Acta Catallactics

časopis za ekonomska i opšta društvena pitanja

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Sadržaj

AN ECOSYSTEM FOR SMART CITIES BASED ON BLOCKCHAIN

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Abstract

This paper analyses the impact of the digital transformation of cities affected by rapid urbanization that tend to endanger their environmental and economic sustainability. Such a transformation is possible through the concept of a smart city. We investigate the opportunities of using blockchain technologies in the realm of smart cities. The paper's main goal is to propose a new business model for blockchain use in the smart city ecosystem that will provide a solution for a sustainable urban environment and improve citizens' life. Smart city ecosystem consists of building blocks: infrastructure, development and self-sustainability, stakeholders and their relationships. Stakeholders can be different subjects, but most often they are government authorities, service providers, blockchain technology providers, IoT device manufacturers, and citizens. Blockchain-based systems facilitate increased citizen engagement and participation. Citizens can provide feedback, contribute data, and interact with smart city services through decentralized applications. The ecosystem operates in an iterative and adaptive manner continuously learning and improving based on the data and feedback received. Insights gained from the blockchain data and citizen interactions drive ongoing enhancements to the smart city infrastructure and applications. The proposed model will, on the other hand, show sustainability by citizens through a reward system using a digital wallet. Citizens actively engaged in energy management or ridesharing platforms can be rewarded with tokens to use for discounts or health check-up services. The proposed ecosystem could serve as a ground for the adoption of blockchain in smart city ecosystems in different countries.

Key words*: Blockchain, Smart City, Smart Contracts, Digital Transformation.*

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1. Introduction

Today, more than a half of the world's population lives in lives in urban areas. There is a report from the United Nation where is stated that 68% of the global population is going to live in cities by 2050 (United Nations, 2018a). And this trend is expected to continue. Growth of the urban population leads to challenges to a city's sustainability and management. As population grows, citizens' welfare is affected by increased traffic jams, air pollution, difficult management of waste disposal, jeopardizes public safety, health services, etc. The solution to these problems as well as providing efficient services are feasible but with a proper management of environmental, social and economic sustainability of resources. Many cities that have encountered similar problems have applied modern technologies such as: Internet of Things (hereinafter: IoT), wearable computing, machine learning, artificial intelligence (hereinafter: AI), blockchain, etc., in order to provide more efficient and accessible services to their citizens during their daily activities. Technologies like Internet of Things, big data, machine learning, wearable computing, crowdsourcing, cloud computing, intelligent devices, etc., enable easy implementation of different services in private or public homes, offices, streets, hospitals and other community places and services and which is why they get the label "smart". Many researchers defined the concept of a smart city, but the common attitude of definitions and researchers is the application of ICT for the purpose of delivering the smart city benefits to its citizens united with aim to increase the quality of citizens' life (United Nations, 2018b)(Jezdović et al., 2021).

The concept of smart city allow citizens and local government authorities to work together to improve the efficiency of city services, and implicitly improve the living welfare and wellbeing of its citizens (Nam & Pardo, 2011)(Tabane et al., 2017). One of the most important aspects of a smart city is its sustainability. Sustainability is also a big challenge that needs to be solved in order to implement centralized and non-fragmented smart city services and maintain and sustain citizen welfare. Blockchain has been proven to facilitate transparency, ensure a secure and efficient dissemination of data, centralization and elimination of intermediaries (Mohd Shari & Malip, 2022) (Alnahari & Ariaratnam, 2022).

In this paper we propose a new business model for an ecosystem for smart cities based on blockchain. The ecosystem consists of infrastructure and interaction among different stakeholders such as government authorities, service providers, providers of blockchain technology, IoT device manufacturers, and citizens (Mohd Shari & Malip, 2022).

The rest of the paper is organized as follows: section 2 gives the theoretical background on the smart city concepts, application domains and blockchain-based services in the smart city; section 3 presents smart city business model based on blockchain and section 4 presents an ecosystem for smart cities based on blockchain. Finally, we give conclusions and implications in section 5.

2. Smart city application domains based on blockchain

Although the concept of a smart city dates back to the 90s of the last century (Attaran et al., 2022), it is written and talked about a lot, and is still a current topic (Albino et al., 2015). Urban problems, today, can be solved by constructing a city based on available resources and smart technologies in a coordinating manner (Bhushan et al., 2020). In its

narrow meaning smart city is based on organization, human and technology (Sun et al., 2016) (Tabane et al., 2017). Technology includes modern information-communication technologies, human dimension is based on people or knowledge, and organization is related to government and policy and institutional relationship (Sun et al., 2016).

Recently, more and more importance has been given to several attributes including smart city sustainability, quality of citizens' life and the inclusion of the component of smart people in the concept of a smart city (Tabane et al., 2017) (Chang & Smith, 2023) (Attaran et al., 2022). Thus, an interesting definition that we can refer to is that smart city investments in human and social resources with traditional and modern communication infrastructure fuel sustainable economic development and high life standards (Caragliu et al., 2011). An overview of the main dimensions will be given in the following chapters.

2. 1. Smart cites application domains

Throughout the literature, different models and application domains of the smart city concept are distinguished. Certain dimensions are common to almost all researchers, while some mention other aspects that are not widespread or often implemented, but are no less important. In paper (Sun et al., 2016) the following dimensions are specified: smart governance, smart mobility, smart living, smart citizens, and smart economy. Some other (Mohd Shari & Malip, 2022) includes smart healthcare, smart education, smart energy, smart building, smart education, smart communication, smart services, etc. and this list will increase. Therefore, smart city dimensions features are proposed below, to better understand its peculiarities.

Smart government. Usually delivers administration and services to citizens, like identity management and authentication, and tax collection. There is a need for improvement in public administration so that the transmission of important data from citizens' administration and vice versa is at the highest level of security and privacy.

Smart living. When smart living is mentioned, its description should include smart homes, smart government, smart education, smart buildings, etc., because all of them are involved in improving the quality of life of the citizens. In smart homes and smart buildings different actuators, sensors, and smart devices provide automated services for the users, helping them in their daily tasks. Smart living services and location-based services also play a big role in citizens' welfare because they provide better experience, new education, and offers based on tracking users' flows and behaviours (Bellini et al., 2022).

Smart energy. As the population grows, expectedly, there is increased demand for energy. In conscious and responsible cities there are efforts to consumption of low-cost energy. It is necessary to achieve communication and good cooperation between suppliers and consumers via smart grids and smart meters. The consumer would have the opportunity to measure consumption through a smart meter, and the supplier would be forwarded the electricity consumption during certain periods. This kind of simultaneous communication would be a benefit for both consumers and suppliers because they would be able to manage consumption and reduce energy losses (Mohd Shari & Malip, 2022) (Bellini et al., 2022). Decision makers, therefore, will have precious data to measure levels of demand and supply.

Smart education. It enables a different approach to education. The traditional way has been replaced by learning at any location and at any time (Mohd Shari & Malip, 2022). This is a kind of non-binding learning and education that way enables greater interaction and response of interested parties. Learning environments should improve the realization of the learning process, by advanced multimedia technologies that increase the efficiency of the process of knowledge transfer (Simic et al., 2016).

Smart healthcare. When it comes to healthcare, overcrowded cities offer an environment that can be threatening to one's health as well as opportunities to improve health. Digitally connected smart cities can make health care smarter and more accessible to citizens. Healthcare systems and data can be integrated and interoperable across healthcare system. Integration can facilitate interactions between all the subjects in the healthcare systems (e.g., medical doctors, patients, hospital management, insurance companies, etc.). With the development of sensors and smart wearable devices, it is possible to monitor the patient's vital signs in real time, during daily activities. Analysed results can be shared with their doctors who will respond remotely with appropriate advice or therapy (Tian et al., 2019) (Bellini et al., 2022). the implementation of emerging technologies in the field of healthcare entails issues of security and data security (Kamel Boulos et al., 2018). Healthcare insurance systems can also be a subject of transformation in smart cities; IoT and other smart technologies can bring transparency and security to all parties involved.

Smart transportation. Transportation systems are the fundamental base for the economic growth of the city. A large number of vehicles on the streets cause nervousness among drivers, and consequently more accidents. In addition, the consumption of fuel in the streets is much higher, so the environment is more polluted. It is one of the most important domains in which blockchain technologies can help to achieve road safety, reduce delays, and improve travel efficiency. In cities, a large number of applications for driving delivery vehicles are being developed. They generate a large amount of data that is difficult to manage. Blockchain technologies with modern cryptographic techniques, and IoT computing, make an excellent solution for the implementation of transportation systems in smart city. They can make decentralized, distributed, interoperable, and transportation systems (Mollah et al., 2021) (Guerrero-Ibáñez et al., 2018).

2. 2. Blockchain-based services in the smart cities

In the smart city ecosystem, emerging technologies are used to improve citizens' welfare and city management. Blockchain technology is receiving recently extensive interest from both academic researchers and industry (Zheng et al., 2020)(Ullah et al., 2023). It is a distributed ledger that allows us to record and share information across a distributed network. A lot of researchers believe that blockchain will play a large role in the global economy's long-term growth, raising people's living welfare (Siddiquee et al., 2022).

Some advantages of using Blockchain technology in smart cities are (Mohd Shari & Malip, 2022)(Laufs et al., 2020):

- Blockchain technology functions as a decentralized system without the need for central authority to control the whole network. In the blockchain transactions are

validated through a consensus protocol and replicated between peer nodes in the network.

- Features of immutability and enhanced security are one of the key characteristics of blockchain technology. Transaction data are stored in blocks. Each block contains it's cryptographically hash and the hash of the previous block, and any change on a current block will affect all the subsequent blocks. No one in the network can affect network characteristics or performance for their own benefit. This way of transferring information makes blockchain immutable and secure.
- The blockchain ledger provides transparency and publicity, so anyone can access and view the transactions on the network. All changes are publicly visible that makes this system highly transparent and resistant to fraud and corruption.
- Consensus protocol is one of the features that allow users to communicate in a distributed setting without a central authority. All transactions in blockchain can be coordinated through consensus protocol performed by nodes in the network and thus reduce human intervention. In this way, the validity and consistency of transactions are ensured.
- Increased capacity is one of the main features of blockchain. It provides a much stronger system than a few devices in the centralized system and it is expected to grow rapidly. The blockchain network is extremely secure due to a large number of computers, unlike one central server computer.

The features of blockchain boost its application in various sectors in smart city ecosystem. The concept of a smart government comprises ways in which government can serve their citizens through the use of new-age technologies. Today, the participation of citizens in making administrative decisions is also of great importance. Blockchain is widely applied in e-voting. Some research shows that blockchain has the potential to ensure the integrity of the electoral process (Daramola & Thebus, 2020). Also, reducing corruption (Parenti et al., 2022) is a sensitive topic that is gaining more and more importance today, and is based on the transparency of data through the blockchain system. The real estate sector has huge socio-economic value to the nation. Therefore, is not surprising that one of the blockchain application in smart city ecosystem is real estate and asset registration (Sladić et al., 2021)

Based on a large number of works, we conclude that blockchain has a large application in healthcare sector. The blockchain main and important features make it easy to manage securely with patients' data and enable health researchers to reach the data. Widespread adoption of blockchain technology in healthcare will make healthcare services more accessible and reduce unnecessary costs while improving medical management (Labus et al., 2022). Due to its decentralization nature, blockchain enables management of huge amount of patients data from various resources like wearable devices, sensors or EHRs and this data can be efficiently accessed by different healthcare subjects with need of an intermediary (Mohd Shari & Malip, 2022) (Dimitrov, 2019). In a paper (Griggs et al., 2018) is proposed blockchain-based smart solution with smart contracts that facilitate security in the process of exchange and analysing medical sensor data. Sensors can communicate with smart devices and write measurement data on the blockchain. It is possible in real-time to send notifications to patients and medical professionals. Besides, many issues in drug management can be addressed with blockchain technology. Transparency at any level in drug supply chain is fundamental (Labaran & Hamma-Adama, 2021) and there

are proposed blockchain-based methods and models for integrity in clinical trials (Huh et al., 2022) or for product traceability (Mars et al., 2021) in the healthcare supply chain.

Blockchain can be used to manage and track the use of public transportation, helping city management to optimize their transportation systems and reduce congestion. The most common areas where blockchain is implemented are real-time parking management, electronic toll collection, automated road speed enforcement, collision avoidance alert system (Sharma et al., 2020), traffic planning (Ren et al., 2019) (Ahmed et al., 2023), and management.

The role of blockchain technology in smart energy grids is gaining attention across the world. The researchers are seeking the way energy is generated, distributed, and consumed. Blockchain can reduce the wastage of energy and efficient consumption with application of smart grids (Tahir et al., 2022). The other application of blockchain is for P2P energy trading where energy consumers can trade energy with their neighbours. Blockchain data is recorded through smart contracts and verified by a distributed network of nodes, so consequently, intermediaries can be eliminated (Ul Hassan et al., 2019).

Another application of blockchain is for the verification of green energy where consumer can verify the renewable energy through the use of blockchain technology (WePower, 2023)

Blockchain-based solution for education are mainly used to keep the process of degrees (Sutikno & Aisyahrani, 2023), credit management, and certificates (Sathya et al., 2021). Besides, blockchain can be used to facilitate online testing and learning, education data mining and analytics (Chen et al., 2022). Also, the process of research article publication can be the area where blockchain can play a major role (Mackey et al., 2019).

The city ecosystem can benefit from the use of blockchain due to maximising efficiency in various domains, like improving the management of energy resources and transportation making a “smart” educational and health system (Alnahari & Ariaratnam, 2022), etc.

The ability of a city to perform its operations and uphold the balance of the ecosystem in all the aforementioned departments is known as sustainability. Through recent literature, sustainability is interpreted as the need to respond to the needs of citizens through sustainable solutions.

Sustainability in the smart city ecosystem can be achieved through the main usage of blockchain technology as a means of exchanging economic assets over the underlying cryptocurrency and digital wallets (Mora et al., 2021).

As previously stated, there are a lot of benefits offered by smart cities. Besides that, as any new technology concept, it leaves behind challenges to overcome. Private and public sectors should be accompanied in contributing to management of a smart city.

3. Smart city business model based on blockchain

The development of an appropriate business model is one of the key elements for successful planning and design of smart cities based on blockchain. The Business Model Canvas is a basis for creating new and documenting current business models as well as an effective management tool (Au et al., 2011). The Business Model Canvas for smart city based on blockchain is presented in the Table 1.

Table 1. Smart city business model based on blockchain

<table>
<tr>
<td>KEY PARTNERS
Service providers for smart cities
Providers of blockchain technology
IoT device manufacturers
Governmental organizations and regulators
Urban planner
Research institutions and academy</td>
<td>KEY ACTIVITIES
Development of blockchain-enabled smart city solutions
IoT devices
Managing and maintaining the infrastructure of the blockchain network
Facilitating transactions and data exchange on the blockchain network
Collaboration with key partners
Smart contracts development</td>
<td>VALUE PROPOSITIONS
Transparent and safe data sharing
Improved efficiency through automatization and decentralization
Cost savings through optimization of city resources
Real-time information for decision-making</td>
<td>CUSTOMER RELATIONSHIP
Education and awareness
Cooperative relationships
Continuous support and maintenance
Feedback and co-creation</td>
<td>CUSTOMER SEGMENT
Residents and citizens of smart cities
City governments and government entities
Businesses involved in smart city operations (infrastructure providers and solution integrators)</td>
</tr>
<tr>
<td></td>
<td>KEY RESOURCES
Technology and blockchain expertise
Smart city expertise and data
Digital infrastructure
Financial capital</td>
<td></td>
<td>CHANNELS
Digital channels
Partner channels
Direct sales
Industry events and conferences</td>
<td></td>
</tr>
<tr>
<td colspan="3">COST STRUCTURE
Blockchain infrastructure development
Research and development
Talent acquisition
Marketing and sales
Operational costs</td>
<td colspan="2">REVENUE STREAMS
Licensing and subscription fees
Data monetization
Value-added services
Transaction-based revenue</td>
</tr>
</table>

Key partners. In order to supply the necessary infrastructure and services for the ecosystem of the smart city, such as power and transportation, the suggested smart city business model calls for partnerships with service providers. Utilizing the resources and experience of blockchain technology providers is essential for building and maintaining the blockchain platform. Collaborations with IoT device manufacturers also make it possible for those products to be seamlessly integrated into the blockchain network. Working closely with regulatory bodies and governmental organizations ensures that laws and regulations are in line with the goals of the blockchain-enabled smart city and makes it easier to access local data and infrastructure. By bringing knowledge of creating sustainable and effective urban environments, urban planners play a significant part in a smart city business model based on blockchain. In order to incorporate smart city technologies and assure the best possible resource usage for improved urban planning and development, they work with blockchain solution providers. Through experience of research and academic institutions in conducting research, analysis, and invention, they contribute to the smart city business model based on blockchain. To investigate novel applications, confirm the efficacy of blockchain technology, and create best practices for implementing blockchain-enabled solutions in smart cities, they collaborate closely with blockchain developers and stakeholders in smart cities. Their academic cooperation and research-driven innovations fuel the development of the smart city.

