digital tools and in managing organizational change, underlying the importance of investing in employee training and communication strategies to facilitate adaptation was crucial for the company.

Deloitte, a global consulting firm, has also enhanced its workforce's skills and knowledge with the help of microlearning. Recognizing the need for a flexible and efficient learning solution for its consultants, who often work in time-sensitive and knowledge-intensive environments, Deloitte developed a microlearning-based platform that delivers targeted, just-in-time training modules (Baer, 2020). With every twist and turn a project takes, consultants who can adjust swiftly set new standards for success and client satisfaction. Deloitte encountered difficulties trying to keep their learning content relevant, while also making sure it fit the wide array of needs across its worldwide team.

The above case studies reveal that mixing microlearning with BPM and RPA can seriously improve efficiency while keeping everyone learning and agile at work. They also state that adopting new tools isn't just plug-and-play. It demands active engagement in learning along with smartly navigating shifts as they come. The experiences of Siemens AG and Deloitte, along with those from JPMorgan Chase & Co. and AT&T, offer valuable insights and a roadmap for organizations seeking to leverage these technologies for operational and educational advancements, while also stressing the necessity of strategic planning to address the challenges of technology adoption and implementation..

Common challenges

The integration of technologies such as microlearning, BPM and RPA in business operations obviously presents a series of transformative advantages for organizations in improving the efficiency and performance of employees but however, these implementations are not without challenges, which will be discussed in the following section and we offer practical solutions to solve them.

***Technological Compatibility and Integration*:** A primary challenge businesses face when integrating BPM, RPA, and microlearning is ensuring technological compatibility among existing IT infrastructure and the new technologies (van der Aalst, 2013). The different nature of existing systems and new digital tools can hinder seamless integration, thus impacting the effectiveness of business processes, but a strategic approach that involves conducting a comprehensive IT infrastructure review and adopting middleware solutions that act as bridges between different systems would be a solution. Additionally, opting for technologies that offer API integration capabilities can facilitate smoother interoperability between these platforms.

***Change Management and Employee Resistance*:** Implementing new technologies can often disrupt established workflows and require employees to adapt to new ways of working. This change may be met with resistance, driven by fear of redundancy or the challenges of learning new systems (Osmundsen, Iden, & Bygstad, 2018), meaning that effective change management strategies are critical in addressing this challenge. This can be resolved by a clear communication regarding the benefits and rationale behind the integration of technology, involving employees in the transition process and providing comprehensive training and support. Building a team of change advocates in the company can make the shift to new tech smoother, as they offer support and spread enthusiasm among their peers.

Scalability and Maintenance**:** As organizations expand, the solutions initially implemented may not efficiently scale to meet increased demands, resulting in performance issues or bottlenecks. Furthermore, the ongoing maintenance of BPM, RPA, and microlearning platforms can strain resources (Lacity & Willcocks, 2016). Kicking things off with scalability in mind, taking things step by step and regularly schedule maintenance and updates, coupled with continuous monitoring of system performance, can prevent potential issues from escalating.

Content Relevance and Engagement in Microlearning**:** Maintaining the relevance, engagement, and tailoring of microlearning content to the needs of a diverse workforce is a significant challenge (Baer, 2020). Outdated or generic content can lead to disengagement and diminish the effectiveness of learning initiatives. This can be solved by adopting a dynamic strategy for clear and personalizing content, leveraging analytics reports to understand employee learning behaviors and preferences as a crucial part in crafting targeted and relevant content, soliciting in the same time feedback on microlearning modules.

Future research

Future studies combining Business Process Modeling (BPM), Robotic Process Automation (RPA), and microlearning should aim to investigate the effects of emerging technologies, tackling not only the potential benefits but the challenges they present too, such as the following:

- *Enhancing Integration with AI and ML*: Investigating how artificial intelligence (AI) and machine learning (ML) can optimize BPM, RPA, and microlearning, focusing on adaptive systems, efficiency improvements, and personalized learning experiences (Cao et al., 2024).
- *Blockchain for Security and Transparency*: Examining blockchain's role in ensuring secure, transparent BPM and RPA implementations, and its potential to revolutionize process and transaction logging (Akram et al., 2024).
- *IoT for Real-time Data Integration*: Exploring how the Internet of Things (IoT) can enhance data collection and analysis, thereby improving decision-making and automating processes based on real-time insights (Hussain, 2024).
- *AR and VR in Microlearning*: Assessing the impact of Augmented Reality (AR) and Virtual Reality (VR) on creating immersive learning experiences that enhance engagement and knowledge retention (Aldoseri et al., 2024; Bratianu et al., 2023).
- *Ethical and Social Implications*: Evaluating the broader implications of automating business processes on employment, privacy, and ethical considerations, particularly in the context of AI (Al Naqbi, Bahroun, & Ahmed, 2024).
- *Effectiveness of Microlearning*: Investigating the long-term impact of microlearning on employee performance, knowledge retention, and its sustainability as a corporate training strategy (Kohnke et al., 2024).
- *Adoption in SMEs*: Examining the unique challenges and opportunities presented by BPM, RPA, and microlearning integration in small and medium-sized enterprises (SMEs), with a focus on innovation and competitiveness (Kakade, 2024).

Exploring these areas will enable future research to provide greater insights into the emerging technologies and the combined use of BPM, RPA, and microlearning, helping organizations understand how to leverage these innovations to improve operational efficiency, create more engaging learning environments, and maintain a competitive edge.

Conclusions

Reviewing each of the approached concepts we can formulate that the synergy between microlearning, BPM, and RPA as outlined in the paper offers a multifaceted approach to enhancing business operations, suggesting that a microlearning platform not only provides precise and effective learning experiences but also utilizes cutting-edge technologies to refine both learning processes and administrative tasks, a strategy suited especially in a business environment that prioritizes agility, efficiency, and ongoing learning.

Incorporating "Business Process Modeling" into educational curricula is seen as an innovative strategy to enhance students' business skills because it integrates theoretical knowledge with hands-on applications of BPM tools, collaboration with the industry, and a focus on developing both technical and interpersonal skills.Our bibliometric analysis positions "business process modeling" as a focal point in research, intricately connected with BPM, process mining, and simulation. This underscores its vital role and the growing trend towards utilizing data analysis to refine processes, coupled with a multidisciplinary strategy that augments the utility and application of models in designing workflows across information systems.

Regarding Robotic Process Automation (RPA), it is transforming business task automation by incorporating advanced technologies such as AI, machine learning (ML), natural language processing (NLP), and optical character recognition (OCR). These technologies enables the automation of complex tasks that require decision-making, significantly boosting operational efficiency, enhancing customer satisfaction, and tailoring educational experiences. The bibliometric analysis centered on "intelligent automation" and associated technologies such as "machine learning" and "natural language processing" emphasizes its pivotal role in integration with AI advancements, suggesting a research direction focused on enhancing automation capabilities with sophisticated algorithms. These developments are applicable in areas from improving computer vision to optimizing business processes, fitting within the larger context of digital and industrial revolutions like Industry 4.0.

The integration of microlearning enhanced by BPM and RPA introduces a transformative approach to business education by offering highly personalized, efficient, and timely learning solutions that meet the needs of today's professionals, thus reshaping the corporate training and professional development landscape. The bibliometric analysis has shown a strong correlation between microlearning and modern educational approaches such as mobile learning, e-learning, and blended learning. This trend leverages technology for accessible, step-by-step learning. Its application in higher and medical education shows its potential to enhance traditional educational methods, while its link to social media, gamification, and COVID-19 highlights its role in innovative, remote learning solutions responding to changing educational demands.

In summary, this approach offers a compelling vision for using technology to cultivate a culture of learning and continuous improvement, making it both relevant and significant amid the challenges of the modern business environment.

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Room 4010, Calea Grivitei no. 2-2A
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Enhancing Business Operations Through Microlearning, Bpm And Rpa
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Unleashing the potential: harnessing generative artificial intelligence for empowering model training
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Digital Frontiers: Assessing the Influence and Ethical Challenges of AI in Online Marketing
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The intersection of entrepreneurship and artificial intelligence (AI)
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The impact of emerging technologies on logistics: A comprehensive analysis

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5 Iulie 2024

Academiei Oamenilor de Știință din România

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BEJINARU, R. & TOMA, M.V. (2024). ***Enhancing Business Operations Through Microlearning, BPM and RPA***.

CONTENT

ACADEMIA OAMENILOR DE ŞTIINŢĂ DIN ROMÂNIA
FONDATĂ 1935
ACADEMY OF ROMANIAN SCIENTISTS

1. Introduction and problem statement

- A forward-looking business company should adopt a number of long-term strategic development directions to maintain its leading position in the field and to fulfil its mission of creating satisfaction opportunities for clients and the community.

- **The scope** of the paper is to offer a forward-looking perspective on employee training and organizational efficiency in the business context of integrating modern technology in professional development.

- **The aim** is to identify what impact might have enhancing business operations using BPM (Business Process Modeling) and RPA (Robotic Process Automation).

Aim of research

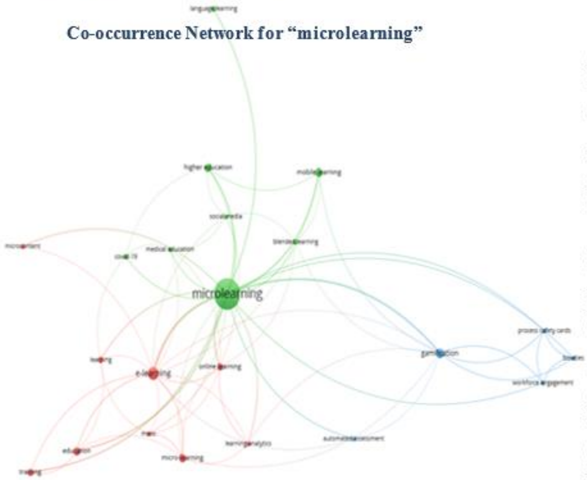
- TO derive insights from the existing body of knowledge in the complex fields of "microlearning", “BPM” and “RPA”.
- TO achieve this goal, we have conducted a bibliometric analysis, a methodology that utilizes quantitative approaches to examine and assess academic literature .
- THE primary role of bibliometric analysis is to uncover research patterns and trends, such as academic productivity, the significance of contributions, and the interconnections among various academic disciplines .

Research methods

- Literature analysis reveals lack of development of BPM, RPA and microlearning applications that can be tested and used in business, both for employees and managers.
- We developed a **bibliometric analysis** of the 3 concepts evolution in business.

DISCUSSIONS

Co-occurrence Network for "microlearning"



-"mobile learning," "e-learning," and "blended learning" are strongly linked, indicating a significant relationship between microlearning and these modern educational methodologies.

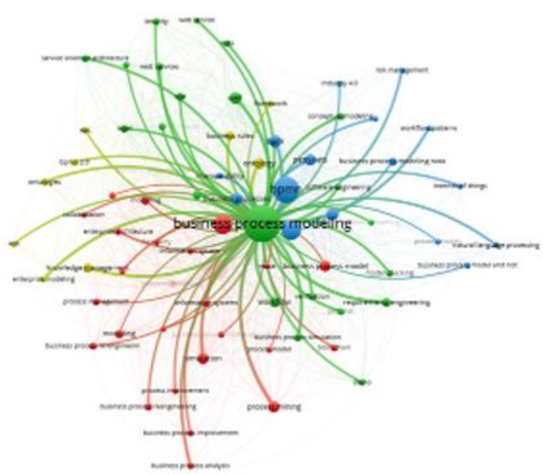
-these show the trend of utilizing technology to facilitate learning in manageable increments, often through mobile and online platforms which allow for flexible and accessible education.

-"higher education" and "medical education" suggests that this approach is being researched and potentially applied in these formal education settings, possibly as a means to enhance the traditional learning experience or to provide additional support and resources.

-"social media" and "gamification" in the vicinity of "microlearning" implies an intersection with more interactive and engagement-focused methods of learning. This could indicate a research interest in how game-like elements and social platforms can be incorporated into microlearning to increase motivation and participation

DISCUSSIONS

Co-occurrence Network for "Business Process Modeling"



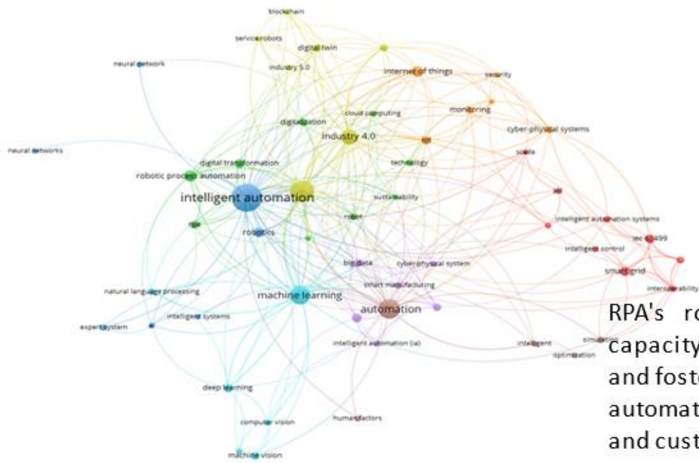
In Figure 2, the central and most prominent cluster is anchored by the term "business process modeling," suggesting it is a primary focus of the research field and frequently associated with other key terms.

