FRI-2G.303-1-CCT1-09

ADVANTAGES OF INTELLIGENT EDUCATIONAL SYSTEMS[9]

MSc Eng. Angel Popgeorgiev, PhD Student
Department of Computing,
"Angel Kanchev" University of Ruse
Tel.: +359 88 512 4442
E-mail: apopgeorgiev@uni-ruse.bg

Princ. Assist. Elitsa Ibryamova, PhD
Department of Computing,
"Angel Kanchev" Univesity of Ruse
Phone: 082-888 827
E-mail: eibryamova@ecs.uni-ruse.bg

Assoc. Prof. Galina Ivanova, PhD
Department of Computing,
"Angel Kanchev" University of Ruse
Phone: 082-888 827
E-mail: giivanova@uni-ruse.bg

Abstract: *The growing access to computer technology has created the so-called digital natives. These people are using technology inseparably in their daily lives and they consume digital information much better than traditional ways. Due to this higher education institutions (HEI) have to create digital learning environments to enhance the knowledge acquisition in the students. Intelligent Educational Systems (IES) are computer-based systems that use artificial intelligence (AI) techniques to enhance the learning experience by adapting to the needs of the individual. This paper explores the advantages of using IES in education compared to the traditional classroom. This paper aims to highlight the potential of IES to improve the quality of learning for students. Some advantages include improving metacognition, decision-making, acquisition of practical skills with immediate feedback, personalized learning, student performance prediction, analytics for educators to monitor students and more.*

Keywords: Education, *Intelligent Educational Systems, Personalized Learning, Digital Information*

INTRODUCTION

Higher Education Institutions (HEIs) have to adapt their teaching methodologies to meet the needs of digital native learners. Today's students are often referred to as digital natives because they grew up heavily immersed in a digital world such as smartphones, tablets, and unrestricted access to information. This upbringing has shaped their perception of knowledge and learning in a different way compared to the previous generation of learners, thus creating a demand for innovative approaches that have to be adjusted to their distinct learning preferences.

Digital devices and information accessibility have significantly influenced the way digital natives consume educational content. They prefer interactive and visual materials, such as infographics or humorous adages, which are more engaging and interactive. Traditional educational content doesn't meet the expectations of this tech-savvy digital generation, who expect educational content that is interactive, engaging and succinct. To meet these expectations, HEIs are adopting Intelligent Educational Systems (IES) to modernize traditional education.

Adopting IES allows for the potential use of data-driven educational decision-making. IES can capture and analyse vast amounts of student data such as performance, preference and learning patterns so that actionable insights are offered to educators. Such insights are important for HEIs to

[9] The paper have been presented on 27.10.2023 in session Communication and Computer Technologies with original tittle: ADVANTAGES OF INTELLIGENT EDUCATIONAL SYSTEMS.

make informed decisions regarding the curriculum, employ specific teaching strategies, and allocate resources appropriately.

IES is a digital learning platform that uses technologies like artificial intelligence, adaptive technologies, and advanced analytics to create personalized learning experiences. These systems cater to the diverse needs of the digital generation, including learning style, previous knowledge, experience, and pace of learning. They enhance engagement, motivation, knowledge acquisition, and comprehension through personalized recommendations, adaptive assessments, and interactive multimedia tools. IES also provides real-time feedback and assessment, transforming traditional grading processes. It allows students to track their progress and identify areas for improvement, encouraging personal initiative in education. The IES also provide an immediate and continuous feedback loop that helps students acquire practical skills through workshops done within the IES. These tools benefit both students and educators, allowing them to focus on specific areas.

The digital generation demands that HEIs adapt to their students' modern expectations and needs. This requires incorporating innovative educational approaches into their curricula. Integrating IES into the curriculum can bridge the gap between traditional education and the digital nature of students. This paper aims to explore the potential benefits of HEIs integrating IES into the educational curriculum of students targeting digital natives. It will briefly examine the unique needs of the digital generation, with a primary focus on the advantages for educators and students.

EXPOSITION

Expectations and Educational Strategies for Digital Natives

Digital natives are individuals who were raised with the pervasive use of digital technology such as smartphones, tablets, computers, instant messaging, and various Internet platforms and services. This technological immersion from an early age caused their distinct preferences and expectations regarding education and how they consume information. They expect the information they consume to be interactive, dynamic, concise, personally intriguing, and relevant to them. These expectations can be met by adopting IES, which utilizes the latest technological advancements, pedagogical methodologies, and data analysis techniques.

It is paramount to utilize appropriate educational strategies that are suited to effectively engage digital natives, improve understanding and focus, and leverage their technological inclination. Such strategies need to incorporate personalized approaches. These strategies are complimented by IES, which aid in the personalization of educational content through adaptive learning algorithms. The system tailors the instructional content’s pace and difficulty to match the individual’s needs and learning progress. This personalized approach optimizes motivation, engagement, and learning outcomes for the digital generation.

To effectively engage digital students, learning environments have to be interactive and multimodal, incorporating multimedia elements such as videos, simulations, and gamification. Virtual reality can create fully interactive exercises, giving immediate feedback to the student that speeds the transfer of skills. These interactive elements align with the expectations of digital natives, enriching their learning journey and equipping educators to better teach digital natives.