Key activities. Blockchain technology is used in the development of the smart city solutions to improve the efficiency and security of services and transactions within the smart city. This advancement enables the capture and exchange of real-time data by connecting IoT devices into the blockchain network. To guarantee its dependability and security, the blockchain network's infrastructure is controlled and maintained. The blockchain network enables safe data exchange and transactions, maximizing efficiency within the ecosystem for smart cities. Working together with important partners is crucial for fostering the development and promotion of blockchain-enabled smart city solutions, building connections and accelerating adoption. The development of smart contracts is essential for automating and streamlining numerous procedures in the smart city, improving operational effectiveness.

Key resources. The technical know-how and assets required to build and manage the blockchain network, including blockchain expertise. Access to pertinent data and knowledge of smart city systems are required to successfully integrate blockchain-enabled solutions. The hardware and software needed to build and maintain the network's digital infrastructure, which supports the blockchain. The financial capital required for investing in research and development projects and for the continued maintenance of the blockchain network.

Value proposition. A blockchain-based business model for smart cities provides improved security and transparency in data sharing, reducing the possibility of fraud and ensuring responsibility. It makes it possible for smart city processes to be automated and decentralized, enhancing their effectiveness and maximizing the use of available resources. Blockchain technology enables cost reductions through resource optimization and creates new revenue-generating options. Additionally, blockchain-based data analytics give decision-makers reliable insights for efficient resource management within the ecosystem of smart cities through real-time information.

Customer segments. The benefits of blockchain-based smart city solutions are mostly enjoyed by the citizens and residents of those cities, since they have better access to the necessities of everyday life like basic services and transactions. The openness, effectiveness, and possible cost savings that blockchain technology provides to their operations are advantageous to city governments and other governmental bodies. Businesses involved in operating smart cities, such as infrastructure providers and solution integrators, can take advantage of blockchain's greater efficiency and transparency to explore new business opportunities and save money.

Customer relationships. As the technology is still in its infancy, it is essential to educate and raise customer knowledge of the advantages and worth of smart city solutions powered by blockchain. For the successful implementation of blockchain-enabled smart city solutions, it is essential to forge cooperative partnerships with key partners and stakeholders, including governmental organizations, infrastructure suppliers, and solution integrators. For long-term profitability and customer happiness, it is crucial to offer continuing support and maintenance to resolve consumer questions and issues.

Channels. To effectively reach and inform customers about blockchain-enabled smart city solutions, digital channels like social media platforms, internet advertising, and email marketing can be utilized. Establishing partnerships with key stakeholders, such as service providers for smart cities and governmental organizations, can be facilitated through partner channels. Direct sales channels, including sales teams and customer service, can provide direct engagement with customers, offering ongoing support and maintenance. Participating in industry events and conferences specifically focused on smart cities allows for showcasing blockchain technology and creating valuable networking opportunities with potential customers and partners.

Cost structure. Setting aside funds for the creation and upkeep of the blockchain network, including costs for hardware, software, and security measures. Investing in research and development efforts to advance blockchain technology regularly and adjust to changing demands in the field of smart cities. Obtaining and keeping hold of qualified personnel with experience in the fields of data analytics, blockchain development, and smart cities. Implementing marketing and sales techniques enable selling blockchain-powered smart city solutions such as advertising campaigns, sales teams, and industry events. Covering operating expenses like office rent, utilities, and overhead expenditures necessary for the blockchain-based smart city business model to operate smoothly.

Revenue stream. Revenue can be generated in a smart city business model based on blockchain by charging customers licensing and subscription fees in return for utilizing the blockchain platform and receiving ongoing support and maintenance. Another source of revenue is through the sale of valuable data derived from blockchain to interested parties, including researchers, city planners, and businesses. Additionally, offering value-added services such as consultation, smart contract development, and personalized analytics reports creates additional streams of revenue. Leveraging business models that generate revenue based on the volume of transactions facilitated by the blockchain network can also contribute to the financial success of the smart city business model.

4. An ecosystem for smart cities based on blockchain

Smart city application domains and key stakeholders for an ecosystem for smart cities based on blockchain are shown in Figure 1.

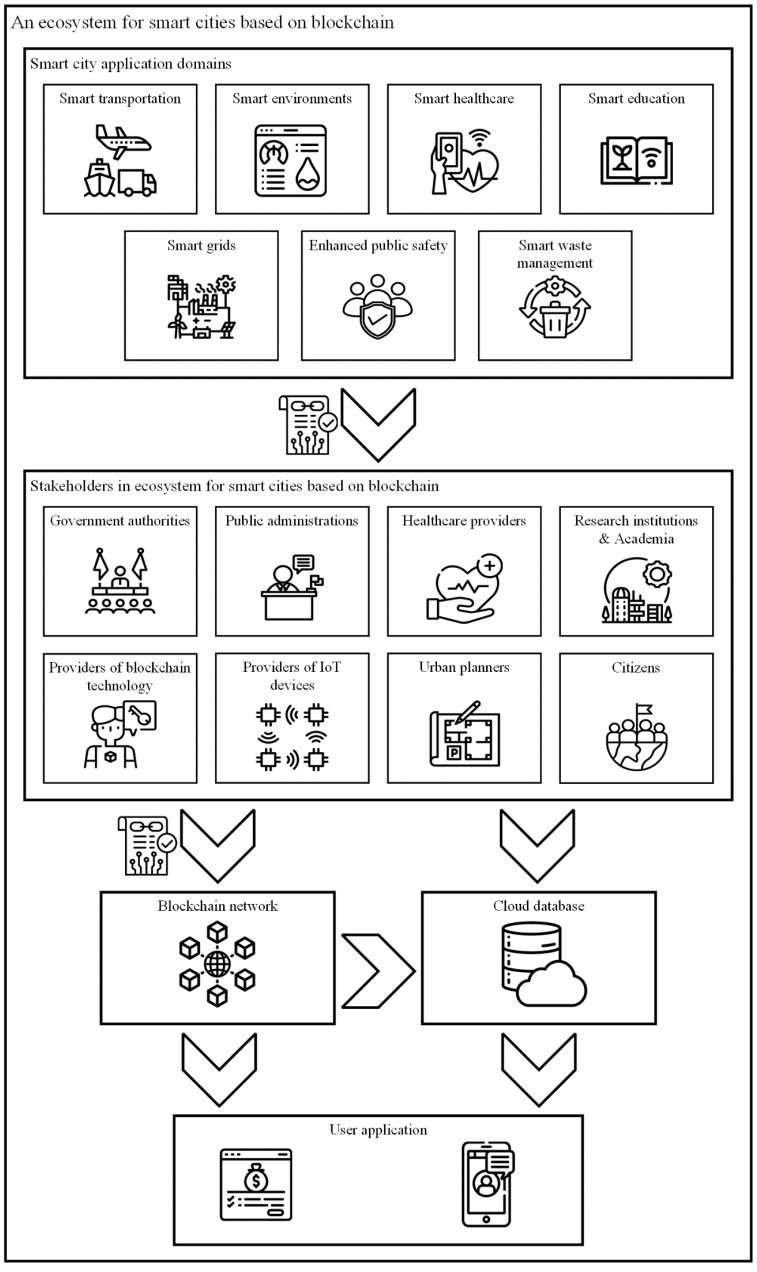

Figure 1. An ecosystem for smart cities based on blockchain

Many different domains can make use of IoT devices and their implementation. Domains that proved to provide the most benefits are:

- **Smart transportation.** The main goal is to improve safety and efficiency in urban traffic conditions. The solution can be found in equipping vehicles and road infrastructure with smart sensors that are able to detect changes in traffic conditions and behaviour of pedestrians. Gathered data can then be combined with real-time communication (Guerrero-Ibáñez et al., 2018).

- **Smart environments.** In this domain, smart devices can be used to collect data from the environment, mostly related to everyday tasks. The data can be used in real-time to track any changes and enable quick reaction in case problems arise.
- **Smart healthcare.** The focus of this domain is to improve traditional medical system by adding efficiency and personalization. For example, significant aspects of patient's health can be collected at any given moment. Then the doctor can revise all the data, providing better treatment plan (Tian et al., 2019).
- **Smart education.** Implementing smart education allows teachers and students to move away from traditional teaching methods. It allows them to embrace their creativity when learning, by providing flexibility regarding different methods of interaction and sharing learning materials.
- **Smart grids.** One of the main goals of smart grids is to help in saving up the energy. Using advanced metering infrastructure and smart distribution boards, improves optimization and provides a way for efficient consumption of energy (Mohd Shari & Malip, 2022).
- **Public safety.** Domain of public safety is mainly mentioned as a part of smart city environment. This aspect is especially important and solutions include video analytics and face recognition software, smart street lighting, etc.
- **Smart waste management.** Focus of this domain is mainly related to recycling used products and their packaging. Implementation of smart sensors can improve efficiency of recycling by notifying waste management services if containers are full and tracking the condition of materials inside.

Stakeholders are essential part in ideation and implementation of smart city services. All end solutions should benefit the life of every citizen. Need for legal support and funding implies cooperation with government institutions and public administration office. Providers of products and services are essential part in implementation of smart city services. Firstly, there are domain specific stakeholders, for example Healthcare providers which are essential for smart healthcare or Research institutions & Academy, whose support is needed for implementation of smart education. Secondly, there are technology providers that include Providers of IoT devices and Providers of blockchain technologies.

Smart sensors and IoT devices are essential part of physical implementation of smart services. They gather information from our surroundings and enable real-time exchange of messages between components in every smart city service. On the other hand, usage of blockchain technology is proposed with the idea to enable transparent communication between stakeholders and build trust. Communication between stakeholders is implemented using smart contracts on blockchain network. Advantage of this approach is that all agreed upon statements of the contract are implemented using programming code. This enables quick fact checking without space for human errors, but also fast payments without bank provisions using cryptocurrency. On the other hand, using blockchain technologies enables access to data for all stakeholders, which improves communication when building any of the smart city service. Since the data that is passed to the blockchain network cannot be altered, and hierarchy of information is recorded, there is no option for deception.

Data is collected using smart devices from every stakeholder. All collected data is uploaded to the cloud database, while only essential data is recorded on the blockchain network. This combination allows for affordable yet secure data storing. Since big part of proposed smart city solutions is to make life better and easier for every citizen, user application is essential to enable simple way to view data and interact with smart services from any device.

There are many services that can make use of blockchain technologies. In the context of smart grids, users are able to generate their own power using solar panels for example. They also have the opportunity to transfer residual power to main energy grid and sell it on the market. Blockchain technology could be used to track if produced energy is from renewable sources. Also, the process of buying and selling energy could be implemented efficiently using smart contracts transactions on blockchain network (Gao et al., 2012).

Smart transportation can also benefit greatly from blockchain technology. Smart sensors can be used to improve efficiency in transportation and track transported goods throughout the supply chain. Smart sensors can aid driver by providing information about possible traffic congestion or inform driver about free parking spaces near the destination (Jan et al., 2019). On the other hand, every step of product journey is recorded, including transportation start time, transportation end time, temperature, humidity, stakeholders that are a part of the chain and other important parameters depending on the product. In this case, blockchain network can be used to store essential data that cannot be altered. Smart contract could also be implemented to check if all conditions were fulfilled during transportation and provide hierarchy of possession between stakeholders.

As mentioned before, smart healthcare services can be used to provide a detailed record of patient's condition. Role of blockchain could be to make this information from medical chart more secure by providing availability only to the patient. A doctor could gain the access to medical chart only when needed and approved by the patient.

5. Conclusion

This paper presents the integration of blockchain technology in the proposed business model for the smart cities ecosystem. Smart cities may improve trust, accountability, and efficiency by utilizing blockchain, laying the groundwork for a more sustainable and connected future. The scientific contribution of this paper is the development of an innovative smart city business model based on blockchain and an ecosystem for smart cities based on blockchain. Smart cities could provide a basis for a more adaptable, open, and highly technological urban environment by adopting blockchain technology.

Future research directions will refer to the development of services for smart cities based on IoT and blockchain technologies. It is planned to implement transactions in the proposed smart cities ecosystem using smart contracts. Algorand blockchain platform and PyTeal programming language will be used for the development of smart contracts and conducting transactions in the proposed smart cities ecosystem.

Reference

1. Ahmed, M., Ahmed, A., & Ahmed, M. (2023). Implementation of IoT and Blockchain in Traffic Control by using Matrix Algorithm. 0–9.
2. Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of Urban Technology*, *22*(1), 3–21. https://doi.org/10.1080/10630732.2014.942092
3. Alnahari, M. S., & Ariaratnam, S. T. (2022). The Application of Blockchain Technology to Smart City Infrastructure. *Smart Cities*, *5*(3), 979–993. https://doi.org/10.3390/smartcities5030049
4. Attaran, H., Kheibari, N., & Bahrepour, D. (2022). Toward integrated smart city: a new model for implementation and design challenges. *GeoJournal*, *87*(s4), 511–526. https://doi.org/10.1007/s10708-021-10560-w
5. Au, M., Oliveira, Y., José, J., & Ferreira, P. (2011). Business Model Generation: A handbook for visionaries, game changers and challengers. *African Journal of Business Management*, *5*(7).
6. Bellini, P., Nesi, P., & Pantaleo, G. (2022). IoT-Enabled Smart Cities: A Review of Concepts, Frameworks and Key Technologies. *Applied Sciences (Switzerland)*, *12*(3). https://doi.org/10.3390/app12031607
7. Bhushan, B., Khamparia, A., Sagayam, K. M., Sharma, S. K., Ahad, M. A., & Debnath, N. C. (2020). Blockchain for smart cities: A review of architectures, integration trends and future research directions. *Sustainable Cities and Society*, *61*, 102360. https://doi.org/10.1016/J.SCS.2020.102360
8. Caragliu, A., Bo, C. Del, & Nijkamp, P. (2011). Smart Cities in Europe. *Journal of Urban Technology*, *18*(2), 65–82. https://doi.org/10.1080/10630732.2011.601117
9. Chang, S., & Smith, M. K. (2023). Residents’ Quality of Life in Smart Cities: A Systematic Literature Review. *Land*, *12*(4). https://doi.org/10.3390/land12040876
10. Chen, X., Zou, D., Cheng, G., Xie, H., & Jong, M. (2022). Blockchain in smart education: Contributors, collaborations, applications and research topics. *Education and Information Technologies*, *28*(4), 4597–4627. https://doi.org/10.1007/S10639-022-11399-5/METRICS
11. Daramola, O., & Thebus, D. (2020). Architecture-Centric Evaluation of Blockchain-Based Smart Contract E-Voting for National Elections. *Informatics 2020, Vol. 7, Page 16*, *7*(2), 16. https://doi.org/10.3390/INFORMATICS7020016
12. Dimitrov, D. V. (2019). Blockchain applications for healthcare data management. *Healthcare Informatics Research*, *25*(1), 51–56. https://doi.org/10.4258/hir.2019.25.1.51
13. Gao, J., Xiao, Y., Liu, J., Liang, W., & Chen, C. L. P. (2012). A survey of communication/networking in Smart Grids. *Future Generation Computer Systems*, *28*, 391–404. https://doi.org/10.1016/j.future.2011.04.014
14. Griggs, K. N., Ossipova, O., Kohlios, C. P., Baccarini, A. N., Howson, E. A., & Hayajneh, T. (2018). Healthcare Blockchain System Using Smart Contracts for Secure Automated Remote Patient Monitoring. *Journal of Medical Systems*, *42*(7), 1–7. https://doi.org/10.1007/s10916-018-0982-x
15. Guerrero-Ibáñez, J., Zeadally, S., & Contreras-Castillo, J. (2018). Sensor technologies for intelligent transportation systems. *Sensors (Switzerland)*, *18*(4), 1–24. https://doi.org/10.3390/s18041212
16. Huh, K. Y., Moon, S. J., Jeong, S. un, Kim, M. J., Yang, W., Jeong, M., Kim, M. G., & Lee, S. H. (2022). Evaluation of a blockchain-based dynamic consent platform (METORY) in a decentralized and multicenter clinical trial using virtual drugs. *Clinical and Translational Science*, *15*(5), 1257–1268. https://doi.org/10.1111/cts.13246
17. Jan, B., Farman, H., Khan, M., Talha, M., & Din, I. U. (2019). Designing a Smart Transportation System: An Internet of Things and Big Data Approach. *IEEE Wireless Communications*, *26*(4), 73–79. https://doi.org/10.1109/MWC.2019.1800512
18. Jezdović, I., Popović, S., Radenković, M., Labus, A., & Bogdanović, Z. (2021). A crowdsensing platform for real-time monitoring and analysis of noise pollution in smart cities. *Sustainable Computing: Informatics and Systems*, *31*. https://doi.org/10.1016/J.SUSCOM.2021.100588
19. Kamel Boulos, M. N., Wilson, J. T., & Clauson, K. A. (2018). Geospatial blockchain: Promises, challenges, and scenarios in health and healthcare. *International Journal of Health Geographics*, *17*(1), 1–10. https://doi.org/10.1186/s12942-018-0144-x
20. Labaran, M. J., & Hamma-Adama, M. (2021). The Nigerian Pharmaceutical Supply Chain: Blockchain Adoption, Counterfeit Drugs and Successful Deployment of COVID-19 Vaccine in Nigeria. *Journal of Scientific Research and Reports*, *27*(2), 20–36. https://doi.org/10.9734/jsrr/2021/v27i230356