Terms such as (BPM), "process mining," and "simulation" are prominently connected to the central term, indicating that these are well-established and significant sub-areas in the domain of business process modeling.

The strong connections between "business process modeling" and "process mining" might indicate a trend in the literature that emphasizes the importance of extracting process-related information from event logs to improve business processes.

DISCUSSIONS

Co-occurrence Network for "Robot Process Automation"



IoT, blockchain
digital twins
Industry 5.0

blockchain
technology

RPA's role in Industry 5.0 underscores its capacity to support personalized production and foster human-robot collaboration,aligning automated processes with human ingenuity and customization demands.

Microlearning

Common Challenges

- *Technological Compatibility and Integration*
- *Change Management and Employee Resistance*
- *Scalability and Maintenance*
- *Content Relevance and Engagement in Microlearning*

Future perspectives

- *Enhancing Integration with AI and ML*
- *Blockchain for Security and Transparency*
- *IoT for Real-time Data Integration*
- *AR and VR in Microlearning*
- *Ethical and Social Implications*
- *Effectiveness of Microlearning Adoption in SMEs*

Conclusions

- "Robotic Process Automation" (RPA) revolutionizes task automation in business, offering a sophisticated blend of technologies like AI, ML, NLP, and OCR to automate complex, decision-requiring tasks beyond traditional rule-based operations, thus significantly enhancing operational efficiency, customer satisfaction, and personalizing the learning experience in education.

- "microlearning", enhanced by Business Process Management (BPM) and Robotic Process Automation (RPA), presents a revolutionary approach to business education, offering personalized, efficient, and just-in-time learning experiences that cater to the modern professional's needs, thereby transforming the landscape of corporate training and professional development.

ACADEMIA OAMENILOR DE ŞTIINŢĂ DIN ROMÂNIA FONDATĂ 1935 ACADEMY OF ROMANIAN SCIENTISTS

THANK YOU for your attention

ENHANCING BUSINESS OPERATIONS THROUGH MICROLEARNING, BPM AND RPA

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RAPORT FINAL DE CERCETARE
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Prelegere conferinta internationala:

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Faculty of Economic Engineering and Business

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***in partnership with* the Stefan cel Mare University of Suceava,**

with the support of *ICA and* Erasmus+ Project Skills4future

in mixed format (online & off-line, bd. Dacia, 41, bl.10, room 415)

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November 7-8, 2024

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Technical University of Moldova, Republic of Moldova
UNCERTAINTY IN REAL ESTATE EVALUATION. INTERNATIONAL EXPERIENCE

CATALIN DRAGOI, Researcher
"Victor Slăvescu" Centre for Financial and Monetary Research, Romanian Academy, Romania
ROMANIA'S BUDGET DEFICIT IN THE EUROPEAN CONTEXT

ALEXANDRU GHENCEA, PhD. student
,,Dunărea de Jos" University, Galați, Romania
THE EVOLUTION OF MOLDOVA'S COMPETITIVE MARKET: GENERATING AGRO-FOOD INCOME BY CHANGING THE VECTOR FROM EAST TO WEST

SECTION II

SUSTAINABLE DEVELOPMENT, INNOVATIONS, EDUCATION AND DIGITALIZATION

aud. 10-415 (link)

Camelia MILEA, PhD.
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DIRECTIONS OF ACTION FOR ATTENUATING ROMANIA'S EXTERNAL DEFICIT

Ana Maria BUCACIUC, PhD.
„Stefan cel Mare" University of Suceava, Romania
SUSTAINABLE DEVELOPMENT OPPORTUNITIES THROUGH ECONOMIC COLLABORATION: FOSTERING ECONOMIC GROWTH AND COMPETITIVENESS IN BORDER REGIONS

Georgiana CHITIGA, PhD.
"Victor Slăvescu" Centre for Financial and Monetary Research, Romanian Academy, Romania
CHALLENGES AND OPPORTUNITIES IN THE FINANCING OF THE CLIMATE TRANSITION AT THE EU LEVEL

Larisa BUGAIAN, PhD. hab.
Technical University of Moldova, Republic of Moldova
ECONOMIC AND SOCIAL EFFICIENCY OF JOINT PROGRAMS

Ciprian APOSTOL, PhD.
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ARTIFICIAL INTELLIGENCE - THE TECHNOLOGY THAT TRANSCENDS OUR IMAGINATION

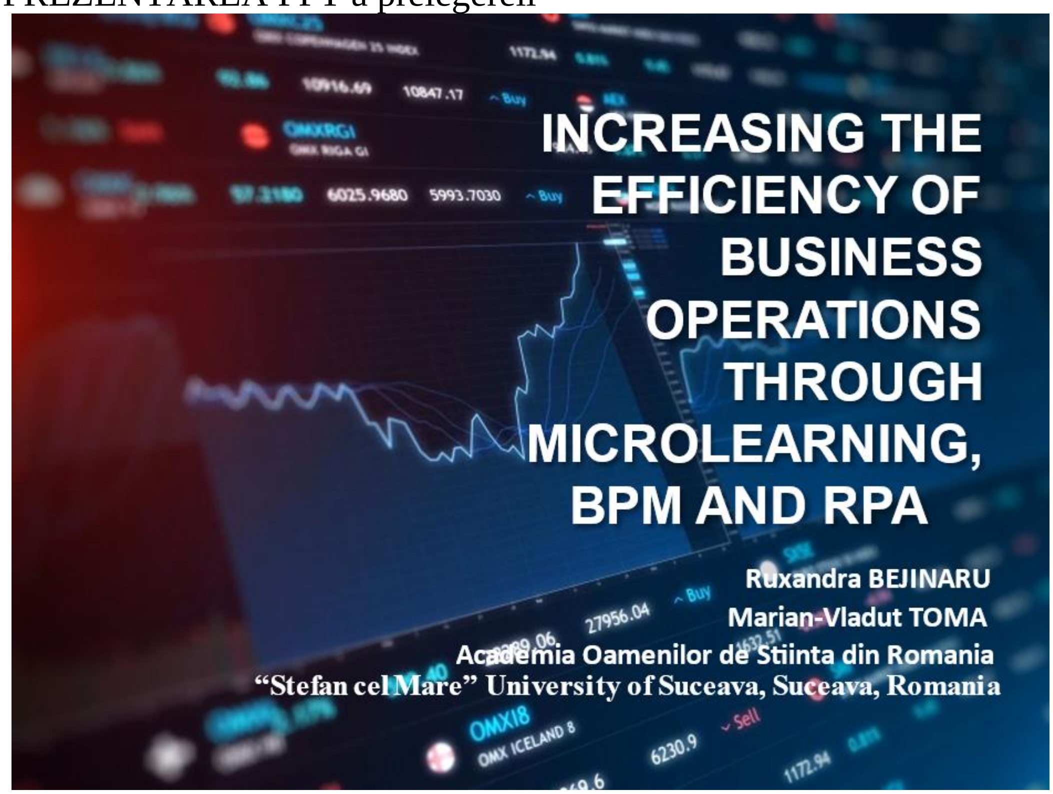
Ruxandra BEJINARU, PhD.
„Stefan cel Mare" University of Suceava, Romania
Marian-Vlăduț TOMA, PhD. student
„Stefan cel Mare" University of Suceava, Romania
INCREASING THE EFFICIENCY OF BUSINESS OPERATIONS THROUGH MICROLEARNING, BPM AND RPA

Călin Lucian BÎZU, PhD.
University of Agricultural Sciences and Veterinary Medicine „Ion Ionescu de la Brad", Romania
PROMOTING THE DIGITALIZATION OF PUBLIC SERVICES IN MOLDOVA AND ROMANIA THROUGH CREATING THE COMMON DIGITAL SPACE

Silvia Elena ISACHI, Researcher
"Victor Slăvescu" Centre for Financial and Monetary Research, Romanian Academy, Romania
ENERGY TRANSFORMATION: SUSTAINABILITY THROUGH EFFICIENCY

Mariana PAVLENCU, PhD.
„Stefan cel Mare" Academy of Ministry of Internal Affairs of the Republic of Moldova
Igor SOROCEANU, PhD. student
„Stefan cel Mare" Academy of Ministry of Internal Affairs of the Republic of Moldova
THE HISTORICAL-POLITICAL FACTORS THAT CONDITION THE APPEARANCE AND EVOLUTION OF ELECTORAL CRIMES

PREZENTAREA PPT a prelegereii



SCOPE: **Platform Development Objectives for Microlearning using BPM and RPA**

Automate the Learning Process
Leverage RPA technology to automate learning workflows, reducing manual tasks and streamlining content delivery.

Personalize Content for Users
Use recommendation algorithms to tailor learning content based on users' knowledge level and preferences, enhancing engagement and effectiveness.

Optimize Learning Workflows
Utilize BPM to enhance the learning process through managed workflows for content creation, task assignment, and tracking user progress.

System Integration
Ensure seamless integration with existing Learning Management Systems (LMS) and business management tools to streamline the overall training process.

Implementation of Microlearning Solutions

Microlearning is a modern approach to learning delivered in short and accessible modules. It enables quick and effective information retention, making it suitable for employees with busy schedules.

The adoption of microlearning solutions has grown across various fields due to its flexibility and accessibility. Microlearning is available on multiple devices, allowing users to access it from any location.

The COVID-19 pandemic has emphasized the need for remote learning solutions, making microlearning essential for efficient and safe distance training of staff.

Robotic Process Automation (RPA) in Microlearning and Education

RPA IS A TECHNOLOGY THAT AUTOMATES REPETITIVE TASKS WITHIN EDUCATIONAL AND ADMINISTRATIVE PROCESSES, REDUCING THE NEED FOR HUMAN INTERVENTION. IT CAN BE USED TO AUTOMATE ENROLLMENTS, MANAGE EXAMS, AND PROCESS DATA.

THROUGH RPA, ACTIVITIES SUCH AS REPORT GENERATION OR NOTIFICATION DISPATCH CAN BE AUTOMATED, SAVING TIME AND RESOURCES. THIS ALLOWS EDUCATORS TO FOCUS ON ESSENTIAL TEACHING ACTIVITIES.

RPA THUS FACILITATES THE OPTIMIZATION OF EDUCATIONAL AND ADMINISTRATIVE PROCESSES, INCREASING EFFICIENCY AND QUALITY OF LEARNING.

Conclusion and Benefits of Microlearning, BPM, and RPA in Training

Microlearning, BPM, and RPA provide organizations with a range of advantages, including flexibility, enhanced efficiency, and cost savings. Together, these technologies ensure scalable and adaptable training methods.

By using microlearning, employees can learn at their own pace, while BPM and RPA help optimize processes and reduce redundancies. This leads to better resource allocation and effective management.

In conclusion, these solutions support organizations in improving overall performance, facilitating a continuous and innovative learning process.

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\AUGMENTED REALITY APP SOLUTION FOR SMART CAMPUS NAVIGATION

Abstract:

Providing access to advanced education and research is a core mission of any proactive, future-oriented university. Equally important is ensuring inclusivity by addressing the needs of students with disabilities, such as those with Autism Spectrum Disorders (ASD). This paper explores the potential of Augmented Reality (AR) technology in creating innovative solutions for smart campus navigation, offering tailored support and enhancing learning experiences. AR applications are presented as tools that not only improve spatial orientation but also foster accessibility, particularly for students with ASD, who possess diverse intellectual potential and can make significant contributions to scientific progress. This study integrates a literature review and a bibliometric analysis to examine current advancements in AR technology for campus navigation. The analysis highlights the extent to which universities globally provide adaptive solutions for orientation and accommodation, addressing the challenges students with ASD face in unfamiliar environments. Furthermore, the research focuses on the technologies and platforms used in developing AR applications, providing insights into their practical and conceptual evolution. The methodology section details the development and implementation of an AR-based application designed for smart campus navigation. Discussions are centered on the advantages, challenges, and future potential of integrating AR into educational settings, supported by user feedback and iterative improvement processes. The study's conclusions emphasize the multifaceted impact of the proposed solution enriching the academic literature, increasing the potential for implementing practical innovations in AR-assisted navigation, raising public awareness and strengthening the university's role in fostering inclusivity and technological advancement. By addressing key aspects such as accessibility, innovation, and practical implementation, this paper presents a compelling case for adopting AR solutions in creating a smarter, more inclusive campus environment.