21. Labus, A., Radenković, M., Bogdanović, Z., Bjelica, D., & Despotović, V. (2022). A blockchain system for healthcare. *5th INTERNATIONAL SCIENTIFIC CONFERENCE ON DIGITAL ECONOMY DIEC 2022*, 23–32.
22. Laufs, J., Borrion, H., & Bradford, B. (2020). Security and the smart city: A systematic review. *Sustainable Cities and Society*, *55*, 102023. https://doi.org/10.1016/J.SCS.2020.102023
23. Mackey, T. K., Shah, N., Miyachi, K., Short, J., & Clauson, K. (2019). A Framework Proposal for Blockchain-Based Scientific Publishing Using Shared Governance. *Frontiers in Blockchain*, *2*, 486144. https://doi.org/10.3389/FBLOC.2019.00019
24. Mars, R., Youssouf, J., Cheikhrouhou, S., & Turki, M. (2021). Towards a Blockchain-based approach to fight drugs counterfeit. *CEUR Workshop Proceedings*, *3067*, 197–208.
25. Mohd Shari, N. F., & Malip, A. (2022). State-of-the-art solutions of blockchain technology for data dissemination in smart cities: A comprehensive review. *Computer Communications*, *189*, 120–147. https://doi.org/10.1016/J.COMCOM.2022.03.013
26. Mollah, M. B., Zhao, J., Niyato, D., Guan, Y. L., Yuen, C., Sun, S., Lam, K. Y., & Koh, L. H. (2021). Blockchain for the Internet of Vehicles towards Intelligent Transportation Systems: A Survey. *IEEE Internet of Things Journal*, *8*(6), 4157–4185. https://doi.org/10.1109/JIOT.2020.3028368
27. Mora, H., Mendoza-Tello, J. C., Varela-Guzmán, E. G., & Szymanski, J. (2021). Blockchain technologies to address smart city and society challenges. *Computers in Human Behavior*, *122*(April). https://doi.org/10.1016/j.chb.2021.106854
28. Nam, T., & Pardo, T. A. (2011). Conceptualizing smart city with dimensions of technology, people, and institutions. *ACM International Conference Proceeding Series*, 282–291. https://doi.org/10.1145/2037556.2037602
29. Parenti, C., Noori, N., & Janssen, M. (2022). A Smart Governance diffusion model for blockchain as an anti-corruption tool in Smart Cities. *Journal of Smart Cities and Society*, *1*(1), 71–92. https://doi.org/10.3233/scs-210122
30. Ren, Q., Man, K. L., Li, M., & Gao, B. (2019). Using Blockchain to Enhance and Optimize IoT-based Intelligent Traffic System. *2019 International Conference on Platform Technology and Service, PlatCon 2019 - Proceedings*, 1–4. https://doi.org/10.1109/PlatCon.2019.8669412
31. Sathya, A. R., Panda, S. K., & Hanumanthakari, S. (2021). Enabling smart education system using blockchain technology. *Intelligent Systems Reference Library*, *203*(May), 169–177. https://doi.org/10.1007/978-3-030-69395-4_10
32. Sharma, A., Awasthi, Y., & Kumar, S. (2020). The Role of Blockchain, AI and IoT for Smart Road Traffic Management System. *Proceedings - 2020 IEEE India Council International Subsections Conference, INDISCON 2020*, 289–296. https://doi.org/10.1109/INDISCON50162.2020.00065
33. Siddiquee, S. M. S., Khan, M. M. H., Al-Ismail, F. S., Ullah, A., Alam, M. S., & Ahmed, H. (2022). Blockchain applications in smart sustainable city context—A systematic mapping study. *Energy Reports*, *8*, 162–169. https://doi.org/10.1016/j.egyr.2022.10.102
34. Simic, K., Despotovic-Zrakic, M., Bojovic, Z., Jovanic, B., & Knezevic, D. (2016). A platform for a smart learning environment. *Facta Universitatis - Series: Electronics and Energetics*, *29*(3), 407–417. https://doi.org/10.2298/fuee1603407s
35. Sladić, G., Milosavljević, B., Nikolić, S., Sladić, D., & Radulović, A. (2021). A blockchain solution for securing real property transactions: A case study for serbia. *ISPRS International Journal of Geo-Information*, *10*(1). https://doi.org/10.3390/ijgi10010035
36. Sun, J., Yan, J., & Zhang, K. Z. K. (2016). Blockchain-based sharing services: What blockchain technology can contribute to smart cities. *Financial Innovation*, *2*(1). https://doi.org/10.1186/s40854-016-0040-y
37. Sutikno, T., & Aisyahrani, A. I. B. (2023). Non-fungible tokens, decentralized autonomous organizations, Web 3.0, and the metaverse in education: From university to metaversity. *Journal of Education and Learning (EduLearn)*, *17*(1), 1–15. https://doi.org/10.11591/edulearn.v17i1.20657
38. Tabane, E., Ngwira, S. M., & Zuva, T. (2017). Survey of smart city initiatives towards urbanization. *Proceedings - 2016 3rd International Conference on Advances in Computing, Communication and Engineering, ICACCE 2016*, 437–440. https://doi.org/10.1109/ICACCE.2016.8073788
39. Tahir, M., Ismat, N., Rizvi, H. H., Zaffar, A., Nabeel Mustafa, S. M., & Khan, A. A. (2022). Implementation of a smart energy meter using blockchain and Internet of Things: A step toward energy conservation. *Frontiers in Energy Research*, *10*(December), 1–14. https://doi.org/10.3389/fenrg.2022.1029113

40. Tian, S., Yang, W., Grange, J. M. Le, Wang, P., Huang, W., & Ye, Z. (2019). Smart healthcare: making medical care more intelligent. *Journal of Global Health*, *3*(3), 62–65. https://doi.org/10.1016/j.glohj.2019.07.001
41. Ul Hassan, N., Yuen, C., & Niyato, D. (2019). Blockchain Technologies for Smart Energy Systems: Fundamentals, Challenges, and Solutions. *IEEE Industrial Electronics Magazine*, *13*(4), 106–118. https://doi.org/10.1109/MIE.2019.2940335
42. Ullah, Z., Naeem, M., Coronato, A., Ribino, P., & De Pietro, G. (2023). Blockchain Applications in Sustainable Smart Cities. *Sustainable Cities and Society*, *97*(September 2022), 104697. https://doi.org/10.1016/j.scs.2023.104697
43. United Nations. (2018a). *The 2018 Revision of World Urbanization Prospects*.
44. United Nations, D. of E. and S. A. (2018b). *68% of the world population projected to live in urban areas by 2050*.
45. WePower. (2023). *Blockdata | WePower*.
46. Zheng, Z., Xie, S., Dai, H. N., Chen, W., Chen, X., Weng, J., & Imran, M. (2020). An overview on smart contracts: Challenges, advances and platforms. *Future Generation Computer Systems*, *105*, 475–491. https://doi.org/10.1016/j.future.2019.12.019

HOW MUCH DO WE TRUST IN AI? EXPLORING THE IMPACT OF ARTIFICIAL INTELLIGENCE ON USER TRUST LEVELS

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Abstract

Artificial intelligence is a broad branch of computer science that deals with the development and study of smart machines and programs, which are increasingly used in private and business environments. Considering that artificial intelligence is in a relatively early stage of wide-range application, it is necessary to investigate the readiness of users to accept it. Given that no more extensive research has been conducted in Croatia on the level of readiness to accept artificial intelligence technologies, nor on the potential implications of its increase, this research provides answers to related questions to a certain extent. Internet users were chosen as the target audience because they are considered to be potential users or users of artificial intelligence. The survey was conducted on 1036 respondents. The research compares respondents' trust in humans, artificial intelligence and humans with the assistance of artificial intelligence, depending on whether they perform on low or high level stakes and risks in different areas of personal and professional life. The assumptions predicting greater trust in humans compared to artificial intelligence were confirmed, but also the assumption that trust in humans with the assistance of artificial intelligence will be greater than in humans alone. The results show that the respondents are aware that artificial intelligence is entering their private and business lives, but they are still very cautious and ready to trust it more significantly only when artificial intelligence has a role of supporting tool.

Key words: *Artificial Intelligence, Trust, Willingness to Accept Technology, AI.*

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1. Introduction

The father of artificial intelligence, John McCarthy (2004), defines artificial intelligence as a scientific discipline that deals with the creation of machines and programs whose behavior can be interpreted as intelligent. Weber and Schutte (2019) state that artificial intelligence was actually born from thinking about how and to what extent machines can replace people in performing certaing actions. Artificial intelligence is the field of numerous scientific and professional studies, and in practice it is applied using computers to perfrom tasks that are usually achieved using human intelligence, and such tasks may include understading images or sounds, recognizing the enivornment and making independent decisions (Nath et al., 2020). Artificial intelligence – based systems can be software-based and operate in the virtual world, such as voice assistants, facial or voice recognition software, but they can also be hardware-based, such as robots, autonomous cars, drones, and the Internet of Things (European Commission, 2018).

The fact that artificial intelligence can both learn and make decisions is of particular importance, as it will be able to replace humans in many areas that were previously the exclusive domain of humans. Technologies based on artificial intelligence are already being widely used to facilitate and improve people's daily lives, both at home and at work. As artificial intelligence advances, it is changing the way people live and perform many tasks in almost every field. Certain difficult, boring, or dangerous tasks have already been or will soon be replaced by artificial intelligence, and people who do not want to do these tasks will no longer have to (Rouhiainen, 2018).

Despite all the benefits that technological progress brings, there is always a flip side to the coin, namely the fact that artificial intelligence can also cause harm, whether tangible (e.g., human health and life or property damage) or intangible (loss of privacy, restriction of fundamental human freedoms, or discrimination), and it is precisely for this reason that it is necessary to define legal regulations to reduce these risks. Some of the fundamental values at risk from the negative influence of AI are the right to freedom of expression and assembly, the right to non-discrimination on the grounds of gender, race, religion and ethnic origin, the protection of personal data and privacy, and the right to a fair trial (European Commission, 2020). Moral dilemmas related to AI are visible in most AI application areas, and the high-risk areas are particularly sensitive. One of the high-risk areas is the application of artificial intelligence in the justice system, and there is scientific evidence that certain artificial intelligence algorithms based primarily on machine learning exhibit gender and racial biases. Trusted relationships are those between trusted parties, whereas artificial intelligence is a systematic set of techniques that enable machines to perform specific data processing tasks, and AI should not be trusted (Ryan, 2020). Trust in artificial intelligence should go hand in hand with trust in the companies that manage the production of such technologies. To build that trust, however, companies need to be transparent about how they use customer data and the decisions they make when developing new products. It is critical that the person providing the data knows how their data will be handled, where it will be stored, and how it will be used when data is needed to help AI make decisions. It is good news that not only governments but also companies are providing solutions to increase transparency in the industry (Rossi, 2019). Nevertheless, Schmidt et al. (2020) note that higher levels of transparency do not necessarily mean higher levels of trust in AI. Building trust is a dynamic process

that involves moving from initial trust to continuous trust growth. Continuous trust will depend on how well AI performs its tasks and fulfills its purpose. Continuous trust growth will be facilitated by AI applications that are easy to use, reliable, and can collaborate and interact well with humans. These AI applications should also be social, foster human engagement, provide good security and privacy protection, and provide an explanation of why decisions or actions were made. Uncertainty about how AI will replace and displace human workers, as well as its potential to endanger humanity, fuels distrust and hinders the growth of trust over time. Like any other trust, trust in AI takes time to build (Siau & Wang, 2018).

2. Literature review

Frank's (2020) dissertation consists of three papers, of which paper 3 examines the adoption of artificial intelligence as a function of the scope of the decision. In the conceptual design of the study, Frank (2020) highlights the differences between decisions where the stakes are high and those where the stakes are low, and presents the scenario where the activity can be performed by a human, an artificial intelligence, or a human using an artificial intelligence. The conceptual research model presented (Frank, 2020) served as the model for this paper's research model because it compares the three options (human / artificial intelligence / human + artificial intelligence) and observes the differences in trust when high stakes options and low stakes options are offered. Frank (2020) examines respondents' willingness to trust humans, artificial intelligence, or humans using artificial intelligence and asks respondents to indicate the perceived level of risk as a function of the entity performing the action and compares them in three application domains – healthcare, justice, and retail. Frank (2020) states that when it comes to trust, respondents are most willing to trust a human in all three sectors, regardless of whether the stakes are high or not, but in the judiciary and retail the differences are not significant, they are only visible in heathcare. Wang et al. (2016) point out that the perception of trust in humans is irrational because humans outperform humans using artificial intelligence. Lockey et al. (2021) also found that humans trust human advice more than AI advice, but they trust most when there is an option where AI gives advice but humans have final authority. The human-in-the-loop approach, where AI supports the human provider's decision, is the option most users prefer. Nevertheless, Frank (2020) notes that confidence in AI adoption depends not only on the superiority of AI, i.e., its competence, but also on consumers' perceptions of what is at stake in a decision involving the use of AI. In the discussion, Frank (2020) notes that perceived trust in humans or competent experts for a given activity area is greater than trust in artificial intelligence, but he notes that in his research, trust in humans with the support of artificial intelligence is not greater than trust in humans alone, especially for activities with higher stakes and risks, which he considers irrational given that the aforementioned combination has been shown to be the most effective. In the past, reliability was considered the most important factor in the adoption of new technologies. However, according to Glickson & Williams Woolley (2020), the relationship between reliability and trust in AI could be complex, as low reliability may not always be associated with lack of use or low trust. Their study of embedded AI found that AI was a decision-making tool that was disregarded due to low reliability, indicating that reliability is important. On the

other hand, in robotic AI, high machine intelligence and immediacy behaviour moderated the effect of reliability on trust, with immediacy behaviour increasing it despite the low reliability that was evident in erroneous actions. Frank (2020) also suggests conducting research in countries that are technologically weaker or more developed than the United States, which is one of the main elements affecting trust in AI, along with timing, cultural differences, and popular media events related to the aforementioned topic.

Another important concept for the design of the research instrument within this paper is the document 'Trust and excellence for artificial intelligence' publiced by European Commussion (n.d.) which lists the risk levels in the implementation of artificial intelligence and explains exactly what a high level of risk would be and what is application is:

- In infrastructure that can threaten the health and safety of citizens (e.g. traffic and transportation), in vocational education that can direct a person's further life (e.g. scoring an exam or cocluding an assessment)
- In the safety parts of the product (e.g. artificial intelligence in robot-assisted surgical operations)
- In recruitment and staffing (e.g. an algorithm for classifying resumes during recruitment)
- In basic private and public services (e.g. credit assessment or financial management)
- In the enforcement of laws that may conflict with fundamental human rights (e.g. judicial process, evaluation of the reliability of evidence)
- In the management of migration, asylum and borders (e.g. checking the authenticity of travel documents)
- In the judiciary and democratic processes (e.g. application of the law to a specific set of facts)

According to the examples given by the European Commission (n.d.), it can be interpreted how the application of high stakes and risks is divided into applications in education (judgement conclusion), medicine / healthcare (robotic-assisted surgical operations), human resources management (algorithm for sorting resumes), finance (credit rating / financial management), justice and law enforcement (court processes / evaluation of the reliability of evidence / passport verification).

Based on the above and the work of Mazurek (2019) and Castelo (2019), a set of questions was created that divided the activity areas into private daily life, medicine and healthcare, education, finance, traffic and transportation, marketing, and justice. Some of the particles and their associated answers were deliberately adapted during the research to the specifics of the population studied and the planned research objectives, in order to minimize the risk of misunderstanding the question. For example, in the financial sector, a low stakes activity is an investment of HRK 2,000.00 (EUR 265.44), which is approximately one third of the median net salary in Croatia, and a high stakes activity is an investment of HRK 20,000 (EUR 2,654.45), which is approximately three times the median net salary in Croatia.

In its study, Capgemini (2018) presents respondents with a dilemma when it comes to the use of artificial intelligence in providing purchase advice for products that are high-consideration and low-consideration products and services. For the two aforementioned groups, respondents can choose whether they prefer the help of humans, artificial

intelligence, or the combined interaction of human and artificial intelligence. The results show that for products and services that require a higher level of consideration (e.g., buying a car or an engagement ring), respondents are most likely to prefer an interaction that combines human and artificial intelligence recommendations (47%), but a slightly lower percentage of respondents (45%) prefer human interaction, and only 8% of respondents prefer artificial intelligence interaction only. In contrast, for products and services that require a lower level of consideration before purchase, 54% of respondents said they prefer an interaction that combines the recommendation of human and artificial intelligence, significantly fewer respondents (30%) prefer interaction exclusively with a human, and 17% of them opted for artificial intelligence, which is more than double the rate for products and services that require a high-consideration products and services. Capgemini (2018) also finds that respondents are more willing to trust a human for activities where the stakes are high than for activities where the stakes are low. Kaplan et al. (2023) found that shared risk, i.e., a situation in which there is collaboration between the human and AI system and both are working toward the same goals, is the only significant predictor of trust in artificial intelligence.

According to Araujo et al. (2020), assessments of the societal impact of automated decision making reveal mixed views about its fairness, usefulness, and concerns about risks. As a result, respondents often rated automated decision making as good as or better than human experts when evaluating the potential fairness, usefulness, and risks of high-impact decisions made automatically by AI. Gillath et al. (2020) suggest that safety improvement can serve as an intervention to increase trust in AI by starting from trust models among humans. As their study suggests, humans are similar in their treatment of one another and the way they interact with or think about artificial intelligence.

To assess trust, risks must first be evaluated. In deciding whether or not an AI requires trust, the user's susceptibility to the AI's actions must be verified by confirming that users believe that some of the AI's actions are unfavorable to them, or that users believe that both the favorable and unfavorable outcomes are realistic (Jacovi et al., 2021). The rational cognitions, affective thoughts and attitudes, and behavioral interactions that are relevant to users' trust in AI can be distinguished based on their orientation. In addition, the concept of users' trust in AI should consider their specific applications (Yang & Wibowo, 2022). Considering the importance of showing different application areas of AI and different levels of risks and stakes, Table 1 was created.

Table 1. The seven application domains and activities with high and low stakes and risks

AREAS OF ACTIVITIES	ACTIVITIES WITH LOW STAKES AND RISKS	ACTIVITIES WITH HIGH STAKES AND RISKS
Private life	Movie recommendation	Partner recommendation for a romantic relationship
Medicine	Simple laser operation of a mole on the hand	Cardiac surgery
Education	Predicting success for students	Decision-making for a student to repeat a grade due to insufficient academic performance

AREAS OF ACTIVITIES	ACTIVITIES WITH LOW STAKES AND RISKS	ACTIVITIES WITH HIGH STAKES AND RISKS
Finance	Purchasing stocks worth 2,000 HRK	Purchasing stocks worth 20,000 HRK
Transportation	Driving a tractor in the field	Operating a commercial passenger aircraft
Marketing	Company slogan recommendation	Managing a marketing campaign
Justice	Court judgment for a person who hasn't paid parking fines for months	Court judgment for a person accused of rape

Source: Modified and adapted from Castelo (2019), Mazurek (2019), Frank (2020)

3. Methodology and research results

The aim of this research is to explore the willingness of Internet users to accept artificial intelligence (AI) technologies. The research focus is on the perceived level of trust in three possible options: 1) in artificial intelligence (AI), 2) in humans (H), and 3) in humans assisted by artificial intelligence (HAI). The research concept predominantly builds upon prior studies (Frank, 2020; Mazurek, 2019, and Castelo, 2019). The level of trust expressed is further differentiated based on whether the activities involve significant stakes and risks or whether the stakes and risks are somewhat lower. This differentiation is also examined across various domains such as medicine, education, human resources, finance, transportation, marketing, justice, as well as activities related to private life. Consequently, it is essential to observe the level of trust in humans concerning these same activities and how this level of trust compares to the trust in humans assisted by artificial intelligence.

According to Eurostat (2021), the EU countries with the highest average percentage of Internet users are Iceland, Norway, Denmark, Ireland, Luxembourg, Finland, and Sweden, where more than 97% of the adult population uses the Internet. Interestingly, most of these countries are in Northern Europe. Among the European Union member states, Croatia ranks among the lowest with 82% Internet users. Only in Bulgaria (78%) and Greece (79%) is the percentage of the adult population using the Internet even lower. However, countries with similar Internet usage rates to Croatia include Serbia with 84%, Montenegro with 83%, Albania with 80% and Bosnia and Herzegovina with 77% of the adult population using the Internet.

Given that the focus of interest is on Internet users, data for this study were collected exclusively through an online survey using the Computed Assisted Web Interviewing (CAWI) data collection technique. Based on testing, the estimated completion time for this survey was between 9 and 12 minutes. A highly structured research instrument was used for the survey, consisting of 55 questions, with a maximum of 49 questions for each respondent to answer, taking into account the branching structure while completing the survey. For the purposes of this study, a 7-point Likert scale was predominantly used.

The total number of participants who accessed the survey was 1,238, of which 334 did not complete the questionnaire. Some participants abandoned the survey during the process, leaving 904 respondents who answered the final question. The data analysis also included a subset of participants who partially completed the questionnaire, specifically those who answered at least 28 questions or completed by the end of the third set of questions. The total number of these participants was 1,036. Participants were recruited using the snowball method, a sampling technique based on purposively selecting a small group of individuals who then expand the sample by sharing the survey with their friends, family, students, and colleagues. Data collection took place from April 27, 2022 to June 24, 2022, with more than 90% of the data collected within the first month of the initial survey distribution. A total of 904 participants completed the survey in full, while 132 participants partially completed the survey, the results will be analyzed in the following sections of the study.

Both descriptive and parametric statistical techniques were used in the data analysis. The parametric tests used included independent samples t-test, paired samples t-test, one-way analysis of variance (ANOVA), repeated measures analysis of variance (ANOVA Repeated Measures), and Pearson's correlation coefficient. The statistical software tools used for data analysis were IBM SPSS Statistics 25, JASP version 0.16.2, and Microsoft Excel, which were utilized for data processing and graph plotting.

3. 1. Sample description

The participants in this study are from the Republic of Croatia representing a segment of Internet users. As shown in Table 2, females are slightly more represented among the total number of respondents (62.1%) compared to males, who constitute 37.3% of the participants. The majority of respondents have secondary vocational education (38.1%), followed by those with high levels of education, who make up 27.5% in total. In addition, 20.1% of the respondents have completed higher professional education or undergraduate studies, while 5.3% have completed postgraduate studies. Only 1.5% of the respondents have completed primary education. It is interesting to note that 73.3% of the respondents earn up to HRK 8,500.00 per month. Furthermore, in Table 2 it is noteworthy that the majority of highly educated respondents have graduated in social sciences (59.7%), while the smallest proportion of highly educated participants have completed studies in natural sciences comprising only 3% of the sample).

Table 2. Respondents demographic characteristics.

Demographic characteristics		Boomers	Gen X	Gen Y	Gen Z	All
		N = 53	N = 216	N = 360	N= 405	N=1036
		(%)	(%)	(%)	(%)	(%)
	Respondents	5,1%	20,8%	34,7%	39,1%	100%
Sex	Male	34,0	31,0	45,8	34,2	37,3
	Female	66,0	69,0	54,2	65,8	62,1

Demographic characteristics		Boomers	Gen X	Gen Y	Gen Z	All
		N = 53	N = 216	N = 360	N= 405	N=1036
		(%)	(%)	(%)	(%)	(%)
Place of residence	Rural environment	22,6	29,6	17,5	33,3	26,5
	Small town	15,1	14,4	13,1	17,0	15,0
	Medium-sized town	24,5	26,9	20,8	22,2	22,8
	Large town	37,7	29,2	48,6	27,4	35,7
Education level	Primary school	7,5	3,2	0,3	0,7	1,5
	Secondary school	41,5	48,6	23,1	45,4	38,1
	Higher vocational / Professional study	13,2	10,2	6,4	6,4	7,5
	Undergraduate study	1,9	2,3	13,9	37,5	20,1
	Graduate study	30,2	27,3	47,5	9,4	27,5
	Postgraduate study	5,7	8,3	8,9	0,5	5,3
Monthly income	Up to 4.000 HRK	25,0	13,5	10,2	47,2	24,4
	4.001 – 6.000 HRK	25,0	22,4	21,7	24,3	23,0
	6.001 – 8.500 HRK	19,2	28,1	35,1	15,3	25,9
	8.501 – 11.000 HRK	21,2	25,0	17,4	6,9	15,8
	11.001 – 14.000 HRK	7,7	4,2	9,0	3,1	5,9
	More than 14.000 HRK	1,9	6,8	6,5	3,1	5,2
Employment status	Employed (full-time)	60,4	78,2	83,3	28,2	59,1
	Seasonal / part-time	0,0	3,2	3,6	4,0	3,5
	Student job	0,0	1,4	5,0	33,3	15,1
	Unemployed	3,8	12,0	8,1	34,6	19,1
	Retired	35,8	5,1	0,0	0,0	3,3
Field of education	Technical sciences	22,2	14,4	19,6	14,2	17,0
	Social sciences	59,6	60,6	58,0	61,5	59,7
	Humanities	7,4	5,8	10,5	10,6	9,6
	Natural sciences	3,7	2,9	3,3	2,8	3,0
	Biomedicine	3,7	10,6	5,8	5,0	6,2
	Biotechnical sciences	3,7	5,8	2,9	6,0	4,5

3. 2. Hypothesis testing

During hypothesis testing, seven domains of activities within private and professional life were compared, specifically examining the perceived level of trust in artificial intelligence, humans, and humans assisted by artificial intelligence for activities with high stakes and risks, as well as for activities with low stakes and risks across all seven application domains.

H1: The perceived trust in humans assisted by artificial intelligence (HAI) is higher than the perceived trust in humans (H) or in artificial intelligence (AI).

During the testing of Hypothesis 1 (H1), each application area is initially tested separately, and subsequently through a composite variable. As evident from Table 3, the assumption that humans assisted by artificial intelligence are preferred has been confirmed in 12 out of 14 possible activities. Particularly interestingly, this assumption holds true for all activities with low stakes and risks. However, there is one activity where the assumption is not confirmed, and that is "partner recommendation for a romantic relationship" (which is a private life item related to high level of stakes and risk). In this case, respondents expressed the least trust in humans ($\bar{x}_{HS1} = 3.26$), followed by humans assisted by artificial intelligence ($\bar{x}_{HS3} = 4.40$) and finally artificial intelligence ($\bar{x}_{HS2} = 4.52$).

Table 3. Comparison of mean values for perceived levels of trust in humans, artificial intelligence, and humans assisted by artificial intelligence

Level of stakes and risks	Artificial Intelligence	Human	Human + Artificial intelligence	H+AI is significantly the highest
Private life				
Low	4.61	5.20	5.37	✓
High	3.26	4.52	4.40	
Medicine				
Low	4.55	5.14	5.46	✓
High	4.21	5.20	5.48	✓
Education				
Low	4.39	4.35	5.11	✓
High	4.16	4.90	5.05	✓
Finance				
Low	4.28	3.79	4.74	✓
High	4.12	4.02	4.70	✓
Transportation				
Low	4.59	5.44	5.54	
High	4.33	5.32	5.59	✓
Marketing				
Low	4.48	5.26	5.43	✓
High	4.52	5.08	5.44	✓
Justice				
Low	4.56	4.85	5.11	✓

Level of stakes and risks	Artificial Intelligence	Human	Human + Artificial intelligence	H+AI is significantly the highest
High	4.29	4.91	5.06	✓

Table 4 shows the results of the ANOVA Repeated measures test for composite variables, where all 14 observed activities are combined. The average value of the composite variable for humans with the assistance of artificial intelligence is the highest ($x^- = 5.16$), then for humans ($x^- = 4.85$), and the lowest for artificial intelligence ($x^- = 4.31$). For the above composite variables, an analysis of the variance of repeated measurements was carried out with the use of Bonferroni Post-Hoc test, which showed that there are indeed statistically significant differences ($F = 353{,}099$, $df1 = 1{,}771$, $df2 = 1682{,}371$, $p < 0{,}01$) in trust in humans, artificial intelligence and humans with the assistance of artificial intelligence when performing the same activity.

Table 4. ANOVA Repeated measures for composite variables

Composite variables	AI / H (J)	Mean Difference (I-J)	Std. Error	p value
Human + Artificial intelligence (H+AI)	H	,313*	,031	,000
	AI	,854*	,028	,000

Based on the results of compared composite variables, and additionally the analyzed data that observes all areas of application individually, regardless of the level of stakes and risks, it can be concluded that the first hypothesis is accepted, i.e. the assumption that trust in humans assisted by artificial intelligence is the highest in comparison to trust in humans or in artificial intelligence.

H2: The perceived trust in artificial intelligence is higher for activities with low stakes and risks (AI_{low}) compared to activities with high stakes and risks (AI_{high}).

When analyzing the data related to testing H2, it is essential to emphasize that respondents expressed their perceived level of trust in artificial intelligence on a Likert scale ranging from 1 to 7. This was done based on whether the activities involved high stakes and risks or low stakes and risks. To compare the mentioned variables, a dependent samples t-test was employed.

The following presents the testing of the perception of trust in artificial intelligence across various analyzed activity domains, while the final decision on the auxiliary hypothesis will be made based on composite variables. In conducting the dependent samples t-test for six out of seven activity domains, a statistically significant difference in the perception of trust in artificial intelligence was confirmed based on whether it is applied in activities with high stakes and risks or in activities with low stakes and risks. As evident from Table 5, the differences in perceived trust in the application of artificial intelligence, depending on the level of stakes and risks, are noticeable in the use of artificial intelligence in private life ($t= 21.370$, $df = 946$, $p < 0.001$), medicine ($t= 5.811$, $df = 943$, $p < 0.001$), education ($t= 4.130$, $df = 940$, $p < 0.001$), finance ($t= 3.376$, $df = 937$, $p = 0.001$), transportation ($t= 4.877$,

df = 934, p < 0.001), and justice (t= 4.570, df= 939, p < 0.001). However, this difference was not observed regarding the application in marketing (t = -0.694, df = 938, p = 0.488).