Keywords: Augmented Reality (AR), Smart Campus Navigation, Autism Spectrum Disorders (ASD), Accessibility in Education, AR Application Development.

INTRODUCTION

To start with, we shall built on the framework of the research subject by connecting to the premises necessary for its development. In order to define and characterize the concept of "smart campus" we will use the concepts of "smart city" and "smart university" because they are interconnected and influence each other. Each but also together, they aim to create sustainable, efficient environments adapted to the needs of citizens, students and university staff. The relevance of this approach lies in rendering both a macro and micro perspective on their impact in real life, economy, society, education (Min-Allah & Alrashed, 2020).

A "smart city" is characterized by the use of technology to improve the quality of life of the inhabitants, to make public services more efficient and to optimize urban resources. The implementation of an infrastructure based on the latest technologies such as IoT, smart mobility solutions and energy management systems are essential for the functioning of a city. These cities use real-time data to effectively monitor and manage traffic, energy consumption, public safety and other essential aspects of urban life (Batty et al., 2012).

In a similar logic, the "smart university" is based on the concepts and technologies developed in the context of the city to create an advanced academic environment, digitized and centered on the individual needs of students. In an "intelligent university" e-learning infrastructure, educational platforms based on artificial intelligence, management of educational resources and optimization of administrative processes through the use of technology prevail. Smart universities play an essential role in training professionals able to contribute to the development of the smart city, integrating technology in education and research (Almarabeh et al., 2021).

At the micro level, this time, the smart university campus is a concrete extension of the smart university concept, applied to the physical space where students and university staff interact. The smart campus is characterized by the use of technology for the efficient management of campus resources, security, the creation of the learning experience and student life, and the creation of a sustainable environment. By analogy with the smart city, a smart campus uses IoT infrastructure, smart mobility, and energy management systems to optimize the daily operation of the campus (Balaji & Gokul, 2022).

We consider it necessary to highlight the idea of connection between these concepts is manifested by the use of similar technologies and principles to achieve the complementary objective. Smart cities and universities are in an interdependent relationship, where universities contribute to the development and testing of the technologies required for smart cities, while cities provide an enabling environment for the implementation and use of these technologies.

Smart campuses, often located within or near the smart city, function as living laboratories where technologies and solutions developed within universities are tested and implemented. This interaction facilitates the transfer of knowledge and technology between academia and urban communities, contributing to the sustainable development and continuous innovation of the city (Komninos et al., 2013).

Thus, smart universities and campuses among the vital components of the smart city, and the success of these initiatives depends on the close cooperation of urban authorities, academic institutions and the private sector.

CONTRIBUTION OF AUGMENTED REALITY FOR SMART CAMPUS NAVIGATION

Augmented reality (AR) is an emerging technology that superimposes a computer-generated image on a user’s view of the real world, thus practically enhancing the real world environment with virtual objects.

AR systems are found in many areas due to their numerous potential applications in healthcare, advertising, education, and navigation. AR technology offers several advantages, such as supplying rich information about real-world objects, supporting heads-up, hands-free interaction, and facilitating context-dependent user tasks. The widespread availability of modern smartphones with sophisticated positioning and sensing capabilities has acted as a catalyst for the spread of AR technology. Applications like Layar, Wikitude, Yelp Monocle, Google Goggles, and Blippar have proven to be highly successful AR apps in the mobile commerce market. (Iatsyshyn et al., 2020)(Alzahrani, 2020)

Wayfinding is a common task that individuals and groups attempt in a wide range of environments, including large indoor spaces (e.g., shopping malls), outdoor settings with minimal manmade infrastructure (e.g., forests), and constructed environments such as colleges. Wayfinding is the action, means, or experience of navigating one's way through an unfamiliar area. Providing support for wayfinding in a specific environment enables users to better understand unfamiliar areas, obtain location-relevant information, and be aware of unseen areas. In the domain of college campuses, prospective students often visit and may have several questions about the campus, and many current students, staff, or campus visitors need to navigate the campus through unfamiliar buildings and structures. There are two main challenges with campus navigation: the campus operates with a complex array of outdoor and indoor wayfinding features, and the campus comprises a constantly changing population of users with diverse needs and expectations. A suitable AR system provides valuable guidelines for users and minimizes the time required to move from one place to another. (Iftikhar et al., 2020) (Jamshidi et al., 2020)

Challenges in Campus Navigation and Current Solutions

The semantic complexity of university campuses makes navigation a challenging task, which often requires visitors to request help from a member of staff. When planning to visit a university or an area of interest within the campus, browsing the university's website will typically provide some options on how to get there. However, this information is limited to a simple map, directions, the nearest bus stops, and parking, accompanied by a set of contact details. In addition, most university maps are simple top-down representations, giving no indication of landmarks or buildings that can be seen from anywhere within and around the campus, such as the numerous building signs. Additionally, it can be difficult to accurately visualize physical space from top-down representations, making it hard to relate observed features to a 2D map. (Dong et al., 2020)(Clemenson et al.2021)

This issue can be addressed using augmented reality technology to deliver information where and when it is needed. An augmented reality application combines virtual images created by a computer with the actual environment seen by the user, thus augmenting the physical reality observed by the user. This technology is particularly appealing for use in a location-dependent service, which provides the user with information related to his/her location. However, an application using augmented reality for aiding campus navigation is scarce to non-existent. These campus-related applications will increase the visibility of the university and will provide visitors with an enhanced experience of its premises by creating a novel navigation tool. (Arena et al., 2022)(Papadopoulos et al.2021)

Design Considerations for an Augmented Reality Campus Navigation App

Although the goal of AR is to overlay digital information in the real world, AR does not have to be exclusively tied to visual or auditory augmentation. AR has increased in popularity in recent years due to the advances in mobile computing capabilities and research focusing on creating high-quality AR app solutions. In the mobile phone sphere, commercial SDKs like Vuforia have made access to AR capabilities much easier for developers. However, it is possible to develop simpler AR apps from scratch since AR is based on 3D transformations and, when combined with live video camera feeds, the effect of augmenting a virtual 3D world in the real 3D world can be achieved. (Siriwardhana et al.2021)

Until now, the vast majority of AR-based systems have used GPS to keep a user localized and aligned in the real world with virtual objects, allowing for spatial and temporal synchronization between the AR and the natural world. However, unlike the majority of AR apps, a college campus can provide a richly detailed map made up of buildings and streets in the form of a 3D campus map, which can be used along with pathfinding algorithms to be the base layer for the AR app. Because of these qualities, a specific approach for the development of an AR university campus navigation app is proposed in this paper, in contrast to a GPS-based project, which is more commonly found. This proposed alternative results in a project that is not only more challenging to implement but showcases how the use of AR and pathfinding algorithms contribute to the serendipity of campus life. (Balakrishnan et al.2021)

Implementation of Key Features and Functionality

This section describes how the key features and functionalities of the campus virtual tour presented in the previous section were implemented. For unparalleled interactivity, the user was required to gaze comfortably around the campus. Several features of the app were implemented in the user's field of view, allowing him/her to engage easily and also feel like the university surroundings were intact. They include dialogues that contained important dynamics and information that were triggered in the user's field of view, thus their users were able to learn about the facilities without the need to extensively manipulate the mobile device. These field of view embedded interactions features were tailored to the imperative information regarding every displayed object in the user's field of view, therefore the probability of the students missing the information was relatively eliminated. The user was presented with a wide range of comfortable assistive and intuitive graphical user interface support control elements on the screen during the navigation of the tour. When the user interacted with an element, the user was able to purchase a virtual facility, also user tracking, shopping, or renting. (Arghashi & Yuksel, 2022)

The non-functional requirements for the implementation of the app were dynamic and static requirements, voluntary, legibility, with a high-performing user interface, interactivity, grouping, easy-to-navigate interfaces, and required speedy response. Several key themes were outlined to guide the development of each feature's functionality. The themes included Realism (providing the student with information), information presentation prioritization, Media Support, Storage and simplicity, advertising, Security, Interactive Support, Business Model, Speed and Contact Forms, and feedback Procedures. The development of the app (Technique and Methodologies) The app business process map was implemented to provide a blueprint that highlighted the steps the university needed to adhere to in order to access the application product and also in conjunction with integration. They included request, requirement specification, business process validation — business and system requirement definition. The design and development app life cycle was used to enable the provision of the app guide project team with a framework. The activities enabled the project team to attend workshops, conduct reviews, and also perform assessments as they interacted with the students and university project teams that had been involved. Inside the campus AR app, the pre-acquisition process required a student and a user contact form. HoloMaps was used as the augmented reality map, which provided customers with an overlay of essential navigational cues showing whether they are facing the right direction, whether they are walking in the right location, and also showing the locations of principal objects. The app was designed and developed as an integrated view (fig. 10). This enabled the university project team and students to interact and walk through the project or prototype form. All forms of feedback were then introduced to ensure that the views of the relevant stakeholders were embedded. Finally, the prototype version was hereby revised and adjusted with each stakeholder's specifications and feedback. 3D and also the AR Technology. A 3D and Augmented Reality Technology was used to enable the campus administrators to source information for their awards and explosive tutorials, an AR app for the campus administrators was also developed and designed. The app's functionality was enabled to fetch concludes all data about a building and its major staff member that was required for undergraduate students to gain more information regarding a life-size AR of the required building. (Panteli et al., 2020)

METHODOLOGY

The main role of bibliometric analysis is to uncover patterns and trends in research, such as academic productivity, the importance of contributions, and the interconnections between different academic disciplines (Ellegaard & Wallin, 2015). This type of analysis is versatile, including various procedures, such as citation analysis to assess the influence of papers, authors, or research areas; co-citation analysis to identify seminal papers and key researchers; co-occurrence analysis to detect dominant concepts and themes by examining the frequency of words in titles or abstracts; and impact analysis using indicators such as citation counts, h-index, or journal impact factors (McAllister et al., 2022). These methods provide numerical and visual interpretations, but also have limitations, such as the possible distortion of research quality or the use of inappropriate indicators, which could distort the results of the analysis (Zupic & Cater, 2015; Alayo et al., 2021).

However, the advantages of bibliometric analysis are significant, despite these limitations. It allows for the extensive analysis of large data sets from diverse sources, helping to identify publication trends and knowledge gaps, thus guiding future research. In addition, the suggestive visual representation of the chronological evolution of writings on a given topic becomes highly relevant for in-depth research on it. Identifying a chronology of works, authors, and journals that have addressed the analyzed topic is useful in shaping the research approach. Also, bibliometric analysis is cost-effective, relying on existing software and online databases. Another notable advantage is the time savings, an essential factor in the research process. The main purpose of bibliometric analysis is to assess the impact of research in a specific field, over a certain period of time, or according to other criteria (Glinyanova et al., 2021; Hillmann, 2021; Agostini et al., 2020; Diez-Martin et al., 2021). Given these benefits, we argue that bibliometric analysis is a valuable tool for providing a comprehensive perspective on the literature in a given field (Dhamija & Bag, 2020).

We applied the standard steps of bibliometric analysis using databases extracted from Scopus, based on the key phrases "smart campus", "mobile augmented reality" and "navigation". The search with these keywords returned only two papers, which led us to abandon the term "navigation" and obtain a more extensive database with the following words: "smart campus" and "augmented reality", generating 444 papers in Scopus. For the analysis of the co-occurrence of keywords, we loaded the database into the specialized software VOSviewer, following the selection of analysis criteria. We adjusted the thresholds for each concept, thus obtaining an acceptable number of relevant words for the subsequent stages of the analysis.

When it comes to keywords, there are several analysis options to consider, such as: Keyword Co-Occurrence Network, Keyword Co-Occurrence Overlap Map, and Keyword Density Map. The Keyword Co-Occurrence Network facilitates the visualization of the relationships between keywords in the database. The nodes in this network represent keywords, and the links between them indicate the frequency with which these words appear together in the same papers. This analysis can highlight groups or clusters of closely related words, suggesting subdomains of interest or emerging trends in research (Shah et al., 2019). The Keyword Co-Occurrence Overlap Map adds an additional layer of information by differentially coloring the nodes according to additional criteria, such as the year of publication or the impact score of the papers containing the keywords. This allows for the observation of the temporal evolution of research interest and the identification of areas that are gaining or losing popularity (Van Eck & Waltman, 2010).

Therefore, keyword co-occurrence analysis plays a crucial role in deciphering the dynamics of a field of study, highlighting emerging trends and emerging topics by identifying frequently combined words. It facilitates the thematic grouping of papers, providing a clear insight into the internal structure and relationships between various research topics. The analysis can also reveal gaps in existing knowledge, indicating underexplored areas where research could make significant contributions (Van Eck & Waltman, 2017).

BIBLIOMETRIC ANALYSIS

For the entire search history in the Scopus database, we identified 444 papers containing the two key terms ("smart campus" and "augmented reality"), which gives veracity and importance to the researched topic. We kept the threshold at 5. We cleaned the list of key terms and gave up on terms that were not important for the analyzed subject, such as: literature review, bibliometric review, academic review; technology; systematic review; bibliometric analysis; augmented reality (ar); ai; teaching; systematic literature review; smart cities; learning; internet of things (iot); iot. Thus, 44 terms remained, based on which we obtained 5 clusters. We set the minimum number of words for a cluster to 5, so that each grouping contains enough terms to convey a message. In the end, we obtained 5 clusters that we will analyze and better understand the approaches in the specialized literature regarding the 2 key concepts ("smart campus" and "augmented reality"). We believe that through this bibliometric analysis we reveal connections with other fields and highlight researchers' trends regarding certain topics and combinations of concepts.

In figure 1. Keywords co-occurrence visualization network, we can easily see the 5 groups of different colors, which are interconnected with a multitude of links that symbolize certain more or less intense connections between the key concepts. This graph represents in a schematic form the 5 clusters, respectively the most significant groupings of articles according to common topics and keywords. The fact that in the center of the figure we see the 2 keywords from which we started the analysis confirms that there is a consistent approach regarding their interconnection, mainly in theoretical terms.

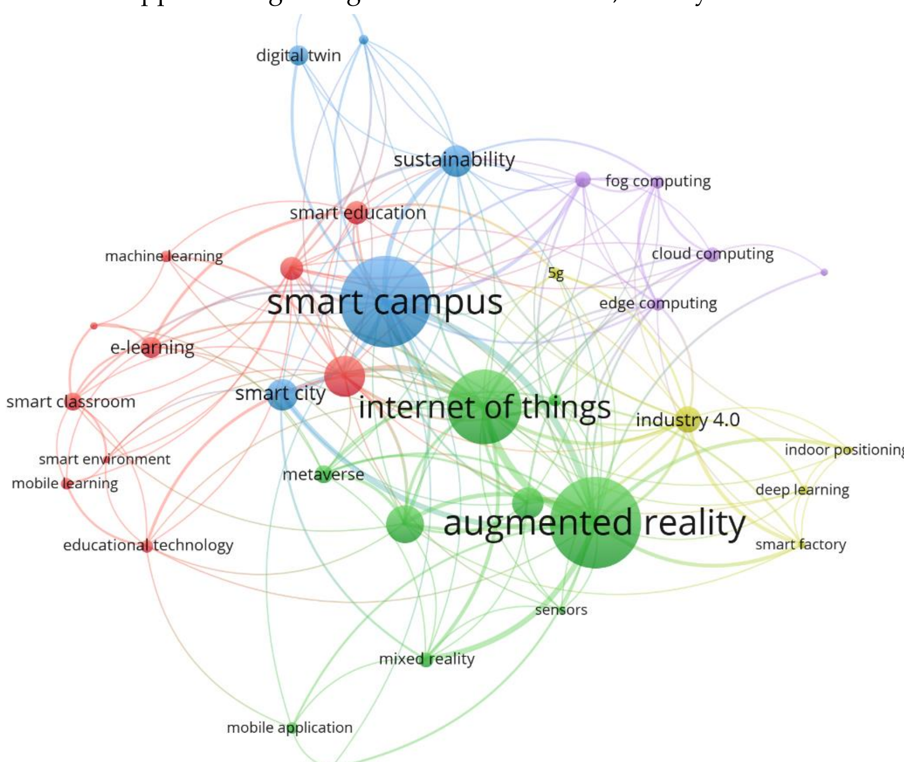


Figura 1. Keywords co-occurrence visualization network

Source: authors elaboration in VOSviewer

Table 1. Characteristics of Cluster 1

CLUSTER 1	Links	Total link **strength**	Occurrences
artificial intelligence	**18**	**31**	**25**
e-learning	9	15	13
educational technology	9	12	8
higher education	17	23	14
learning management systems	4	6	5
machine learning	5	6	7
smart education	10	15	14
mobile learning	5	6	7
smart classroom	9	13	11
smart environment	7	8	5

Source: authors elaboration in VOSviewer

As can be seen in both Figure 1 and Table 1, the keywords that make up the first and most significant cluster are: "artificial intelligence," "e-learning," "educational technology," "higher education," "learning management systems," "machine learning," "smart education," "mobile learning," "smart classroom," and "smart environment." The reason they form a cluster is that they are frequently used together in academic works due to their convergence and interdependence in the context of modern education. The central message behind this grouping of keywords reflects an integrative vision of the future of education, in which technology plays a crucial role in transforming the way we learn and teach.

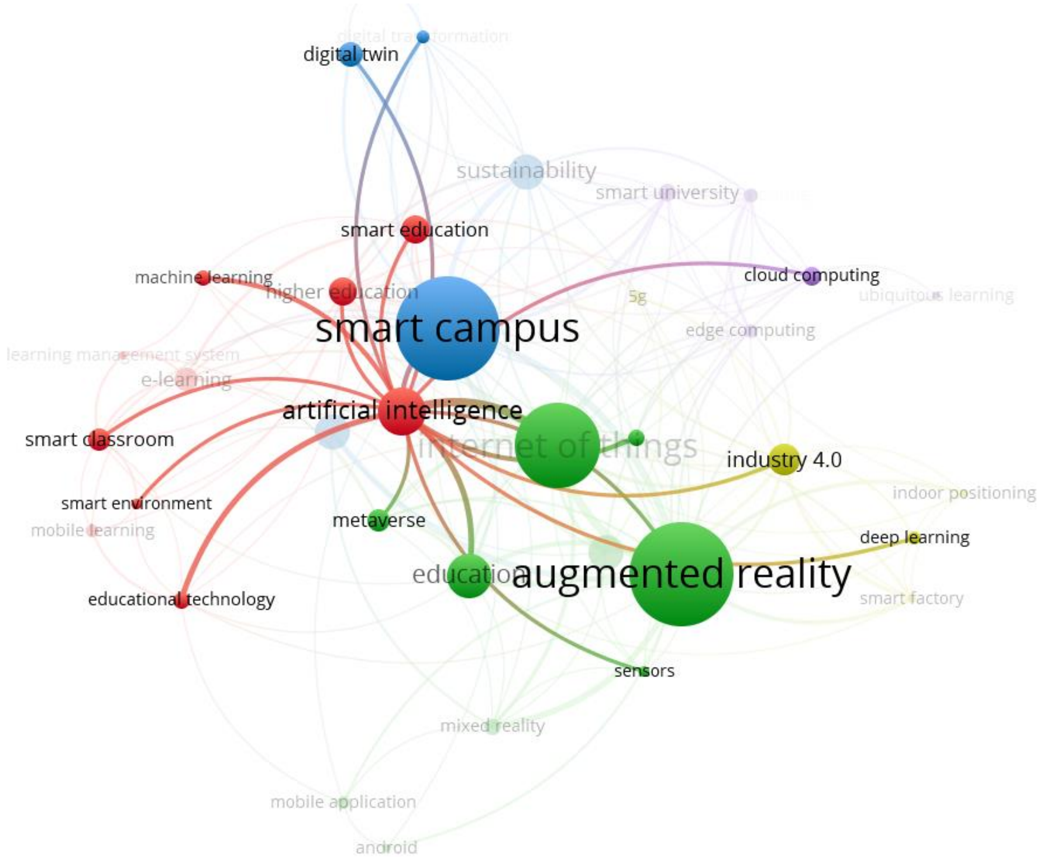


Figure 2. Individual representation of CLUSTER 1

Source: authors elaboration in VOSviewer

Analyzing the connection of the central keyword (Artificial Intelligence) with the rest of the terms in the cluster, we can deduce a series of approaches such as:

Artificial Intelligence (AI) and machine learning are essential technologies that have begun to be used to improve educational processes. They allow the development of smarter learning management systems (LMS), capable of personalizing learning experiences according to the needs and progress of each student.

Educational Technology and e-learning represent the pillars on which the modernization of education is based. These concepts are often associated with online education and digital platforms that provide access to educational resources regardless of location.

Mobile Learning expands access to education, allowing students to learn anywhere and anytime, thus integrating flexibility into the learning process.

Higher Education adaptation is a context in which these technologies are often implemented and studied. Universities and colleges are adopting these technologies to meet modern requirements, such as distance learning, efficient resource management and optimization of administrative processes.

The Smart Education Perspective, identified by the terms smart education, smart classroom and smart environment, reflects the trend of creating intelligent learning environments that use technology to improve the interaction between students and educational resources. Through them, adaptive learning, real-time interaction and data collection are supported to optimize teaching and learning processes.

This cluster offers a clear perspective on a research direction focused on a dynamic, adaptive and technology-based education, in which both students and teachers benefit from innovative tools to improve the educational experience.

The second cluster, dominated by the color green, is centered on the second most important keyword, namely "augmented reality". Analyzing the terms in the cluster, we can discern a series of arguments that converge to justify the usefulness of this technology (AR) in relation to HEIs and students.

Table 2. Characteristics of Cluster 2

CLUSTER 2	Links	Total link strength	Occurrences
android	3	4	5
augemented reality (AR)	**27**	**79**	**55**
blockchain	11	17	8
education	14	29	23
internet of things	26	67	45
metaverse	10	15	11
mixed reality	9	19	9
mobile application	5	6	7
sensors	7	7	5
virtual reality	10	22	19

Source: authors elaboration in VOSviewer

The essence of this cluster is the *integration of multiple emerging technologies* (AR, VR, IoT, blockchain, metaverse) to create advanced and secure solutions. This approach indicates the following:

AR applications for navigating smart campuses are an example of how digital technologies are transforming education. They not only facilitate spatial orientation, but also enrich the educational experience by providing contextual and interactive information.

The combination of AR, VR, and mixed reality suggests that users do not just navigate the campus, but experience interactive environments that help them better understand the spaces and resources available. These technologies create a navigation experience that is both practical and educational.

The integration of blockchain indicates a concern for data security and identity protection, which is essential in an educational environment where data privacy and integrity are critical.

The incorporation of the metaverse concept reflects a futuristic vision in which physical navigation is complemented by exploration and learning in virtual environments. This suggests an extension of educational experiences beyond the physical boundaries of the campus. This term is positioned centrally, very close to the core of the cluster ("augmented reality") – being also strongly connected to the idea of education through: education and e-learning, but also with AI and IoT.

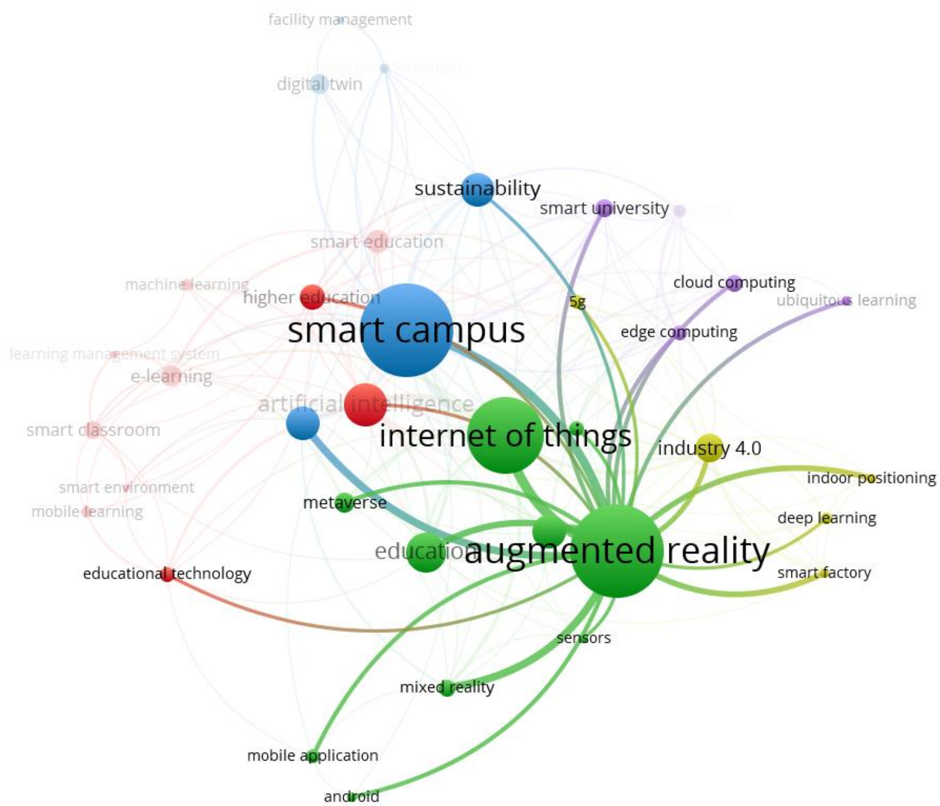


Figure 3. Individual representation of CLUSTER 2 ”AUGMENTED REALITY”

Source: authors elaboration in VOSviewer

Moreover, we must note the clues reflected by the graphic color scheme, in shades of green, which also show us the cross-cutting connections with other technologies and sub-domains. In conclusion, the frequent use of these keywords together, with *"augmented reality"* as its central core, indicates that smart campus navigation solutions are not only about physical orientation, but also about creating an advanced, safe and immersive educational environment that harmoniously combines the latest digital technologies to support the educational process.