Taking into consideration that the research instrument presented this set of questions to respondents, enabling them to express their perceived trust in artificial intelligence through a Likert scale ranging from 1 to 7, where 1 signifies "not trusting at all" and 7 denotes "completely trusting", the mean value being 4.0, it is evident that only one element has a value below 4.0. Specifically, this element pertains to the application of artificial intelligence in private life during activities with high stakes and risks, which, in this particular research, refers to partner recommendation for a romantic relationship. On the other hand, the highest value is also related to the application of artificial intelligence in private life, but, in this case, for activities with low stakes and risks, which, in this context, would correspond to movie recommendations.

Furthermore, it is interesting to observe that for marketing (Element 6), the only element where no statistically significant differences were found, the perceived level of trust is higher for activities with high stakes and risks than for activities with low stakes and risks ($\bar{x}_{LS}6 = 4.48 > \bar{x}_{HS}6 = 4.52$). This is the only instance in which the perceived level of trust in artificial intelligence for activities with high stakes and risks is higher than for activities with low stakes and risks. However, in the subsequent sections of the study, it is evident that this perceived trust in artificial intelligence differs from the perceived level of trust in humans or in humans assisted by artificial intelligence. Moreover, it is worth noting that for the perceived level of trust in artificial intelligence, none of the elements have an average value higher than 5.0 on the scale ranging from 1 to 7.

Table 5. Independent samples t-tests for the perceived level of trust in artificial intelligence across different application domains

Level of stakes and risks	Mean ($\bar{x}$)	Standard deviation	Standard error of the mean	T-test
Private life				
Low	4,61	1,690	0,055	t = 21,370 df = 946 p < 0,01
High	3,26	1,570	0,051	
Medicine				
Low	4,55	1,779	0,058	t = 5,811 df = 943 p < 0,01
High	4,21	1,643	0,053	
Education				
Low	4,39	1,586	0,052	t = 4,130 df = 940 p < 0,01
High	4,16	1,634	0,053	
Finance				
Low	4,28	1,683	0,055	t = 3,376 df = 937 p < 0,01
High	4,12	1,610	0,053	
Transportation				

Level of stakes and risks	Mean (x^-)	Standard deviation	Standard error of the mean	T-test
Low	4,59	1,737	0,057	t = 4,877 df = 934 p < 0,01
High	4,33	1,693	0,055	
Marketing				
Low	4,48	1,567	0,051	t = -0,694 df = 938 p > 0,05
High	4,52	1,512	0,049	
Justice				
Low	4,56	1,760	0,057	t = 4,570 df = 939 p < 0,01
High	4,29	1,758	0,057	

For hypothesis testing, composite variables were formed by averaging the responses for all tested activity domains based on the level of stakes and risks, separately for humans, artificial intelligence, and humans assisted by artificial intelligence. The composite variable encompassing all 7 activities with low stakes and risks performed by artificial intelligence has an average value of $x^- = 4.50$, while the composite variable for all 7 activities with high stakes and risks performed by artificial intelligence has an average value of $x^- = 4.15$. To compare the mentioned composite variables, a dependent samples t-test was employed, indicating statistically significant differences ($t = 15.855$, $df = 949$, $p < 0.001$).

Based on the analysis of the composite variables, it can be concluded that Hypothesis 2 is accepted, confirming the assumption that perceived trust in artificial intelligence will be higher for activities with low stakes and risks compared to activities with high stakes and risks. This hypothesis was further elaborated based on the presented results of data analysis for individual activity domains, where the assumption was confirmed in 6 out of 7 activity domains.

H3: The perceived trust in humans assisted by artificial intelligence is higher for activities with low stakes and risks (HAI_{low}) compared to activities with high stakes and risks (HAI_{high}).

This hypothesis focuses on the perceived level of trust in humans assisted by artificial intelligence, depending on whether the activity involves high or low stakes and risks. First, the tests are presented for individual activity domains, and then a final decision is made based on the composite variables. It is particularly interesting to observe that the assumption of significant differences in trust between activities with low stakes and risks compared to activities with high stakes and risks is confirmed only for activities related to private life ($t = 17.741$, $df = 938$, $p < 0.001$). However, for other domains, no statistically significant differences were observed. Specifically, for activities related to medicine ($t = -0.482$, $df = 938$, $p = 0.630$), education ($t = 1.222$, $df = 939$, $p = 0.222$), finance ($t = 0.767$, $df = 937$, $p = 0.443$), transportation ($t = -1.171$, $df = 940$, $p = 0.242$), marketing ($t = -0.189$, $df = 935$, $p = 0.850$), and justice ($t = 1.117$, $df = 939$, $p = 0.264$), no statistically significant differences were found.

As with the previous hypotheses, a comparison of composite variables was also performed here, where the average value of the composite variable for humans assisted by artificial intelligence in activities with low stakes and risks was $\bar{x} = 5.24$, and for activities with high stakes and risks, it was $\bar{x} = 5.09$. The results of the dependent samples t-test confirmed that there are statistically significant differences between the observed variables ($t = 7.872$; $df = 952$; $p < 0.001$).

Table 6. Independent samples t-tests for the perceived level of trust in humans assisted by artificial intelligence across different application domains

Level of stakes and risks	Mean (x^-)	Standard deviation	Standard error of the mean	T-test
Private life				
Low	5,37	1,539	0,050	t = 17,741
High	4,40	1,700	0,055	df = 938 p < 0,01
Medicine				
Low	5,46	1,635	0,053	t = -0,482
High	5,48	1,567	0,051	df = 941 p > 0,05
Education				
Low	5,11	1,532	0,050	t = 1,222
High	5,05	1,546	0,050	df = 939 p > 0,05
Finance				
Low	4,74	1,672	0,055	t = 0,767
High	4,70	1,635	0,053	df = 937 p > 0,05
Transportation				
Low	5,54	1,585	0,052	t = -1,171
High	5,59	1,527	0,050	df = 940 p > 0,05
Marketing				
Low	5,43	1,496	0,049	t = -0,189
High	5,44	1,507	0,049	df = 935 p > 0,05
Justice				
Low	5,11	1,586	0,052	t = 1,117
High	5,06	1,618	0,053	df = 939 p > 0,05

However, it is necessary to comment that in 6 out of 7 activity domains, statistically significant differences were not found, as evident from Table 6, with only one domain showing such a difference. The domain where a statistically significant difference was found is private life, specifically in the application of artificial intelligence for activities with low stakes and risks, having an average value of $x^- = 5.37$, while for activities with high stakes and risks, it was $x^- = 4.40$. Considering that no other activity domain has a difference greater than 0.06 in average values for low and high levels of stakes and risks, it can be concluded that the significant difference in perception for activities with high stakes and risks compared to activities with low stakes and risks in the domain of private life has contributed to the dependent samples t-test showing a statistically significant difference in the composite variables.

Therefore, based on the compared composite variables, it can be concluded that Hypothesis 3 is accepted, meaning that there are statistically significant differences in

trust in humans assisted by artificial intelligence depending on different levels of stakes and risks. However, considering all other elements related to this assumption, Hypothesis 3 should be interpreted conditionally. If composite variables were created without the domain of private life, the results would show that the average value of perceived trust in humans assisted by artificial intelligence for activities with low stakes and risks is $\bar{x} = 5.22$, and for activities with high stakes and risks, it is $\bar{x} = 5.21$, which is almost identical. In this case, the dependent samples t-test did not find statistically significant differences between the observed composite variables ($t = 0.772$, $df = 952$, $p = 0.441$).

3. 3. Research limitations and guidelines for future research efforts

A significant limitation of this study arises from the fact that respondents come from only one country, which may affect the potential generalization of research results. Another limitation of this study is the highly comprehensive and not clearly defined concept of artificial intelligence, which leads to the conclusion that not all respondents perceive the term in the same way, despite the provided definition and explanation of artificial intelligence and algorithms. Even for those who understand the functioning of artificial intelligence, there is a high probability that they are not adequately informed about all branches of application for which they are asked, ranging from medicine, traffic, human resources to education, finance, marketing, and judiciary. Additionally, a limitation of this work is partly due to the fact that the obtained data are not fully comparable to the studies upon which the conceptual design of this research was based, as certain items have been modified compared to the original works. Different measurement scales were used, some variables were excluded to simplify the study, while others were expanded to cover a broader area of research interest for the authors of this paper.

Given the specificity of this topic and the rapid pace of technological advancements related to artificial intelligence discussed in this study, conducting similar research periodically would be beneficial to track the progress in the acceptance of artificial intelligence and the understanding of this technology. Furthermore, it would be valuable to replicate the research in other countries, especially in regions where the use of smart home technologies, virtual voice assistants, and other modern technologies is more widespread, and where people exhibit higher levels of trust in governmental institutions compared to the respondents in Croatia. Trust in the system is crucial for the results of this research, as if the respondents do not trust human authorities (such as judges or doctors), it becomes challenging to draw a parallel to their trust in artificial intelligence and to determine the current state of confidence in this technology.

Researchers in the field of AI and human-computer interaction should further investigate the factors that influence trust in AI, taking into account cultural and societal differences. Cross-cultural studies could shed light on how trust perceptions differ across regions and populations. Future research should explore the role of explainable AI models and user interfaces in enhancing trust. Understanding how explaining AI decisions positively impacts user trust could lead to the development of more user-friendly and trustworthy AI systems.

4. Discussion and conclusion

A full comparison with the work of Mazurek (2019), Castelo (2019), and Frank (2020) is not fully possible due to modifications in the research instrument and the different measurement scale. Nevertheless, the results of this research show that trust in humans is greater than trust in algorithms and artificial intelligence. Castelo (2019) states that there is a gap between trust in humans and trust in artificial intelligence. It can be seen that for all elements in this work, trust in humans was higher than trust in artificial intelligence, but humans using artificial intelligence receive the most trust from respondents. According to Capgemini (2018), trust in humans using artificial intelligence is highest regardless of whether the activities are low or high stakes and risks, while Frank's (2020) data does not give such a clear answer, trust is highest for humans with assistance of artificial intelligence for certain activities,and for others for humans. The results of this work show that trust in humans with assistance is actually greater than trust in humans or artificial intelligence in 12 of 14 possible activities. However, no statistically significant differences were found in 6 out of 7 activity domains, but in one area the difference is so large that it alone dominates the t-test results. The explanation is probably that the differences in stakes and risks are to big. In particular, a low level of stakes and risks is about recommending a movie, and a high level is about recommending a partner for a romantic relationship. At this point, it is important to note that the average value of perceived trust in a person for recommending a relationship is convincingly the lowest of all activities. There are two possible reasons for this: First, people simple refuse to have so much intrusion into their intimate lives, whether they are humans or algorithms, and second, it can be assumed that a large number of respondents are in a relationship or married and find the idea of someone recommending a partner to them inappropriate or repulsive.

Our research findings provide valuable insights into the factors influencing AI adoption, particularly the role of trust in human-assisted AI technologies. This contributes to a deeper understanding of the psychological mechanisms driving user adoption of AI and sheds light on the importance of perceived trust in shaping attitudes toward AI adoption. For researchers, this opens new avenues to study the dynamic relationship between trust, human engagement, and AI technologies, and promotes a more comprehensive understanding of the adoption process. The relevance of our findings to practice lies in their potential to help companies and organizations effectively integrate AI technologies into their operations. By recognizing the importance of human-powered AI and its impact on trust, practitioners can develop AI systems that complement, rather than completely replace, human decision making. This approach fosters a sense of collaboration and empowerment among users, improving the overall user experience and adoption of AI solutions.

In summary, our research has practical implications for businesses, policymakers, and the wider community by highlighting the central role of trust in the adoption of human-powered AI. By recognizing the impact of trust on user attitudes toward AI technologies and promoting the responsible use of AI, we are paving the way for a more inclusive and ethical AI landscape in which humans and AI work together to improve societal well-being. In addition, our findings contribute to the evolving body of knowledge on the use of AI and encourage further research to explore the complex dynamics between trust, human engagement, and AI technologies.

Literature

1. Araujo, T., Helberger, N., Kruikemeier, S., & De Vreese, C. H. (2020). In AI we trust? Perceptions about automated decision-making by artificial intelligence. *AI & society*, 35, 611-623.
2. Capgemini (2018). *The Secret to Winning Costumers' Hearts With Artificial Intelligence – Add Human Intelligence*. Capgemini Digital Transformation Institute. Available at: https://www.capgemini.com/wp-content/uploads/2018/07/AI-in-CX-Report_Digital.pdf [Accessed on July 20th, 2023]
3. Castelo, N. (2019). *Blurring the line between human and machine: marketing artificial intelligence*. Columbia University in the City of New York. PhD thesis
4. European Commission (2018). Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. Artificial Iintelligence for Europe. Eur-Lex. Avaiable at: https://eur-lex.europa.eu/legal-content/en/TXT/?uri=COM:2018:237:FIN [Accessed on: July 20th, 2023]
5. European Commission (2020). White Paper on Artificial Intelligence: a European Approach to excellence and trust. European Commission. Avaiable at: https://commission.europa.eu/publications/white-paper-artificial-intelligence-european-approach-excellence-and-trust_en [Accessed on: July 20th, 2023]
6. European Commission (n.d.). Excellence and trust in artificial intelligence. European Commission. Available at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/excellence-and-trust-artificial-intelligence_en [Accessed on July 24th, 2023]
7. Eurostat (2021). *Digital economy and society*. Eurostat. Avaiable at: https://ec.europa.eu/eurostat/databrowser/view/ISOC_CI_IFP_IU__custom_3119405/default/table?lang=en [Accessed on July 18th, 2023]
8. Frank, D.A. (2020). *Consumer Adoption of Artificial Intelligence Technology: The Role of Ethics and Trust*. Aarhus BSS, Denmark, PhD thesis
9. Gillath, O., Ai, T., Branicky, M. S., Keshmiri, S., Davison, R. B., & Spaulding, R. (2021). Attachment and trust in artificial intelligence. *Computers in Human Behavior*, 115, 106607.
10. Glikson, E., & Woolley, A. W. (2020). Human trust in artificial intelligence: Review of empirical research. *Academy of Management Annals*, 14(2), 627-660.
11. Jacovi, A., Marasović, A., Miller, T., & Goldberg, Y. (2021). Formalizing trust in artificial intelligence: Prerequisites, causes and goals of human trust in AI. In *Proceedings of the 2021 ACM conference on fairness, accountability, and transparency* (pp. 624-635).
12. Kaplan, A. D., Kessler, T. T., Brill, J. C., & Hancock, P. A. (2023). Trust in artificial intelligence: Meta-analytic findings. *Human factors*, 65(2), 337-359.
13. Lockey, S., Gillespie, N., Holm, D., & Someh, I. A. (2021). A review of trust in artificial intelligence: Challenges, vulnerabilities and future directions. *Proceedings of the Annual Hawaii International Conference on System Sciences*. 2021, 5463–5472.
14. Mazurek, K. (2019). Human vs. Artificial Intelligence. A consumer behavioral study on advice taking among Gen Y. Barcelona School of Management. Master thesis
15. McCarthy, J. (2004). *What is artificial intelligence*. Dostupno na: http://www-formal. stanford. edu/jmc/whatisai. [Accessed on: July 20th, 2023]
16. Nath, S. V., Dunkin, A., Chowdhary, M., & Patel, N. (2020). *Industrial Digital Transformation: Accelerate digital transformation with business optimization, AI, and Industry 4.0*. Packt Publishing Ltd.
17. Rossi, F. (2018). Building trust in artificial intelligence. *Journal of international affairs*, 72(1), 127-134.
18. Rouhiainen, L. (2018). *Artificial Intelligence: 101 things you must know today about our future*. Lasse Rouhiainen.
19. Ryan, M. (2020). In AI we trust: ethics, artificial intelligence, and reliability. *Science and Engineering Ethics*, 26(5), 2749-2767.
20. Schmidt, P., Biessmann, F., & Teubner, T. (2020). Transparency and trust in artificial intelligence systems. *Journal of Decision Systems*, 29(4), 260-278.
21. Siau, K., & Wang, W. (2018). Building trust in artificial intelligence, machine learning, and robotics. *Cutter business technology journal*, 31(2), 47-53.
22. Wang, D., Khosla, A., Gargeya, R., Irshad, H., & Beck, A. H. (2016). Deep learning for identifying metastatic breast cancer. arhiv preprint arhiv:1606.05718.
23. Weber, F., & Schütte, R. (2019). A domain-oriented analysis of the impact of machine learning the case of retailing. *Big Data and Cognitive Computing*, 3(1), 11.
24. Yang, R., & Wibowo, S. (2022). User trust in artificial intelligence: A comprehensive conceptual framework. *Electronic Markets*, 32(4), 2053-2077.