Table 3. Characteristics of Cluster 3

CLUSTER 3	Links	Total link strength	Occurrences
digital transformation	9	12	6
digital twin	5	7	12
facility management	2	3	5
smart campus	**23**	**63**	**55**
smart city	8	19	19
sustainability	13	23	19

Source: authors elaboration in VOSviewer

The third cluster is distinguished by the term "smart campus", which equals "augmented reality" regarding the number of occurrences, namely 55; which also explains the visual appearance that is so similar between the two in terms of the central positioning on the network, as well as the size of the green and blue spheres. However, this cluster contains different terms, also having blue on the graph although it is very strongly connected with terms from other clusters.

Thus, "smart campus" is the central term and the largest node in the cluster, which indicates that this concept is a focal point in associated research. It is connected to numerous other concepts and technologies, suggesting a complex integration of various technological innovations in the development of smart campuses. We can observe alongside this term, those essential and complementary technologies in the development of smart campuses.

"Digital transformation" emphasizes the process by which campuses and cities become "smart" by adopting advanced digital technologies.

“Digital twin” refers to digital replicas of physical structures, which can be used to monitor and manage campus infrastructure. In AR navigation applications, digital twins can provide an accurate and up-to-date representation of the campus, aiding in efficient navigation and integrating facility management functions.

“Facility management” refers to the efficient management of campus resources and infrastructure.

“Smart city” has significant connections to the concept of “smart campus,” reflecting the idea that a smart campus can be seen as a micro-version of a smart city. Innovations and technologies developed for smart cities are often applicable in the context of campuses as well. The connection between “smart campus” and “smart city” suggests that AR-based navigation solutions are not just for campuses but can be integrated into the broader ecosystems of smart cities, contributing to more efficient and sustainable urban mobility.

“Sustainability” becomes an implicit effect of the application of these technologies and the development of smart cities and smart campuses.

In an overall perspective on this blue-shaded cluster (no.3), we can notice that the grouping of keywords rather highlights the desiderata of the implementation of advanced technologies. Thus, "digital transformation", "digital twin" and "facility management" imply the transition from traditional orientation methods to innovative solutions based on AR, which improve the user experience and operational efficiency. Also, the desiderata of "smart cities" and "smart campus" align in terms of facilitating urban mobility and streamlining navigation on the university campus.

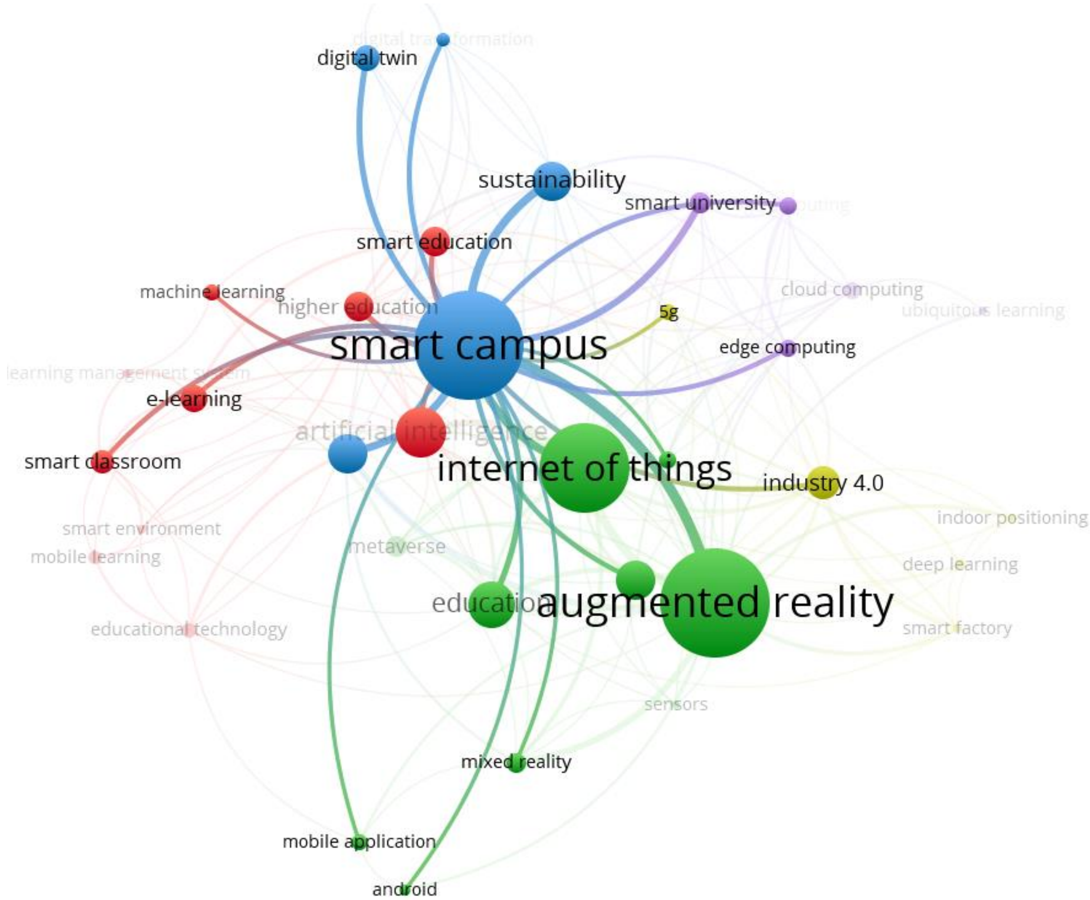


Figure 4. Individual representation of CLUSTER 3 "SMART CAMPUS"

Source: authors elaboration in VOSviewer

Table 4. Characteristics of Cluster 4

CLUSTER 4	Links	Total link strength	Occurrences
5G	7	9	7
deep learning	6	7	6
indoor positioning	6	9	5
industry 4.0	**16**	**31**	**16**
smart factory	7	14	5

Source: authors elaboration in VOSviewer

If in the previous cluster (3) we discussed an accumulation of desiderata, projections, objectives, in this cluster, colored yellow, we have a set of resources. The terms 5G, deep learning, indoor positioning, and smart factory are connected through their complementary use to create an advanced, efficient, and adaptable navigation system in a smart campus.

5G is an essential resource for Augmented Reality (AR) applications, especially in complex environments such as a smart campus, in the sense that users can receive precise and instantly updated visual instructions, considerably improving the navigation experience.

Deep Learning can be used in AR applications for smart campus navigation to personalize routes, improve object recognition, and interpret context around users.

Indoor Positioning is also critical for AR applications in a smart campus, where traditional GPS-based navigation systems may be insufficient. By implementing indoor positioning technologies, such as Bluetooth, Wi-Fi, or specific sensors, AR applications can provide precise directions even inside campus buildings or in areas where GPS signals are weak. This allows users to easily navigate new and complex spaces such as libraries, laboratories, or auditoriums.

As for the term “smart factory” included in this keyword graphic, it is most likely an analogy. For example, a campus that functions as a “smart factory” can use AR to automatically guide deliveries of teaching equipment or manage inventory in real time through a combination of indoor positioning and deep learning.

The yellow cluster graph clearly shows that the terms "5G," "deep learning," "indoor positioning," are resources and tools for the development of industry 4.0 and subsequently indirectly connect with AR, IoT or smart campus. For example, from the active graph in the VOSviewer software, one can see the direct connection between "indoor positioning" and "smart university" in the purple cluster. And "deep learning" is directly connected with AI in the first cluster, the red one.

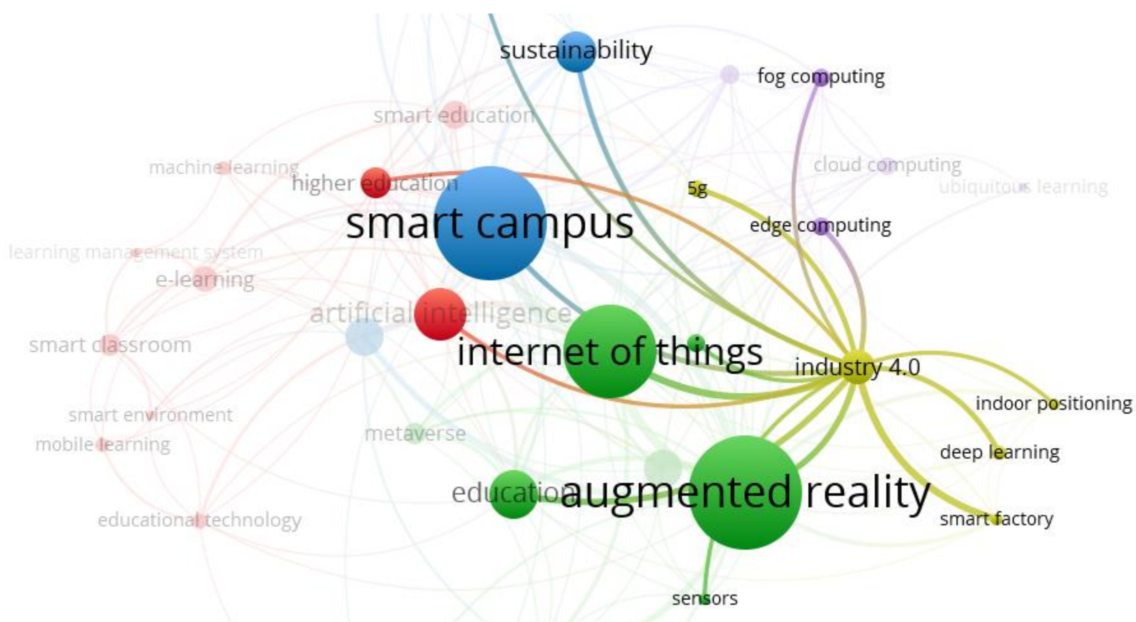


Figure 5. Individual representation of CLUSTER 4 ”Industry 4.0”

Source: authors elaboration in VOSviewer

Table 5. Characteristics of Cluster 5

CLUSTER 5	Links	Total link STRENGTH	Occurrences
cloud computing	9	13	9
edge computing	11	18	8
fog computing	9	15	8
smart university	**12**	**18**	**10**
ubiquitous learning	2	3	5

Source: authors elaboration in VOSviewer

The numerical indicators of the terms in this cluster are very close, which indicates a strong interdependence as researchers are forced to address them together when presenting a paper on "smart university" for example.

Smart university is the general framework in which these technologies are implemented, ensuring that the digital infrastructure is robust enough to support advanced applications, such as AR for navigation.

Cloud, edge, and fog computing are complementary technologies that work together to support the infrastructure required for a smart university and support ubiquitous learning. In the context of AR for navigation applications, these technologies enable fast data processing, reduced latency, and the delivery of augmented content in real time, significantly improving the user experience.

Ubiquitous learning is the end result of the integration of these technologies, allowing students and staff to access information and learn anywhere and anytime, with the help of AR applications that transform interaction with the environment into a continuous educational experience.

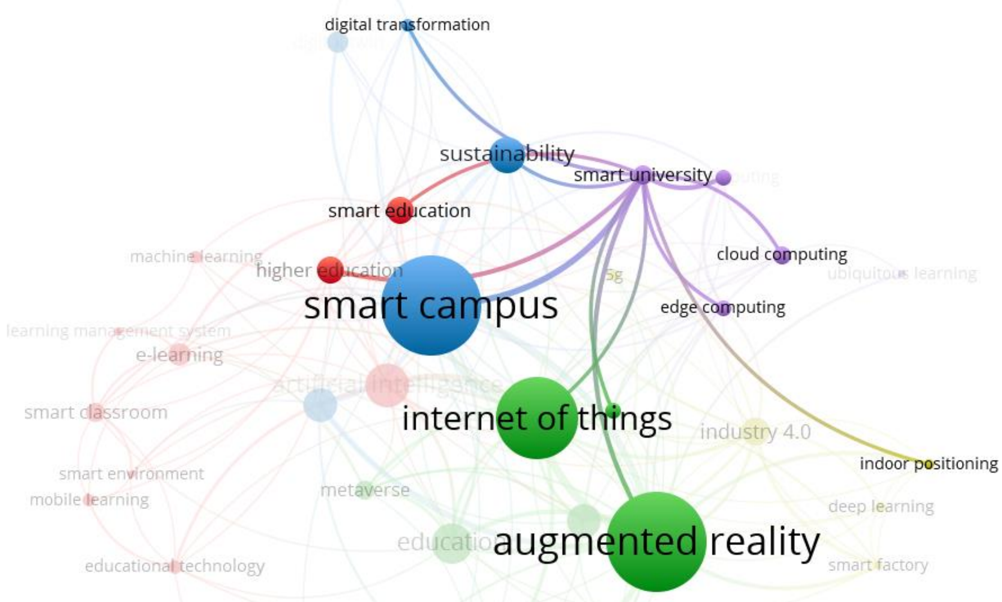


Figure 6. Individual representation of CLUSTER 5 ”Smart University”
Source: authors elaboration in VOSviewer

The appearance of these terms together shows that they are interdependent in applicability and utility. In the context of a smart campus, cloud, edge, and fog computing provide the technological infrastructure necessary to support AR applications, which improve navigation and ubiquitous learning.