REVIEWING STUDENT PROJECTS USING AI

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Abstract

The rise of artificial intelligence (AI) has impacted various domains, including education, where the need for efficient assessment methods has grown. This paper explores the application of AI in reviewing student projects, examining its benefits, challenges, and implications for education. The objectives of this paper are twofold. Firstly, we will delve into the various AI techniques employed in the reviewing process, including natural language processing (NLP), machine learning, and computer vision. We will explore how these technologies enable the analysis of textual, visual, and multimedia elements present in student projects, facilitating more comprehensive and insightful assessments. Secondly, we will discuss the implications and considerations surrounding the adoption of AI in education, including concerns related to privacy, ethics, and the role of professors in the AI-assisted review process. This paper further aims to shed light on the challenges and limitations of implementing AI-based review systems, highlighting the need for careful validation, data quality assurance, and interpretability of results. Additionally, we will examine the potential benefits for students, instructors, and educational institutions, such as improved feedback delivery, increased consistency in evaluations, and enhanced learning outcomes. By exploring the use of AI in reviewing student projects, we hope to contribute to the ongoing discussion on leveraging technology to enhance educational practices and to provide insights into the potential future directions of AI-assisted assessment methods.

Key words: *ChatGPT, Student Projects, NLP, Machine Learning, Computer Vision.*

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1. Introduction

In recent years, the emergence of artificial intelligence (AI) has revolutionized various domains, including education. One notable area of interest is the application of AI in reviewing student projects. This paper delves into the use of AI techniques to enhance the evaluation process of student projects, exploring the benefits, challenges, and implications associated with this approach.

Traditionally, the reviewing and assessment of student projects have been labor-intensive and subject to potential biases. However, the advent of AI technologies offers promising opportunities to streamline and improve this process. By leveraging AI algorithms and computational tools, instructors can assess student projects more efficiently and objectively, while providing valuable feedback tailored to individual students.

One of the key advantages of employing AI in the reviewing process is its ability to handle large volumes of student work. AI algorithms can quickly analyze and process diverse project types, such as written reports, multimedia presentations, and coding assignments. This scalability allows instructors to provide timely feedback and assessments, fostering a more productive and engaging learning environment.

Moreover, AI techniques enable a more objective evaluation process. By utilizing machine learning and natural language processing, AI algorithms can analyze the content, structure, and quality of student projects, reducing the potential for subjective biases. This objectivity ensures a fair and consistent assessment for all students (Dimitrova, Mizoguchi and B. du Boulay, 2009).

However, the implementation of AI in reviewing student projects also poses challenges and considerations. Privacy concerns surrounding student data and the ethical implications of automated assessments need careful attention (Carolyn Penstein Rosé et al., 2018). In addition, striking the right balance between AI-driven evaluation and human involvement is crucial to maintain the educational value of instructor-student interactions.

This paper aims to explore the various AI techniques employed in the reviewing of student projects, including natural language processing, machine learning, and computer vision. It will examine case studies and research findings that showcase the effectiveness of AI-based evaluation systems. Furthermore, the paper will address the potential limitations and considerations of using AI in this context, emphasizing the importance of striking a balance between technology and pedagogy(Carolyn Penstein Rosé et al., 2018).

Ultimately, this research contributes to the ongoing dialogue on leveraging AI technologies in education. By shedding light on the benefits, challenges, and ethical considerations of reviewing student projects using AI, this paper aims to inform educators, policymakers, and researchers about the potential of AI-driven evaluation methods to enhance the learning experience and promote academic growth.

1. 1. Exposition

The education system has long relied on instructors manually reviewing and assessing student projects, a process that is time-consuming, subjective, and susceptible to human biases. However, recent advancements in artificial intelligence (AI) have opened up

new possibilities for enhancing the evaluation of student work. AI technologies, such as machine learning, natural language processing, and computer vision, offer the potential to automate and improve the reviewing process.

The exposition of this paper focuses on the use of AI in reviewing student projects, highlighting its advantages over traditional manual methods. By leveraging AI algorithms, instructors can overcome the limitations of manual review, such as scalability, subjectivity, and timeliness (Morteza Dehghani and Boyd, 2022). AI-powered systems have the capacity to handle large volumes of student work efficiently, ensuring timely feedback and assessment. Furthermore, AI techniques enable more objective evaluations, reducing the impact of subjective biases in the assessment process.

The potential benefits of employing AI in the reviewing process extend beyond efficiency and objectivity. AI algorithms can analyze different types of student projects, ranging from written reports to multimedia presentations and coding assignments. This versatility allows for a comprehensive evaluation of various project aspects, including content quality, organization, creativity, and technical proficiency. With AI, instructors can provide more detailed and tailored feedback to individual students, promoting their learning and growth.

However, using AI in reviewing student projects is not without challenges. Privacy concerns and ethical considerations arise when handling student data and automating assessments (Dimitrova, Mizoguchi and B. du Boulay, 2009). Striking the right balance between AI-driven evaluation and human involvement is crucial to ensure the educational value of instructor-student interactions. The exposition explores these challenges and considerations, emphasizing the need for responsible implementation and continuous evaluation of AI systems.

By exploring the potential of AI in reviewing student projects, this paper aims to contribute to the growing body of knowledge surrounding AI's role in education. It sets the stage for a deeper examination of the AI techniques employed, their effectiveness, and the implications for both educators and students. Furthermore, it calls for thoughtful and responsible integration of AI technologies in educational practices to enhance the evaluation process and promote meaningful learning experiences.

2. Education and AI

The use of artificial intelligence in education represents a new challenge that has experienced its expansion precisely with the emergence of the ChatGPT tool, which is a creation of the company OpenAI. The public had its first direct contact with artificial intelligence through the use of the ChatGPT tool.

Today, with the rapid development of technology and the rapid advancement of artificial intelligence, and with the focus of all industries being precisely on artificial intelligence, the question arises about the quality and moral principles in education. Artificial intelligence has significantly changed the way specific knowledge is acquired. Previously, researchers had to spend a significant amount of time cycles to confirm or refute certain scientific evidence, while today, through the use of artificial intelligence, the time required for analysis, study, and drawing conclusions on a particular issue has been greatly reduced. AI has advanced to the extent that it can now analyze learning patterns of

individuals and groups, their interests, specific knowledge, and weaknesses. Based on the conducted analysis, AI can create new patterns to isolate certain knowledge or enhance it, depending on the set goal.

Through its development, AI can tailor specific knowledge to each student and focus on the individual's growth within the group. Personalized learning towards each individual increases motivation and reduces the gap among students attending a particular subject.

The use of AI in education doesn't have to be direct; we also have an indirect application where, by utilizing AI tools, we can enable the development of an educational plan and program that aligns with each student's interests, knowledge, and more. AI tools can assist students in solving tasks and explain to them, in simple terms, the procedures that happen behind the scenes of solving a task. Students can verify information during the course of the educational process using AI tools, gather literature, search sources, check citations, highlight key parts, explore certain questions, and so on (Aminzadeh, Cenk Temizel and Yasin Hajizadeh, 2022).

With the emergence of AI, questions of morality and ethics arise. It is necessary to properly prepare AI tools so that they find their place in education in an ethical manner, preventing students from misusing AI to create content and presenting it as their own, thus violating all ethical codes in the world of education. In addition to ethical principles, there are principles of transparency, accountability, personal data protection, and more. There are numerous challenges that need to be addressed first before AI can officially start being used in educational institutions; currently, all tools are still in the preparation phase.

3. Description of the Research

The research is designed in such a way that through the analysis of completed project tasks and submitted samples, a verification, evaluation, and grading of project tasks are performed. In this example, students are required to submit a project task written in the C++ programming language. The task description involves creating a terminal application through which they will navigate using menu commands numbered from 1 to n. The application is designed to include features such as display, addition, deletion, and other arbitrary actions by students. Students worked on project tasks in groups.

In this research project, we have three samples that we will test and on which we will perform an analysis and evaluation of the submitted project task.

3. 1. Research Objective

The main goal of the research is to utilize the methods and techniques currently at our disposal to attempt to determine the extent to which the analyzed project task has been completed using artificial intelligence and, if possible, present this in percentages or numerical values ranging from 1 to 10.

3. 2. Criterion and Description of the Criterion

Artificial intelligence is constantly evolving, making it very challenging to keep track and provide a definitive judgment on whether a piece of source code has been written by artificial intelligence or is the personal work of an author. Currently, there are several parameters that can reveal whether a code has been written using AI, but it is necessary to thoroughly examine everything and evaluate each part separately.

Criteria for Analysis are:

- Unusual patterns and styles,
- Lack of consistency,
- Changes in code writing style,
- Use of rare functionalities,
- Simple tasks,
- Combination of multiple languages or algorithms.

Description of the mentioned criteria:

1) Unusual patterns and styles, in this aspect, it is easiest to recognize whether a code has been written using artificial intelligence. The structure and style may vary several times within a single project; this is crucial considering that students are expected to work independently on project tasks. The complexity of their code can be at a low or medium level.

1) Lack of consistency, AI can sometimes create code that lacks consistency in writing style and structure, which may indicate code generation.

1) Sudden changes in style, if abrupt changes in code writing style are identified, there may be suspicion of AI involvement.

1) Use of rare functionalities, a generator may employ functionalities or concepts that were recently introduced to the programming language or are present in a newer version of the programming language.

1) Simple tasks, AI excels at performing simple tasks successfully, so the use of artificial intelligence might be suspected on repetitive simple tasks.

1) Combination of multiple languages or algorithms, if a combination of different programming languages and algorithms not typically associated is observed, it could be a clear sign of AI generation.

3. 3. Criterion assessment

Criterion assessment is presented using a Likert scale ranging from 1 to 5, where a score of 1 represents the lowest-rated criterion, while a score of 5 represents the highest-rated criterion. The following table displays the criterion ratings.

Table 1. Criterion Assessment Score

Value	Description
1	It doesn't matter at all
2	It doesn't matter
3	Neither important nor unimportant
4	It matters
5	It matters a lot

The next table presents the evaluation of each criterion separately and determines its significance for recognizing AI-generated code.

Table 2. Display of Criterion Assessment

Criterion	Rating
Unusual patterns and styles	5
Lack of consistency	4
Changes in code writing style	5
Use of rare functionalities	3
Simple tasks	3
Combination of multiple languages or algorithms	5

3. 4. Sample Testing and Assessment

Currently, 2 samples have been selected for research purposes. All samples have been generated as results of a student project task, where they were required to create a terminal library application using the C++ programming language. The application should include features such as reading, deleting, adding, and more. The fundamental data storage methods are vectors and .txt files.

First Sample

The group consists of four students who have developed an application in the C++ programming language. All criteria required by the project documentation have been successfully fulfilled, and the application contains all necessary features. The alternative rating is defined using numbers from 1 to 10, where 1 represents the lowest score and 10 represents the highest score. Rating 1 indicates a high probability that artificial intelligence was used in project development, while rating 10 indicates a high probability that the project was done independently by students.

Criterion 1. Unusual Patterns and Styles

In the first sample, a part of the code was noticed that is used at an intermediate level of programming. Students encountering programming in their first years of study usually employ if-else conditions to check certain possibilities. In this example, we observe that students used a while loop with a condition that must be fulfilled.

Proof:

```
void setJMBG (string JMBGulaz)
  {
    while(JMBGulaz.size()!= 13)
 {
       cout<<"Pogresan unos, pokusajte ponovo: "<<endl;
       cin>>JMBGulaz;
    }
    JMBG = JMBGulaz;
  }
```

Grade: 3 (Three)

Criterion 2. Lack of Consistency

Lack of consistency has not been noted; there are minor differences, but it's taken into consideration that the project task was done by multiple students.

Grade: 7 (Seven)

Criterion 3. Changes in Code Writing Style

Changes in code writing style have been documented in the work, particularly noticeable in classes. Students used a different syntax and comments in the classes, while in the main method, they did not include comments nor maintained proper and consistent spacing between lines.

Proof:

```
// Main
string nule = "000";
cout<<" Posudjena knjiga : " + posudjenaKnjiga;
cout<<", Kategorija clanstva: " + kategorijaClanstva<<endl;

// Klasa
int brojSvihDodatihKnjiga=0;
#endif // KLASEVEKTORI_H_INCLUDED
```

Grade: 2 (Two)

Criterion 4. Use of Rare Functionalities

In this work, the use of rare functionalities has not been observed. There are a few anomalies, but they can be attributed to exploration on some of the platforms where developers share their code with the broader community of programmers.

Grade: 8 (Eight)

Criterion 5. Simple Tasks

Repetitive simple tasks have not been found, but we do have a few simple tasks that, due to their logic and syntax, raise suspicion that this portion of the code was generated using AI. Students used 'void' for printing surnames, which differs from other project tasks where students attempted to incorporate as much code as possible into if-else conditions or loops.

Proof:

```
 void printPrezime ()
 {cout<<prezime<<endl;}
```

Grade: 5 (Five)

Criterion 6. Combination of Multiple Languages or Algorithms

The combination of multiple programming languages and algorithms in this project task has not been identified.

Grade: 9 (Nine)

Second Sample

The group consists of four students who have developed an application in the C++ programming language. All criteria required by the project documentation are fulfilled, containing all necessary conditions for the work to be evaluated. The alternative grade is defined numerically from 1 to 10, where a grade of 1 represents the highest likelihood that the work is plagiarism or that artificial intelligence was used in completing the project task.

Criterion 1. Unusual Patterns and Styles

Unusual styles have been noted during the creation of the main.cpp file. The students' knowledge is limited to specific areas, so the appearance of these instances can be considered an unusual style.

Proof:

```
 void ukloniKnjigu(Biblioteka& biblioteka, string naslov) {
   biblioteka.ukloniKnjigu(naslov);
 }
```

Grade: 3 (Three)

Criterion 2. Lack of Consistency

A lack of consistency has not been observed in the mentioned project. There are certain exceptions, but they are not worth recording and analyzing.

Grade: 8 (Eight)

Criterion 3. Changes in Code Writing Style

Changes in code writing style are noticed in the main.cpp file, which contains certain anomalies in code writing. Based on the examples, there is a suspicion that artificial intelligence was used in the development of the mentioned methods.

Proof:

```
 // case 1
string naslov; getline(cin, naslov);

// case 2

cin >> police; cin.ignore();
```

Grade: 4 (Four)

Criterion 4. Use of Rare Functionalities

The use of rare functionalities is also present in the previous criterion, where students used the 'cin. ignore();' part of the code, which is rarely used in academic studies at the fundamentals of programming or intermediate level.

Grade: 3 (Three)

Criterion 5. Simple Tasks

Simple tasks present in this project assignment have not been recognized as parts of artificial intelligence, as everything is already determined according to the syllabus.

Grade: 9 (Nine)

Criterion 6. Combination of Multiple Languages or Algorithms

The combination of multiple languages has not been recorded. Changes in algorithms are docu-

mented, particularly in the part where the input values in string form are controlled.

Proof:

if (knjige.size() == 0)
if (knjiga.naslov == “”)

Grade: 3 (Three)

3. 5. Research Results

In the following table, the research results are presented with methods and alternative calculations.