OVERLAY visualization map – provides us with important information about the evolution of this concept in the debates in the specialized literature. As we can see on the timeline, the dark color keywords, indigo, are the most distant, respectively appearing in publications from the years 2019-2020, such as: indoor positioning, smart factory, mobile application or android.

Regarding the years 2021-2022, represented by the color turquoise, terms such as: mobile learning, e-learning, deep learning, smart computing, smart classroom prevailed in publications. These terms suggest a trend focused on the learning process adapted to advanced and innovative technologies.

The next period, which is also the most recent, the year 2023, is visually represented by the lime and yellow spheres. The yellow keywords are representative of the most current approaches within this theme. Thus, we identify terms located in the center of the map such as: artificial intelligence, metaverse, and other terms located towards the extreme of the map such as: digital twin or digital transformation.

The appearance of the term metaverse in the center of the graph, and moreover, connected to the main clusters, suggests an exploratory trend of researchers, namely, to expand academic debates towards disruptive innovations as much as possible.

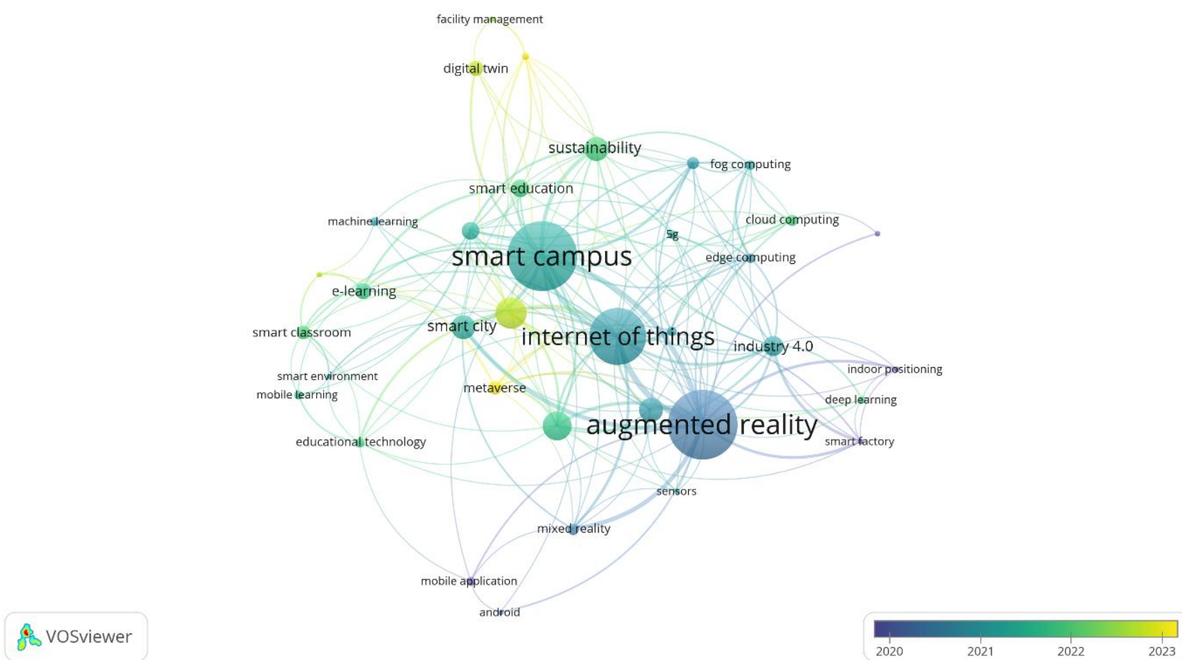


Figura 2. Keywords co-occurrence overlay visualization

Source: authors elaboration in VOSviewer

Density visualization chart – shows the concentration and connection of keywords based on their positioning and the intensity of the color they emit. In this type of visualization, terms with a high density, that is, those that appear frequently and are strongly connected in the network, are represented by the color yellow and are bright spots on the map. Terms with lower density are represented by cold colors, such as green and spots of smaller size.

The clusters retain the same positioning as in Figure 1, with the difference that the lines between the keywords have been replaced by their higher or lower brightness.

Essentially, the Density Visualization chart helps to understand the internal structure of a research field, providing an overview of the concentration and distribution of academic interests.

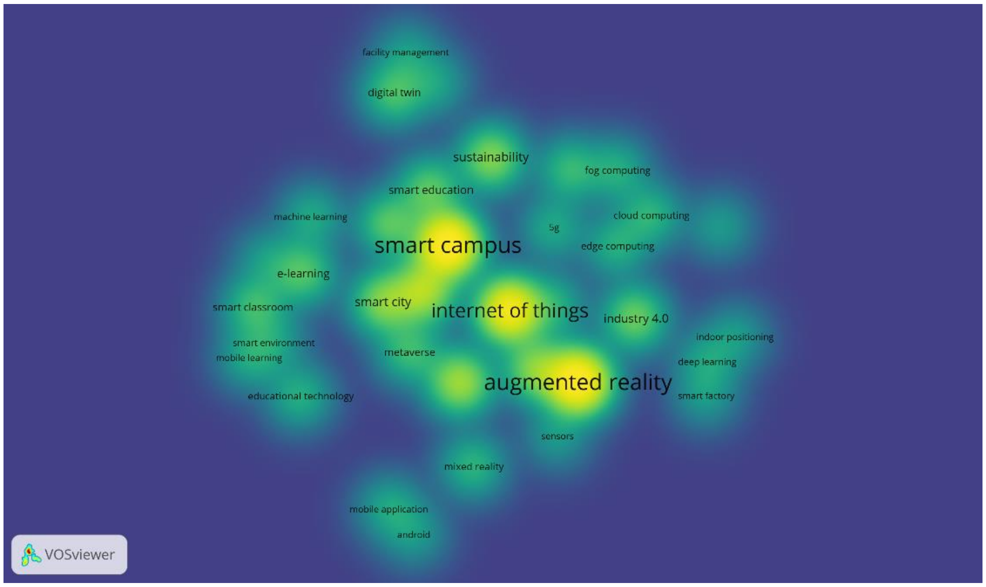


Figura 3. Keywords co-occurrence density visualization
Source: authors elaboration in VOSviewer

Materials and Methods

The objective of the present work is to develop a mobile application based on augmented reality for orientation in university campus buildings. The choice of mobile applications was driven by their widespread acceptance and the fact that students and campus visitors already possess a smartphone device, obviating the need for additional equipment. Given the distinctive characteristics of each university campus, including its architectural design, the location of buildings and rooms, it is essential to develop a bespoke application that aligns with the specific building plan. In this instance, the application has been developed for Stefan cel Mare University in Suceava, which has an enrollment of over 11,000 students. In addition to the primary beneficiaries, namely the students, the application will also be utilized for other academic, cultural, and artistic events that occur on the university campus and involve individuals from outside the campus. Potential applications include, but are not limited to, the following:

- outdoor orientation, between campus buildings;
- indoor orientation to lecture halls, seminars, laboratories, teachers' offices or faculty secretariats and providing information about them (timetables, appointment scheduling, etc.);
- orientation to conference or event rooms;
- orientation to various services such as security, cashier and restrooms;
- providing information on various hot spots on campus (exhibitions, events);
- giving information about accessibility (the path to the elevator, if available, or if the route to a room is also dedicated to people with disabilities).

Technologies and platforms

The application was developed using Unity 3D, which offers integration with the ARway SDK. Unity 3D is a software platform that offers comprehensive functionality for developing a wide range of digital assets, including games, interactive applications, simulations, and more. Its graphic capabilities are particularly noteworthy, offering a robust and versatile engine for visual rendering and animation. It is notable for its compatibility with over 20 platforms, including Windows, Linux, Android, iOS, PlayStation, Xbox, and AR/VR devices (HoloLens, Oculus, etc.), facilitating the deployment of applications for different platforms with minimal modifications. This allows the same application to be deployed on several different devices without requiring any significant alterations to the code. The decision to select this platform was largely informed by its extensive support for AR/VR applications, facilitated through the AR Foundation. This integration allows for the use of key native APIs such as ARKit (for iOS) and ARCore (for Android), particularly given that the planned application is intended for dedicated use with smartphone mobile devices. In terms of scripting, Unity 3D relies on C# as its primary programming language, providing flexibility and straightforward integration with a wide range of external application programming interfaces (APIs) and software development kits (SDK's), including ARway.ai. Furthermore, it facilitates collaborative work, optimizes application performance, provides resources such as 3D models, textures, and scripts through the Unity Asset Store, thereby reducing development time, and has an online community and extensive documentation.

ARway is an advanced software solution for the creation and management of augmented reality (AR) experiences, with a particular focus on navigation and immersive interaction in physical spaces. The platform is well known for its capacity to deliver AR solutions without the necessity for supplementary hardware (e.g., beacons or 3D scanners), through the utilization of technologies such as SLAM (Simultaneous Localization and Mapping) and VPS (Visual Positioning System). The software development kit (SDK) provided by ARway allows for straightforward integration with Unity 3D, leveraging its capabilities and the capacity to create applications tailored to mobile operating systems. It facilitates the generation of visual routes and waypoints to assist users in navigating intricate environments such as university campuses, museums, shopping centers, and office buildings.

Application development

The targeted application was developed using Unity HUB 3.9.1 with the Unity Editor version 2022.3.50f1 and the ARway Software Development Kit (SDK) version 2.5.1. To run the application, the device in question must be equipped with the requisite capabilities for augmented reality. Currently, augmented reality technology is compatible with most contemporary mobile devices that satisfy certain hardware and software prerequisites. However, in principle, it must support the ARCore platform (Google Android requires an operating system version 7.0 or later) and the ARKit platform (Apple requires an operating system version iOS 11 or later). The application logic diagram is presented in Figure 1.

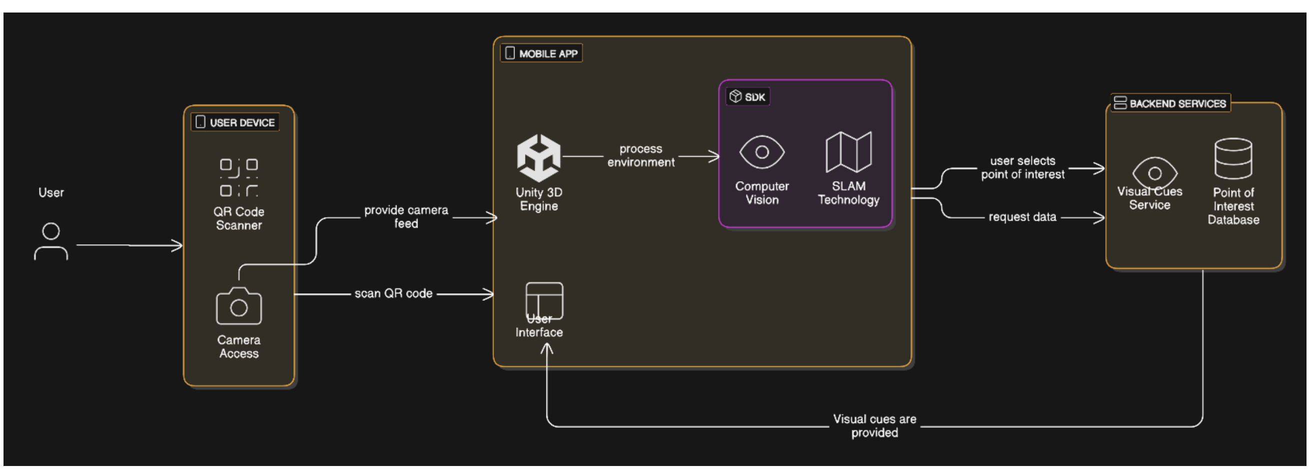


Figure 1. Application logic diagram.

Mapping and adding POI's

The process of spatial orientation makes use of an existing building plan in order to establish routes and correlate navigation cues. By means of advanced computer vision technologies, the map is initialized and a primary access QR code is then placed in a physical location, which is subsequently correlated with its location on the digital map. Relative to this Quick Response (QR) code, anchors are positioned in easily recognizable locations on the map (for example, corners). In this phase, simultaneous localization and mapping (SLAM) technology plays a pivotal role in monitoring the device's position by leveraging the mobile device's camera, accelerometer sensor, and gyroscope. These devices utilize these reference points to ascertain the device's precise location in space. Figure 2 provides a code snippet involving the creation of anchors.

```
public void CreateAnchorProcessStart(Vector3 position)
{
    // Raycast against planes and feature points
    const TrackableType trackableTypes =
        TrackableType.FeaturePoint |
        TrackableType.PlaneWithinPolygon;

    // Perform the raycast
    if (m_RaycastManager.Raycast(position, s_Hits, trackableTypes))
    {
        // Raycast hits are sorted by distance, so the first one will be the closest hit.
        var hit = s_Hits[0];

        // Create a new anchor
        var anchor = CreateAnchor(hit);
        if (anchor != null)
        {
            // Remember the anchor so we can remove it later.
            m_Anchors.Add(anchor);
            Debug.Log("Anchor created successfully!");
        }
        else
        {
            Debug.LogError("Error creating anchor");
        }
    }
    else
    {
        Debug.LogWarning("No valid surface [illegible] for anchoring.");
    }
```

Figure 2. Anchor placing.

In the subsequent phase, an additional decision must be made concerning the accessibility of the planned navigable paths. The options are either that all users, including the disabled, are to be permitted access or that only walking is permitted. Based on the available paths, directions are provided to reach a specific destination, such as a classroom. Subsequently, we can add various forms of content to specific locations on the map, including location pins, text, images, audio, video, or 3D content. For purposes of illustration, location pins have been added to indicate the location of key facilities, such as classrooms, restrooms, security, and other pertinent points of interest. Additionally, textual annotations have been included on the map, such as a warning to proceed with caution along a particular staircase. Figure 3 presents a representative sample of a configured map, showcasing the integration of navigable pathways and identified points of interest.

Additional details are provided with each location, such as a few representative images pertaining to the objective, the category in which it belongs, the faculty in question, and, if applicable, whether the space is a classroom, a lecture room, a conference room, an office, or another type of room. Additionally, contact information, including a phone number and an email address, is provided. In cases where the location is a classroom, a link to the corresponding timetable is also included. Alternatively, if the location is a teacher's office, a link to make an appointment is provided. The content in question exhibits a high degree of diversity about both its nature and its geographical positioning on the map, thereby opening up a multitude of potential applications. In addition to directions to the desired destination, various hotspots can be added with supplementary information and 3D models of additional objectives encountered along the route.

Figure 3. Paths and POI's.

Results

The current application is the result of the successful combination of innovative technologies and seamless integration with existing devices, including smartphones with Android or iOS operating systems. It has been designed to provide visual cues and information superimposed over the real world, effectively augmenting the existing space with additional materials. The application's marker-based positioning methodology obviates the need for additional positioning equipment such as beacons, thereby enabling implementation in a wide range of environments, including outdoor settings. In this instance, the access QR codes are situated in multiple locations throughout the building, typically in proximity to entrances or exits. These prompt visitors to scan the QR code and access the application. The codes can be placed on digital media, such as screens, or on printed media, including panels and stickers placed on the floor. They should be positioned in areas that are easily visible and accessible.

In accordance with the logical diagram of the system, the user scans the QR code and gains access to the application. From this point onwards, the user can access the available maps, a contextual menu for the search function, the Home button, and the user profile settings. Once the QR code associated with the desired area has been scanned (the same code may be used to access the application), a menu is made available that allows the selection of "Directory," which lists all points of interest, "Restrooms", and "Recharge Stations" - additional QR codes or image access points may also be scanned to enhance positioning and prevent deviation from the route due to distance from the initially scanned reference point. The points of interest have been organized into the following categories:

- Faculties, which include subcategories;
- Classrooms;
- Offices;
- Secretaries;
- Conference rooms;
- Lecture amphitheaters;
- Libraries;

Other locations may be included in more than one category, such as faculties and classrooms or amphitheaters. Other locations of interest, such as the cashier, stairs, access routes to other buildings, or the security post, were not included in a specific category. However, these locations are available for viewing alongside the categories. To illustrate the functionality of the application, we selected room A110 as the location. Upon selecting the location, a representative image and pertinent information are displayed, including the category, estimated time of arrival, distance in meters, a brief description, supplementary file, contact details, and even a timetable for the respective room. It should be noted that

the specifics of these details may vary depending on the location. For instance, in an office setting, one may access a form to schedule an appointment with the relevant instructor.
Upon clicking the "Get Directions" button, the user is presented with a visual representation of their current location on the map, along with the location of the specified point of interest. Additionally, the route to be traversed is displayed. Subsequently, the user is provided with visual cues, such as arrows for orientation, instructions regarding the necessary steps (e.g., whether to turn left or right in 10 meters), and information regarding the location of the room. Additionally, audio cues are incorporated into the system. Upon arrival at the designated location, the user is informed of their arrival, the elapsed time, and the distance traversed. The application user interface and experience is demonstrated in figure 4.

Discussion

In addition to the functionalities illustrated in this case study, it is evident that the application is highly versatile and has the potential to be implemented across the entire university campus and beyond. The potential for implementation in a variety of contexts is considerable. The adaptability of the application to different spatial settings, including other university campuses, allows for its integration into a diverse range of environments, considering factors such as size and location. The current situation regarding orientation indications on many campuses is characterized by the use of boards and various markings applied to the floor or walls. These methods provide simple, static, non-adaptable content and lack the capacity for interaction with the user. Such augmented reality applications provide valuable content that is tailored to the specific context of the academic environment. In this setting, the content is updated regularly to reflect the frequent changes in timetables, study spaces, and activities. Additionally, these applications facilitate the coordination of various events and initiatives, such as those related to student life or academic pursuits.
Additionally, prior studies have demonstrated the efficacy of augmented reality (AR) applications in academic settings. They have shown promise in enhancing the learning process and facilitating access to educational services for individuals with disabilities. To be specific, an individual with a locomotor disability may be excused from traversing a route that includes a staircase at a certain point, provided that there is no elevator or special ramp available. In this case, the augmented reality application allows the individual to enter the point of interest, determine the accessibility of the route for individuals with disabilities, and ascertain the availability of an elevator in the vicinity. Moreover, in consideration of social inclusion of those with neurological disabilities, such as Autism Spectrum Disorder (ASD), it has been demonstrated that the use of augmented reality by those with ASD and their caregivers results in enhanced learning and development processes, with content customized to their needs. In this regard, the application can be adapted and deliver personalized content, thereby addressing diverse categories of people.

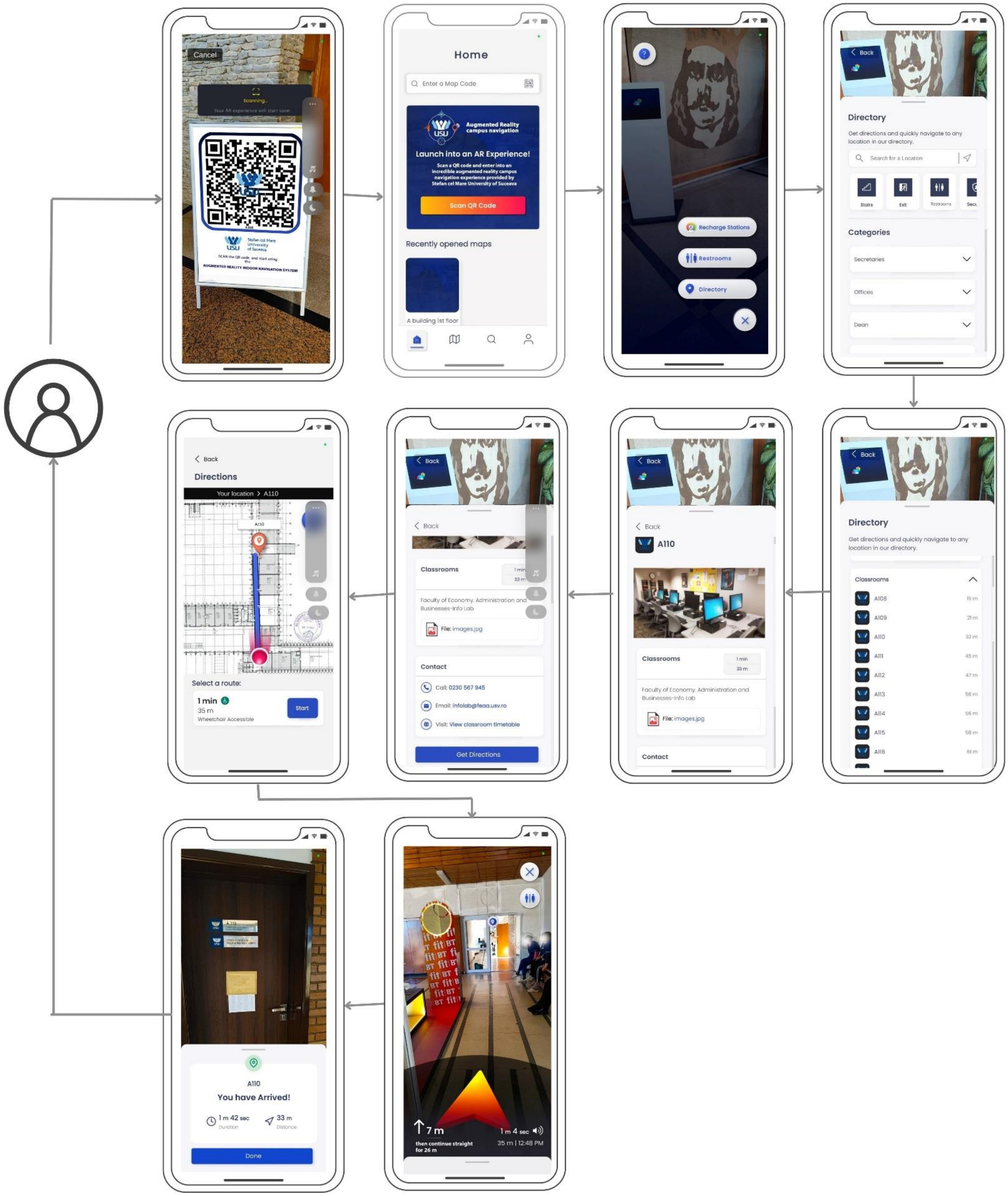


Figure 4. Application user interface flow

Conclusions

The article's presentation of the application illustrates the potential of augmented reality to significantly impact the user experience in complex environments. It provides a solution to the traditional issue of dependence on physical signs and static maps. Instead, it offers a dynamic, interactive solution adapted to the individual needs of users. The application facilitates a more intuitive and efficient orientation, with users benefiting from real-time navigation and precise directions in the campus environment. By incorporating the capabilities of ARway SDK, the application employs advanced technologies, including SLAM, computer vision, and the hardware capabilities of mobile devices, to create a digital representation of the campus. This digital map is then accessible directly from the user's mobile device. Furthermore, the application is notable for its adaptability and scalability. The capacity to anchor AR content to fixed points, whether on flat surfaces or other areas, enables the adaptation of displayed information to different scenarios. This could be exemplified by the need to find a specific room, such as a classroom, library, or laboratory, on a campus setting. From the perspective of the user, the application improves the experience by rendering the navigation process more enjoyable and efficient. For academic institutions, the solution reduces the need for the maintenance of complex physical systems, while simultaneously providing them with a cutting-edge digital tool that can be updated rapidly.

In conclusion, the application not only addresses existing orientation issues but also paves the way for new integration possibilities of AR into educational settings for both typically developing individuals and those with locomotor or neurological disabilities. To reach its full potential, however, the application may require expanded functionalities, such as support for multiple languages, integration with other digital platforms on campus, or the possibility of using it without an internet connection, which we are considering for further research and development. At the same time, the long-term success of the application depends on its accessibility for end users, both in terms of hardware requirements and ease of use.

***Acknowledgment**: The present paper has been financially supported by the Academy of Romanian Scientists, within the program AOSR-TEAMS II EDITION 2023-2024, DIGITAL TRANSFORMATION IN SCIENCES, allocated to the project entitled "Facilitating access to education through Augmented Reality and stimulating dynamic learning in business through microlearning".*

REFERENCES

Eroare! Fără sursă de referință.