Tabel 3. View ratings

Criterion	Criterion assessment	Sample 1	Sample 2
Unusual Patterns and Styles	5	3	3
Lack of Consistency	4	7	8
Changes in Code Writing Style	5	2	4
Use of Rare Functionalities	3	8	3
Simple Tasks	3	5	9
Combination of Multiple Languages or Algorithms	5	9	3

Calculation of the First Sample:

$$5(3)+4(7)+5(2)+3(8)+3(5)+5(9) = \boldsymbol{137}$$

Calculation of the Second Sample:

$$5(3)+4(8)+5(4)+3(3)+3(9)+5(3) = \boldsymbol{118}$$

In the research results using the Scoring method, we can observe that the second sample has a high likelihood of plagiarism based on the specified and defined evaluation criteria. The second part includes verification using AI tools to check the generated code. If the results align with the research findings, it can be concluded that AI verification tools perform their task successfully.

Testing AI Tools

All tools used are free and enable verification of text, images, or code if there are elements of artificial intelligence in their creation. The first tool is contentdetector.ai. After inputting the samples into the testing application, the following results were obtained:

The first sample (AI generated at a rate of 50%),

The second sample (AI generated at a rate of 77%).

The second tool for verification is copyleaks.com, which returned the following results based on the samples:

The first sample (AI generated at a rate of 46%),

The second sample (AI generated at a rate of 71%).

The research results show a correlation between the data obtained from the manual evaluation of criteria and verification using AI tools. It is important to note that currently, we do not have tools that can definitively confirm whether a document, image, or code is 100% generated using AI. There are some possibilities that companies could add a hidden signature to their AI generators, which could be identified after a user copies or downloads the content.

4. Conclusion

In conclusion, the use of artificial intelligence (AI) in reviewing student projects presents significant opportunities for improving the evaluation process in education. The advancements in AI technologies, such as natural language processing, machine learning, and computer vision, have the potential to enhance scalability, objectivity, and efficiency in assessing student work.

By automating and augmenting the reviewing process with AI, instructors can provide timely and comprehensive feedback to students, fostering a more engaging and personalized learning experience. The objectivity of AI algorithms helps mitigate subjective biases, ensuring fair and consistent evaluations for all students. Furthermore, AI techniques can analyse diverse project types and provide insights into content quality, organization, creativity, and technical proficiency.

However, the adoption of AI in reviewing student projects comes with its own set of challenges and considerations. Privacy concerns regarding student data and ethical implications surrounding automated assessments need to be carefully addressed. Additionally, maintaining a balance between AI-driven evaluation and human involvement is essential to preserve the pedagogical aspects of education.

Moving forward, it is crucial to conduct further research, validation, and refinement of AI systems for reviewing student projects. The responsible integration of AI technologies in educational practices requires ongoing evaluation, ethical guidelines, and professional development for educators. Collaboration between researchers, educators, and policymakers is necessary to address these challenges and harness the full potential of AI in improving the evaluation process.

By embracing the benefits of AI and addressing the associated challenges, educational institutions can unlock new possibilities for enhancing the assessment of student projects. The future of reviewing student work using AI holds promise for providing more effective and personalized feedback, promoting student growth, and facilitating continuous improvement in education.

In summary, the integration of AI in reviewing student projects represents a transformative shift in the evaluation process. Leveraging AI techniques offers

opportunities to overcome the limitations of manual assessment, enhance objectivity, and provide meaningful feedback to students. As we navigate the evolving landscape of educational technology, the responsible and thoughtful adoption of AI has the potential to revolutionize the way we evaluate student work, fostering a more engaging and effective learning environment.

References

1. Aminzadeh, F., Temizel, C., & Hajizadeh, Y. (2022). *Artificial Intelligence and Data Analytics for Energy Exploration and Production*. John Wiley & Sons.
2. Cambria, E., White, B. (2019). *Artificial Intelligence in Education: Promises and Implications for Teaching and Learning*. United States.
3. contentdetector.ai. AI Content Detector - Detect ChatGPT Plagiarism. https://contentdetector.ai (01.08.2023).
4. copyleaks.com. Copyleaks: AI & Machine Learning Powered Plagiarism Checker. https://copyleaks.com (01.08.2023).
5. Dehghani, M., & Boyd, R. L. (Eds.). (2022). *Handbook of language analysis in psychology*. Guilford Publications.
6. Dimitrova, V., Mizoguchi, R., & du Boulay, B. (Eds.). (2009). *Artificial Intelligence in Education: Building Learning Systems that Care: From Knowledge Representation to Affective Modelling* (Vol. 200). IOS Press.
7. Maybury, M. T. (1998). *Intelligent Tutoring Systems: Lessons Learned*. United States.
8. McNamara, D. S., Graesser, A. C., McCarthy, P. M., & Cai, Z. (2014). *Automated evaluation of text and discourse with Coh-Metrix*. Cambridge University Press.
9. Nkambou, R., Mizoguchi, R., and Bourdeau, J. (2010). *Artificial Intelligence in Education*. United States.
10. Romero, C., Ventura, S., Pechenizkiy, M., & Baker, R. S. (Eds.). (2010). *Handbook of educational data mining*. CRC press.
11. Rosé, C.P., Martínez-Maldonado, R., Hoppe, H.U., Luckin, R., Mavrikis, M., Porayska-Pomsta, K., McLaren, B. and Du Boulay, B. eds., (2018). *Artificial Intelligence in Education: 19th International Conference, AIED 2018, London, UK, June 27–30, 2018, Proceedings, Part I* (Vol. 10947). Springer.

THE THEORY OF PLANNED BEHAVIOUR AS PREDICTOR OF ENTREPRENEURIAL INTENTIONS OF STUDENTS IN BOSNIA AND HERZEGOVINA

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Abstract

This study assists in understanding the perceived influence the Theory of planned behaviour (TPB) has on entrepreneurial intention (EI) of students and further show the intricacies of this relationship. The study was conducted inside Bosnia and Herzegovina with a sample of students from different public and private universities with the aim to investigate how the model fairs within the Bosnian cultural and structural environment. The questionnaire was based on previous research and measures to preserve the reliability and validity of the results and SPSS was used to investigate our data through a series of tests. There have only been a few studies relating Theory of Planned behaviour to EI in Bosnia and Herzegovina, so our research supports and follows previous authors conclusions and is a valuable reference in support of future research of entrepreneurial intent in this country. The end goal of proving the TPB is a valuable predictor of entrepreneurial intention is important as it gives added reasoning to foster the constructs in the TPB through structural and educational support proven previously to be strong influences on personal attitudes, subjective norms, and perceived behavioural control. Entrepreneurs from Bosnia and Herzegovina oftentimes overachieve given the lack of educational and governmental support they receive during their career, showing that with a more structured approach B&H is bound to produce higher levels of entrepreneurial success across the board.

Key words: *Theory of Planned Behaviour, Entrepreneurial Intention, Personal Attitudes, Subjective Norms, Perceived Behavioural Control.*

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1. Introduction

After the era of personality traits, a big shift in explaining behaviour came about with the social psychology theories main one being Ajzen's Theory of Planned Behaviour. Personality as the main factor of entrepreneurship was set aside and new research supporting these new social models started multiplying putting the individual and their own capabilities, attitudes, and influences in the driver's seat of decision making.

Ajzen's theory of reasoned action (1985.) later expanded (Ajzen, 1991) to Theory of Planned Behaviour (TPB) stipulates that any decision a person makes is influenced by their attitudes towards the behaviour, subjective norms related to the behaviour, and perceived behavioural control they have over it. Even though entrepreneurial intention is a much more complex volitional behaviour than choosing which ice cream flavour we want or is wearing shorts to school appropriate, it fits the mould when it comes to the explanation power that PA, SN and PBC give it.

In our research we used Ajzen's classical model adapted to intention rather than behaviour as we research a pre-behaviour effect of the TPB on EI. Entrepreneurship as a behaviour is very complex to predict due to the many environmental factors that aren't considered in most models and that affect everyone differently. Things like lack of motivation, noted by Ajzen (1991) as well as Deci and Ryan (2020) can in finality lead to people not pursuing their intentions to finality. With that said intention has been proven to be the greatest predictor of behaviour, and as such an intention to pursue entrepreneurship should hold weight in predicting that same behaviour. This invites future research in Bosnia and Herzegovina to test the transition from intention to behaviour and investigate all the factors that may influence it.

2. Theory and hypotheses

Theory of planned in its core has three main factors that influence intention. Personal attitudes (PA) are shaped by an individual's beliefs about the advantages of running a business as well as the potential risks and difficulties that come with such a career. It is important to note sometimes people delve into entrepreneurship based on necessity rather than their own preference, and those businesses have higher chances of failure because of it (Block et Al, 2014).

Kautonen (2010.) talked about this as a good mechanism to fight poverty, but a negative influence on the first-time business owner to ever open a business again if it fails. Improvement in personal attitudes has been described by Lüthje C. & Frank, N. (2003) as an important level in improving EI, hence it is considered a valuable part of the TPB. Gibson and Barron (2003) and Karimi et Al. (2014) emphasise the importance of role models at universities usually found in different professors or classmates as they found that role models improve PA and coherently EI.

Subjective norms (SN) are theorised to have a significant influence on EI through social circle pressures and expectations related to entrepreneurship. It is important to note that SN are highly dependent on the cultural and social backgrounds of the sample and as such often provide contradicting results. Astuti (2012) and others proved a significant

influence of SN on EI while in Krueger et Al. (2000) SN was deemed insignificant. Even in Bosnia and Herzegovina mixed results were achieved by different authors.

Katono et Al (2011) proposed that social circle should be expanded to peers and role models as they are often important in students' decisions, and we did this through adding colleagues and university support as added items of the SN construct. Through studies like Alferaih (2022), Dick and Rallis, (1991) and others we presumed a significant role of SN in predicting EI and often negative due to prejudice of a risky career choice. An important consideration we had is that Bosnia as a collectivistic country, if consistent with the patterns of others, would have stronger SN influence due to its collectivistic nature.

Behaviours not fully under our control are considered to have perceived behavioural control (PBC) as an influence. Ajzen (2002) has focused on PBC being a factor with two main subcategories, those being self-efficacy (belief in one-self) and controllability (level of control one has over a behaviour) and as such we included items for both these dimensions. Bandura (2002) confirmed this in his paper stating that competency is not only having skills, but believing we can use them and that modelling influences (like professors) should implement teaching both.

Others like Bagheri et Al (2013) stressed that PBC stems from education and that students benefit from a supportive environment. All in all, it is logical to conclude that students more exposed to entrepreneurship will have higher levels of PBC and as presumed their intention will also be stronger through the influence of PBC. Based on the previously mentioned research and our adaptation of Ajzen's (1991) model (Figure 1) we formulated below Hypotheses for testing:

H1: Personal attitudes towards entrepreneurship significantly influence students' entrepreneurial intention.

H2: Subjective norms significantly influence students' entrepreneurial intention.

H3: Perceived behavioural control significantly influences students' entrepreneurial intention.

H4: PA, PBC and SN together as parts of the TPB explain the entrepreneurial intentions of students.

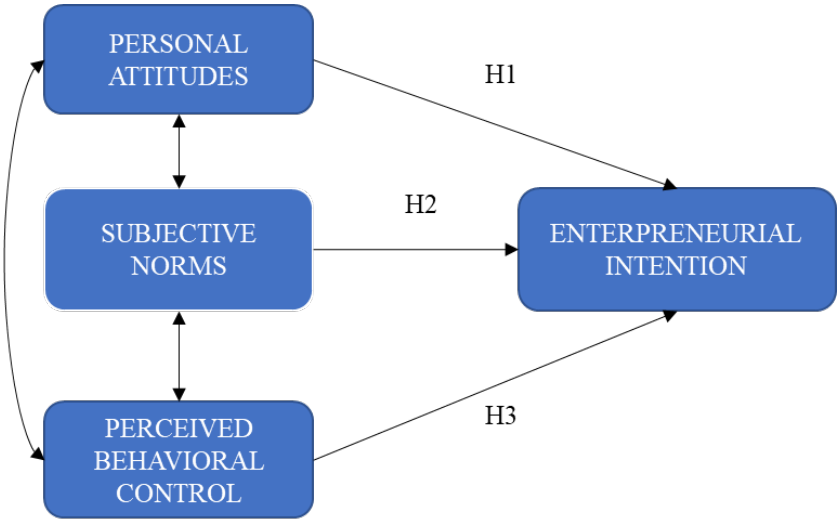

Figure 1. TPB Model adapted from Ajzen (1991)

1. Methodology and results

The methodology used is the processing of primary data acquired by administering a questionnaire. Our questionnaire was based on the original constructs of the TPB (attitude toward the behaviour, subjective norms, perceived behavioural control and entrepreneurial intention). We have also gathered respondent demographics for potential insights into what drives a student to be an entrepreneur as well as what is the potential best suited "type" of person, as a predictor of entrepreneurial intention. The questionnaire was administered through an online survey platform and the participants were provided with clear instructions on how to complete it. Our model has been tested among a convenience sample of 305 students from these public and private universities: International Burch University (IBU), University of Sarajevo (UNSA), University of Zenica (UNZE), University of Tuzla (UNTZ), University of Mostar (UNMO), International business-information academy in Tuzla (IPIA), University of Bihać (UNBI) and Sarajevo School of Science and Technology (SSST).

Table 1. Demographics of sample

VARIABLE	% OF SAMPLE
GENDER	
Male	48.2%
Female	51.8%
PROGRAMME	
Economics and Management	39%
Information Technologies	28.9%
Others	32.1%
AGE (Mean Value)	23.18
UNIVERSITY TYPE	
Private	50.5%
Public	49.5%

The sample has included students from different areas, programs, ages, and backgrounds so it serves as a good representation of the general intentions of students in B&H. The demographics measured above in Table 1. show a noticeably equal spread across groups which is confirmation for the above-mentioned conclusion. The demographics measures investigated were not only supported by other researchers (Alferaih, 2017; Arnaut et Al., 2022) but are important in showing potential differences in backgrounds of those with intentions compared to those without.

Reliability and validity of our questionnaire were kept by using previously tested variables and scales adjusted to the Bosnian language for better response rate. With that said, we aimed to further expand some of the scales from different authors and research that proved to be the most successful and reliable. For measures of PA, SN, PBC and EI we have used Linan and Chen (2009) items tested through a 7-point Likert scale (from totally disagree to totally agree). We have supplemented SN with 5 more items and PA with 2

more with considerations to Autio (2001), Ajzen (1991) and Katono (2011) scales adding the role of university to the mix. The constructs were tested with the newly added items, and all were proven reliable (Table 2). Social norms were lowest out of the TPB constructs with a Cronbach alpha of 0.734 and after testing if the scale would improve if we deleted some of the items, it was proven it worked best with all the items tested.

Table 2. Reliability of hypothesised models constructs

CONSTRUCT	NUMBER OF ITEMS	CRONBACH ALPHA
SN	8	0.734
PBC	6	0.923
PA	7	0.893
EI	6	0.961

PBC and EI for which we included the classic measures from Linan and Chen (2009) proved to be excellently reliable constructs with a Cronbach alpha of 0.923 and 0.961 respectively. PA for which we added an additional measure also proved to have good reliability with a Cronbach alpha of 0.893. This meant that the model's trustworthiness of findings was confirmed, and the conclusions made were based on accurate and consistent data.

We have checked the validity of items for each construct through Exploratory factor analysis (EFA) and have concluded that all constructs have internal validity (as shown in Table 3) above the advised 0.5 value. PA items ranged in validity from 0.614 to 0.898, PBC's were between 0.780 and 0.896 while EI's validity ranged from 0.834 to 0.937.

SN on the other hand was classified as multidimensional, which was logical since we used measures describing 3 different effects on the participant, those being: social support, extent of importance (of the social circle) and lastly university support as an added important factor of every student's journey. All the measures were valid in explaining the construct for their specific dimension and have been in the range 0.785-0.914 (Table 4).