SESIUNEA ȘTIINȚIFICĂ A TINERILOR CERCETĂTORI DIN COMPETIȚIA AOSR-TEAMS EDIȚIA 2023-2024 ȘI EDIȚIA 2024-2025

4 Decembrie 2024

1. Abordarea teoretica a temei

SMART CITY /// SMART UNIVERSITY /// SMART CAMPUS

- Pentru a defini și caracteriza conceptul de „campus inteligent” vom folosi conceptele de „oraș inteligent” și „universitate inteligentă” deoarece sunt interconectate și se influențează reciproc.
- Fiecare, dar și împreună, își propun să creeze medii durabile, eficiente, adaptate nevoilor cetățenilor, studenților și personalului universitar.
- Relevanța acestei abordări constă în redarea unei perspective atât macro, cât și micro asupra impactului lor în viața reală, economie, societate, educație.

3. Analiza bibliometrica: 5 clustere

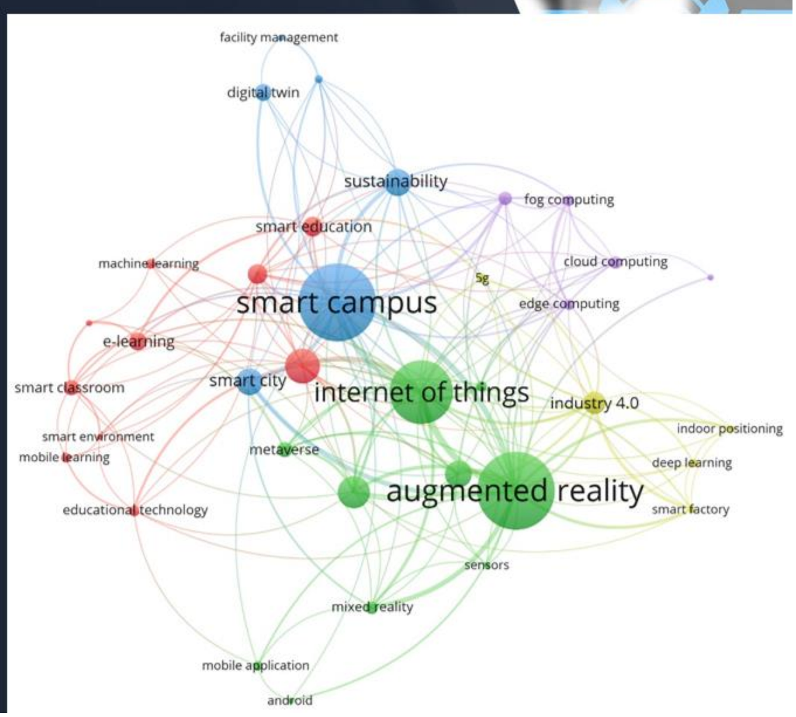
1.Artificial Intelligence

2. Augmented Reality

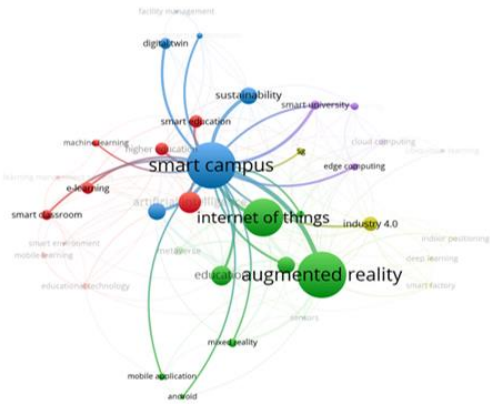
3. Smart Campus

4. Industry 4.0

5. Smart University



Cluster 3. Smart Campus



CLUSTER 3	Links	Total link strength	Occurrences
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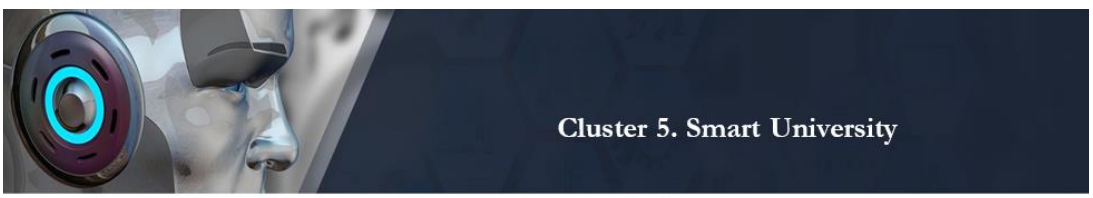
digital twin	5	7	12
facility management	2	3	5
smart campus	**23**	**63**	**55**
smart city	8	19	19
sustainability	13	23	19

- **Smart campus „Campus inteligent"** este termenul central și cel mai mare nod din cluster, ceea ce indică faptul că acest concept este un punct focal în cercetarea asociată.
- Este conectat la numeroase alte concepte și tehnologii, sugerând o integrare complexă a diverselor inovații tehnologice în dezvoltarea campusurilor inteligente. Pe lângă acest termen, putem observa acele tehnologii esențiale și complementare în dezvoltarea campusurilor inteligente.

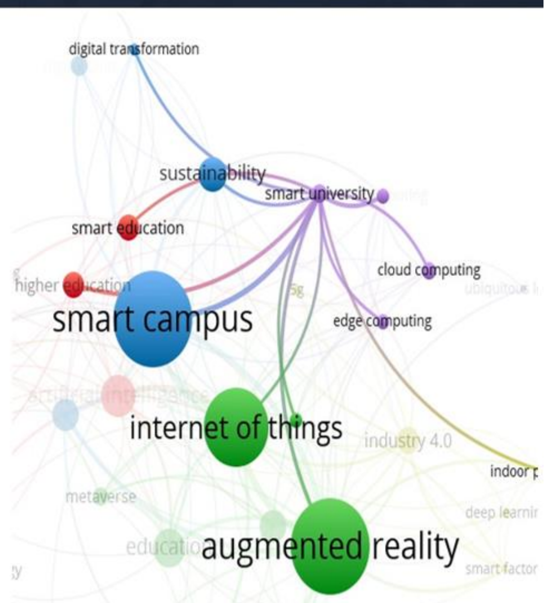


Cluster 5. Smart University

- **Smart university - Cluster MOV**

- Universitatea inteligentă este cadrul general în care sunt implementate aceste tehnologii, asigurându-se că infrastructura digitală este suficient de robustă pentru a suporta aplicații avansate, cum ar fi AR pentru navigație.

- Cloud, edge, și fog computing sunt tehnologii complementare care lucrează împreună pentru a susține infrastructura necesară pentru o universitate inteligentă și pentru a sprijini învățarea omniprezentă.



Utilitatea aplicatiei AR

- Dezvoltarea unei aplicații mobile bazate pe realitate augmentată (AR) pentru orientarea in campusul universitar.

- Necesitate: fiecare campus universitar are caracteristici arhitecturale distincte, iar o soluție digitală personalizată poate simplifica navigarea.

- Locație pilot: Universitatea Ștefan cel Mare din Suceava, cu peste 11.000 de studenți înscriși.

- Utilizări multiple: orientare pentru studenți, evenimente culturale și academice, vizitatori externi.

Tehnologii Utilizate

Platforma principală: Unity 3D cu suport ARway SDK.

- Unity 3D:

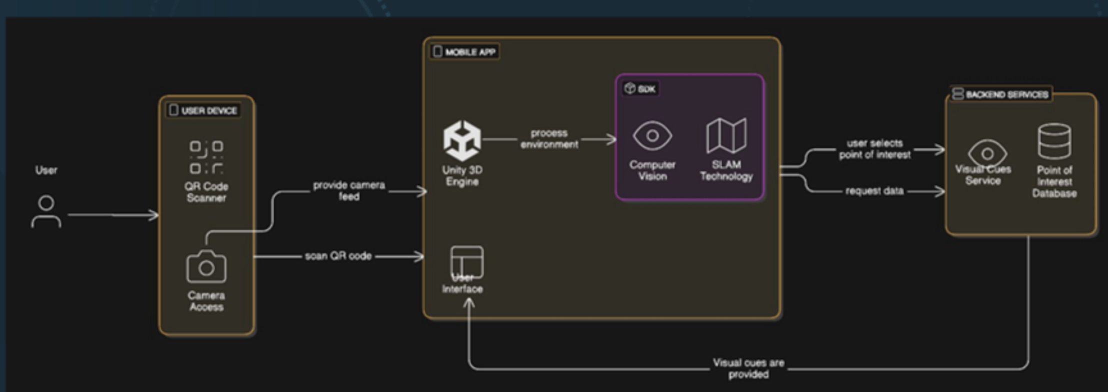
• Motor grafic versatil, suport pentru peste 20 de platforme (Windows, Android, iOS, etc.).

• Limbaj de programare: C#, resurse multiple prin Unity Asset Store.

- ARway SDK:

• Tehnologii avansate: SLAM (Simultaneous Localization and Mapping) și VPS (Visual Positioning System).

• Posibilitatea creării de rute vizuale și ancore digitale fără echipament hardware suplimentar.



Funcționalități Cheie

<u>- Orientare în campus:</u>

• Interioară: către săli de curs, laboratoare, birouri.

• Exterioară: între clădiri ale campusului.

<u>- Accesibilitate:</u>

• Rute dedicate persoanelor cu dizabilități.

• Informații privind lifturi sau alte facilități de acces.

<u>- Informații adiționale:</u>

• Timpi de sosire, distanțe, programări la birouri sau profesori.

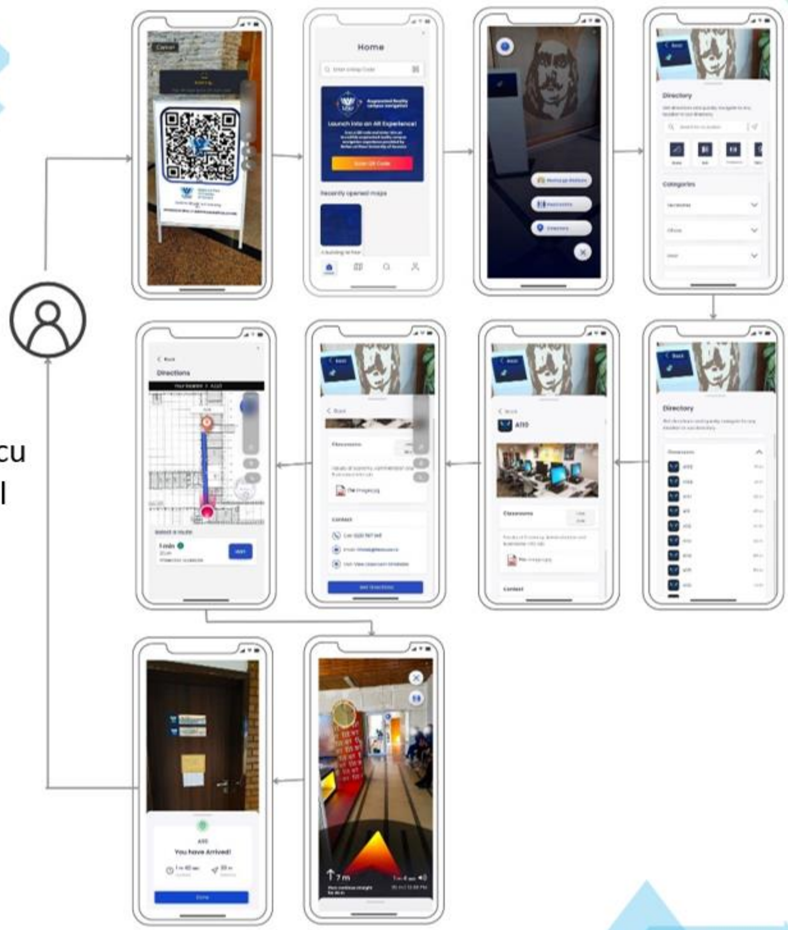
• Locuri de interes (ex. toalete, securitate, casierie).

Implementare Practică

- Aplicația folosește coduri QR pentru inițierea navigării.

- Hartă digitală cu puncte de interes:
  • Săli, birouri, spații de conferințe, servicii auxiliare.
  • Marcaje vizuale și audio pentru orientare.

- Integrarea de conținut multimedia:
  • Texte, imagini, videoclipuri, modele 3D la locații specifice.



Fluxul interfeței cu utilizatorul aplicației

Concluzii și Perspective

- Aplicația rezolvă problemele tradiționale de orientare printr-o soluție digitală interactivă.

- Beneficii:

- Navigare intuitivă, economie de timp, actualizare rapidă a informațiilor.
- Reducerea dependenței de marcaje fizice.

- Perspective de dezvoltare:

- Suport multilingv, integrare cu alte platforme universitare.
- Utilizare offline, extindere la alte campusuri și medii diverse.

VĂ MULȚUMIM.