Table 3. Validity scores of items for PBC, PA and EI constructs

CONSTRUCT	VALIDITY OF ITEMS	VARIANCE EXPLAINED
PBC	0.780- 0.898	72.42%
PA	0.614- 0.898	62.67%
EI	0.834- 0.937	81.17%

Table 4. Items validity across the components of the subjective norms construct

Rotated Component Matrix			
STATEMENTS	Component		
	1	2	3
SN1	0.855	0.009	0.141
SN2	0.913	0.022	0.02
SN3	0.785	0.149	0.295
SN4	0.149	0.759	0.123
SN5	0.108	0.891	-0.115
SN6	-0.113	0.880	0.125
SN7	0.345	0.014	0.831
SN8	0.043	0.09	0.914
EXPLAINED VARIANCE	77.53%		

The figures above also show the percentage of variance when all the items were tested against their respective constructs. All the constructs are well explained with variance well above the threshold of 50% (Samuels, 2017). Looking at the descriptive statistics of the main constructs (Table 5) we see that all have a positive connotation as they are above the middle value of 4.

It is notable that the PBC is the variable with the lowest mean which we presume is because only around 50% of the sample have had proper entrepreneurial education and only 30% had entrepreneurial experience. This sample is then deemed to have lower levels of PBC not only lacking the necessary know-how and skills that would make them feel more in control, but also not feeling confident in their own abilities due to the same. SN surprisingly has the second highest mean, even with putting in the additional items to the construct and expanding its reach to not only family, but other influences. This implies that the addition of university support items and inclusion of colleagues in the social circle validates the high mean value compared to other research done in similar cultural environments.

Table 5. Means and deviations of the constructs

Construct	Mean	Standard Deviation
EI	4.796	1.541
PBC	4.209	1.379
SN	4.805	1.014
PA	5.255	1.183

Confirming results of Arnaut et Al. (2022) sample, PA was the strongest rated construct, and this might as well be according to Lüthje C. & Frank, N. (2003) due to the involvement of education in PA growth. The sample itself was made of more than half of students that

received some form of entrepreneurial education. All these students were more exposed to the positives (and the negatives) of entrepreneurship as a career shaping their attitudes in the meantime through introductions of courses, mentors, and role- models.

When we go further to test the correlations of the constructs included in the model as shown in Table 6, it is quite visible all of them correlate and all with a value of p<.001. Entrepreneurial intention is strongly correlated with PA and moderately to PBC while having weak (but significant) correlation with SN and EE which could potentially mean that they don't fit the model in describing EI.

Table 6. Correlations between the constructs

CORRELATIONS	EI	PBC	SN	PA
EI	1	.649**	.234**	.795**
PBC		1	.358**	.619**
SN			1	.242**
PA				1
**. Correlation is significant at the 0.01 level				

One important relationship we found worth mentioning is choosing of university compared to the constructs where we have gotten significant (p<.001) correlation between the university we attend and all constructs. In Table 7 we see PBC was found to be most affected cementing the notion that entrepreneurial knowledge and experiences are not equally distributed in all institutions. The difference is most noticeable if looking at those privately owned universities compared to governmentally owned. The effect is visible in most cases due to the governmental plans and strategies for SME growth that are misaligned and skewed towards some other goals and objectives rather that entrepreneurship. That in turn leads to students unprepared for opening their own enterprise, but incapable of finding a job in a country where unemployment rate stood at 57.5 percent in 2021. This motivated young people to find employment where opportunities are not lacking and caused one of the biggest brain-drains in Europe in these last 10 years.

Table 7. University choice effect sizes on constructs

Construct	Measure	Point Estimate	Effect size
SN	Eta-squared	0.129	Medium
PBC	Eta-squared	0.154	Large
PA	Eta-squared	0.106	Medium

EI	Eta-squared	0.112	Medium

After running the proposed model through a linear regression analysis and testing the potential effects of different factors on entrepreneurial intention we have concluded that the model makes sense as significance is at $p < .001$ and the TPB factors together explain 66.9% of EI (Table 8).

Table 8. Proposed model summary extracted from SPSS

Model Summary			
Model	R	Adjusted R Square	Sig. F Change
1	.820[a]	0.669	<0.001
a. Predictors: (Constant), SN, PA, PBC			

Looking at Table 9 we can confirm that only PA and PBC have a significant influence on the entrepreneurial intention, while SN is an insignificant predictor. Interestingly SN is also negative hence if it were significant, it would be considered to have a deterring effect to entrepreneurial intention.

Table 9. Significance and effects of constructs in influencing EI

Coefficients[a]			
Model	Standardized Coefficients	t	Sig.
CONSTRUCT	Beta	-2.293	.023
PBC	.257	5.891	<.001
PA	.639	15.198	<.001
SN	-.012	-.346	.730
a. Dependent Variable: EI			

From the different types of analyses, we have done throughout our research we have gathered many important and noticeable results, that will surely be valuable references for future research on similar topics in Bosnia and Herzegovina and worldwide. A regression analysis of our proposed model proved that Hypothesis 1 is confirmed with personal

attitudes not only being significant influence on students EI, but also having the strongest effect on them at a beta of 63.9%, meaning that if the mean of PA improved for 1 due to the before mentioned improvements in the media, education and infrastructure, EI would proposedly improve for 0.639. As proven by other research (Krueger et Al. 1993) exogenous factors such as education and experiences are often mediated through personal attitudes, so we can presume that PA influence is to some degree due to a person's background.

Hypothesis 2 was rejected as social norms were found to be an insignificant influence on entrepreneurial intention. Added to that as mentioned it showed a negative beta, meaning the improvement of SN would cause decrease in EI. Kalayci E. (2017) also showed a negative effect of SN through her case studies, proving that opposition to entrepreneurship in the family circle can stagnate the entrepreneurial process. This is not uncommon as many researchers up to this point have concluded the same due to different factors like cultural backgrounds, the countries collectivistic/individualistic nature etc. Krueger et Al. (2000) proved the insignificance of SN on EI, and looking at Bosnia and Herzegovina studies so did Arnaut et Al. (2021) and these studies serve as confirmation of our work. Šestić et al. (2017) on the other hand found SN very significant, so further studies investigating this would be valuable for support.

Perceived behavioural control significantly influences students' entrepreneurial intentions and thus proves Hypothesis 3. It has a beta of .257 or strength in improving EI of 25.7%. It was very important to prove this hypothesis due to its close relationship with education and experience. Research like Remeikiene et Al (2013) and Peterman and Kennedy (2003) would reconfirm that improvement of education is highly influential in improvement of PBC and thus we consider it a valuable influence on the EI through the PBC.

Finally, Hypothesis 4 was confirmed, so we proved that the classic TPB model predicts entrepreneurial intention with $p<0.001$ significance and a 0.669 variance meaning our model explains 66.9% of TPB. This is deemed to be an acceptable amount of variance explained based on previous research and it is quite high considering entrepreneurship being not the most controllable behaviour. Wang and Wong (2004) for example found that TPB is limited in predicting EI in developing countries but based on our sample we managed to reach a significant explanatory power through the use of the TPB model.

3. Conclusion

Based on the literature reviewed and the conclusions of fellow researchers, we have shaped our study to investigate all interesting and relevant relationships among groups, constructs and tested the explanatory effect of TPB on EI as the main goal. The results to some degree showed that exposure to education improves all the other constructs and especially EI with those exposed to entrepreneurial education having a .53 higher mean than those without exposure. The summary of our tested hypotheses below in Figure 2 shows the hypotheses accepted and rejected based on our sample and research.

Looking at the classical TPB constructs, we have disproven the direct effect of SN on EI reconfirming the findings of Krueger et Al, (2000). Although this might have been due to different reasons like the items added to the original scale, the sample, or some other

factors. If we take into consideration that others like Dick and Rallis, (1991) proved effect of SN on PA and PBC and seeing significant correlations between these classic constructs in our own study, a mediating effect of SN on EI through PA and PBC might be proposed for future studies to investigate.

HYPOTHESIS	
H1: Personal attitudes towards entrepreneurship significantly influence students' entrepreneurial intention.	ACCEPTED
H2: Social norms significantly influence students' entrepreneurial intention.	REJECTED
H3: Perceived behavioural control significantly influences students' entrepreneurial intention.	ACCEPTED
H4: PA, PBC and SN together as parts of the TPB explain the entrepreneurial intentions of students.	ACCEPTED

Figure 2. Summary of tested hypotheses

We believe research into the effects of TPB and entrepreneurial education on entrepreneurial intention could show more significant practical implications for both policymakers and educational institutions. This could improve the design of educational programs that foster entrepreneurial thinking, improve skills, and influence intentions, all concluding in improved rates of entrepreneurial activity and economic growth. The fact alone that those who attended entrepreneurial education courses have higher EI is for us enough to discuss improving the education system following the work of Fayolle (2006) who proposed the same.

Except the quality of the program itself we also believe many factors like gender, culture, prior entrepreneurial experience, and personal traits can all influence how individuals respond to entrepreneurial education. Understanding these nuances can help customise programs to a number of students with different learning styles and backgrounds.

It would be valuable to research the long-term effects of education on EI, so future research could provide insights into the rate at which entrepreneurial education along with the TPB as its vehicle leads to actual enterprise creation and success through some experimental format. Longitudinal studies tracking students who have participated in entrepreneurial education can shed light on the long-term impact of these interventions and be useful for future educational strategies.

Our research reconfirms the importance of a positive image of entrepreneurship as a career fostering stronger PA and the improvements in PBC created though university studies and the network that is created during this time. Both go hand in hand in creating more intention to open businesses in Bosnia and Herzegovina as proven by our study. This in turn would not only improve the state of the job market, but also the country's economy as a whole in the long run.

References

1. Ajzen, I. (1985). From intention to actions: A theory of planned behavior. In J. Kuhl, & J. Beckman (Eds.), Action control: From cognition to behavior (pp. 11-39).https://doi.org/10.1007/978-3-642-69746-3_2
2. Ajzen, I. (1991), The theory of planned behavior, Organizational Behavior and Human Decision Processes, Volume 50, Issue 2. https://doi.org/10.1016/0749-5978(91)90020-T
3. Ajzen, I. (2002), Perceived Behavioral Control, Self-Efficacy, Locus of Control, and the Theory of Planned Behavior. Journal of Applied Social Psychology, 32: 665-683. https://doi.org/10.1111/j.1559-1816.2002.tb00236.x
4. Alferaih, A. (2017). Weight- and meta-analysis of empirical literature on entrepreneurship: Towards a conceptualization of entrepreneurial intention and behaviour. The International Journal of Entrepreneurship and Innovation, 18(3), 195-209. https://doi.org/10.1177/1465750317722114
5. Alferaih A. (2022), Starting a New Business? Assessing University Students' Intentions towards Digital Entrepreneurship in Saudi Arabia, International Journal of Information Management Data Insights, Volume 2, Issue 2.https://doi.org/10.1016/j.jjimei.2022.100087
6. Arnaut, D., Stanić, M. i Bećirović, D. (2022). Exploring entrepreneurial alertness and entrepreneurial intention in times of the COVID-19 pandemic. Management, 27 (1), 237-249. https://doi.org/10.30924/mjcmi.27.1.13
7. Astuti, Rifelly Dewi and Martdianty, Fanny (2012) "Students' Entrepreneurial Intentions by Using Theory of Planned Behavior: The Case in Indonesia," The South East Asian Journal of Management: Vol. 6: No. 2, Article 3.https://doi.org/10.21002/seam.v6i2.1317
8. Autio, E., Keeley, R. H., Klofsten, M., Parker, G. G. C., & Hay, M. (2001). Entrepreneurial Intent among Students in Scandinavia and in the USA. Enterprise and Innovation Management Studies, 2(2), 145–160. https://doi.org/10.1080/14632440110094632
9. Bandura, A. (2002), Social Cognitive Theory in Cultural Context. Applied Psychology, 51: 269-290. https://doi.org/10.1111/1464-0597.00092
10. Block, Jörn Hendrich; Kohn, Karsten; Miller, Danny; Ullrich, Katrin (2014) : Necessity Entrepreneurship and Competitive Strategy, IZA Discussion Papers, No. 8219, Institute for the Study of Labor (IZA), Bonn. http://dx.doi.org/10.2139/ssrn.2448795
11. Byabashaija, Warren & Katono, Isaac. (2011). The impact of college entrepreneurial education on entrepreneurial attitudes and intention to start a business in Uganda. Journal of Developmental Entrepreneurship (JDE). 16. 127-144.https://doi.org/10.1142/S1084946711001768
12. Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. Contemporary Educational Psychology, 61, Article 101860. https://doi.org/10.1016/j.cedpsych.2020.101860
13. Dick, T. P., & Rallis, S. F. (1991). Factors and influences on high school students' career choices. Journal for Research in Mathematics Education, 22(4), 281–292. https://doi.org/10.2307/749273
14. Fayolle, A., Gailly, B. and Lassas-Clerc, N. (2006), "Assessing the impact of entrepreneurship education programmes: a new methodology", Journal of European Industrial Training, Vol. 30 No. 9, pp. 701-720. https://doi.org/10.1108/03090590610715022
15. Gibson, Donald & Barron, Lisa. (2003). Exploring the impact of role models on older employees. Career Development International. 8. 198-209. DOI: 10.1108/13620430310482571
16. Jr Norris F. Krueger & Alan L Carsrud (1993) Entrepreneurial intentions: Applying the theory of planned behaviour, Entrepreneurship & Regional Development, 5:4, 315-330, https://doi.org/10.1080/08985629300000020
17. Kalayci E. (2017) Stakeholder Relationships in the Framework of R&D-based Startups: Evidence from Turkey. Foresight and STI Governance, vol. 11, no 3, pp. 61–70. http://dx.doi.org/10.17323/2500-2597.2017.3.61.70
18. Karimi, S., J.A. Biemans, H., Lans, T., Chizari, M. and Mulder, M. (2014), "Effects of role models and gender on students' entrepreneurial intentions", European Journal of Training and Development, Vol. 38 No. 8, pp. 694-727. https://doi.org/10.1108/EJTD-03-2013-0036
19. Kautonen, T., Palmroos, J. (2010) The impact of a necessity-based start-up on subsequent entrepreneurial satisfaction. Int Entrep Manag J 6, 285-300.https://doi.org/10.1007/s11365-008-0104-1
20. Krueger, N., Reilly, M.D., & Carsrud, A.L. (2000). Competing models of entrepreneurial intentions. Journal of Business Venturing, 15, 411-432.https://doi.org/10.1016/S0883-9026(98)00033-0
21. Linán, F. & Chen, Y.W. (2009). Development and Cross-Cultural Application of a Specific Instrument to Measure Entrepreneurial Intentions. Entrepreneurship Theory and Practice, 33(3), 593-617. https://doi.org/10.1111/j.1540-6520.2009.00318.x
22. Lüthje C. & Frank, N. (2003). The Making of an Entrepreneur, Testing a Model of Entrepreneurial Intent Among Engineering Students at MIT. R&D Management,33 (2),135-147. https://doi.org/10.1111/1467-9310.00288
23. Nicole E. Peterman and Jessica Kennedy (2003);Enterprise Education: Influencing Students' Percep-

tions of Entrepreneurship Volume 28, Issue 2;https://doi.org/10.1046/j.1540-6520.2003.00035.x
24. Remeikiene, Rita, Dumciuviene, Daiva and Startiene,, Grazina, (2013), Explaining Entrepreneurial Intention of University Students: The Role of Entrepreneurial Education, p. 299-307, ToKnowPress. http://www.toknowpress.net/ISBN/978-961-6914-02-4/papers/ML13-258.pdf
25. Samuels, Peter. (2017). Advice on Exploratory Factor Analysis. https://www.researchgate.net/publication/319165677
26. Šestić, M., Bičo Ćar, M., Pašić-Mesihović, A., & Softić, S. (2017). Poduzetničke namjere studenata poslovnih studija u Bosni i Hercegovini. Obrazovanje za poduzetništvo-E4E: znanstveno stručni časopis o obrazovanju za poduzetništvo, 7(2), 147-160. https://hrcak.srce.hr/191721
27. Wang, Clement & Wong, Poh Kam. (2004). Entrepreneurial Interest of University Students in Singapore. Technovation. 24. 163-172. https://doi.org/10.1016/S0166-4972(02)00016-0
28. Zaidatol Akmaliah Lope Pihie, Afsaneh Bagheri, Z. Haslinda Abdullah Sani,(2013); Knowledge of Cognition and Entrepreneurial Intentions: Implications for Learning Entrepreneurship in Public and Private Universities,Pages 174-181,ISSN 1877-0428, https://doi.org/10.1016/j.sbspro.2013.10.219.