About Intelligent Educational Systems and Fields of Application

Intelligent Educational Systems (IES) are computer-based systems that use advanced technologies with artificial intelligence to enhance and optimize the educational process by providing to individual needs. They utilize various technologies such as machine learning, data analytics, cognitive modeling, language processing, data mining, text extraction, and others. These systems provide data-driven insight from all the available data through the use of the system itself.

Intelligent tutoring systems (ITS) are the predecessor of IES (Terzieva, 2021) and feature four classical models: student, pedagogical, domain, and user interface models, of which various systems have proposed improvements (Kahraman, 2010). IES share history with adaptive and intelligent web-based educational systems (AIWBES), as IES are both adaptive and intelligent. AIWBES was a change in the dominant ITS AI-Ed paradigm during the 2000s (Brusilovsky, 2003) which enabled

ITS to evolve into IES. It is common for contemporary systems to feature elements such as web-based platforms, adaptive hypermedia content, content management systems, student profiling, adaptive instruction, assessment, intelligent tutoring, and data analytics.

The fields of application of IES are computer science, followed by medicine and mathematics (Mousavinasab, 2018). Other fields, such as physics and languages, also utilize IES. Some examples of IES applications include (Almasri, 2019): In computer science: programming tutoring for C++, Java, and others; UML modeling; entity relationship modeling in databases; network and web learning; and more. In languages: grammar, dialogue, deaf learners, and more. In other fields: predicting learning styles; legal argument hypothesis in law; circuit analysis in electronics. The use of IES throughout the years and across disciplines is varied (Guo, 2021).

Many IES systems with different designs have been developed throughout the years, presenting various approaches to student modeling (Chrysafiadi, 2013) and applied to distant learning or to a specific goal in an educational field or within a course (Almasri, 2019). The most popular technologies used in IES are Bayesian networks (from AI), neural networks, K-nearest neighbors, genetic algorithms, and decision trees (Kabudi, 2021).

Education is the field with possibly the largest volume of data, making it very attractive for utilizing data mining techniques in IES (Dutt, 2016). Various data mining tools exist that can be used alongside an IES. The most useful data mining methods used in IES are statistics, data visualization, clustering, classification, association rule mining, sequential pattern mining, text mining, and others (Dutt, 2016). Clustering can be used to group students, questions, or tests together and promote group-based collaboration. Some examples of uses of classification are predicting student performance or final grade, detecting system misuse such as gaming, finding misconceptions that students possess, and much more. Association rule mining is at the core of recommender systems, which can be used to recommend activities and materials most suitable to the student. Sequential pattern mining is used to extract information about activities for a single student, and its uses include customizing and adapting the learning resources, comparing the behavior with the ideal learning path, generating activities for each student, and more. Text mining is typical for the field of information retrieval, and it finds uses in IES as well. Some examples include grouping the forums' posts and threads and estimating the technical depth of a contribution. They can also identify articles to automatically create textbooks for students, identify the main points of multimedia, and many more (Dutt, 2016).

Benefits of Integrating Intelligent Educational Systems into Students' Curriculum

Traditional classrooms typically consisted of textbooks made out of paper, a whiteboard, a projector, and a lecturer. Nowadays, classrooms are being modernized by the inclusion of new technologies within the classroom: tablets, smart IoT devices, IoT sensors, lasers, cameras, interactive displays, and even students bringing their own devices. The classrooms are being transformed into smart classrooms. The inclusion of such smart devices also brings the underlying software and advanced technologies, such as artificial intelligence. With sufficiently well-designed IES, the smart classroom with IES data can be viewed in real time through augmented reality. For example, the educator can see the IES's judgment of how a student feels or their performance. The devices in the smart classroom assist the students and educators in positively influencing the learning process, making their work more effective than in the traditional classroom.

IES are at the core of a smart classroom (Terzieva, 2021) as they bring advanced technologies such as data and learning analytics, artificial intelligence (AI), and neural networks to the smart classroom. IES systems collect and analyze data, providing insights for educators to tailor their pedagogical strategies. They also create personalized educational content, accessible during class or at home for assignments. These intelligent and adaptive systems, when combined with skilled educators, enable personalization in learning, enhancing the learning experience.

A smart classroom isn't a necessary requirement for the integration of IES into the student curriculum. IES can still benefit a humbler classroom as it is an interactive medium for educational content, not only using IoT devices. The content is created by the educators using dedicated authoring tools, after which the content can be included by the IES. It can feature multimedia

(video, audio, and text), which benefits different styles of learning, be made interactively, and include problems and exercises. This is a big contrast (Fig. 1) to the traditional web-based systems that featured educational content like a textbook. In IES, this content is intelligently adapted to the personal needs of the student. Students and educators can use forums in the IES like a virtual classroom for discussion, collaboration, and communication. Group projects can be done in real time in a virtual setting for distant learning. Integrating IES into the students' curriculum by HEIs can bring benefits and novelty to both students and educators alike.

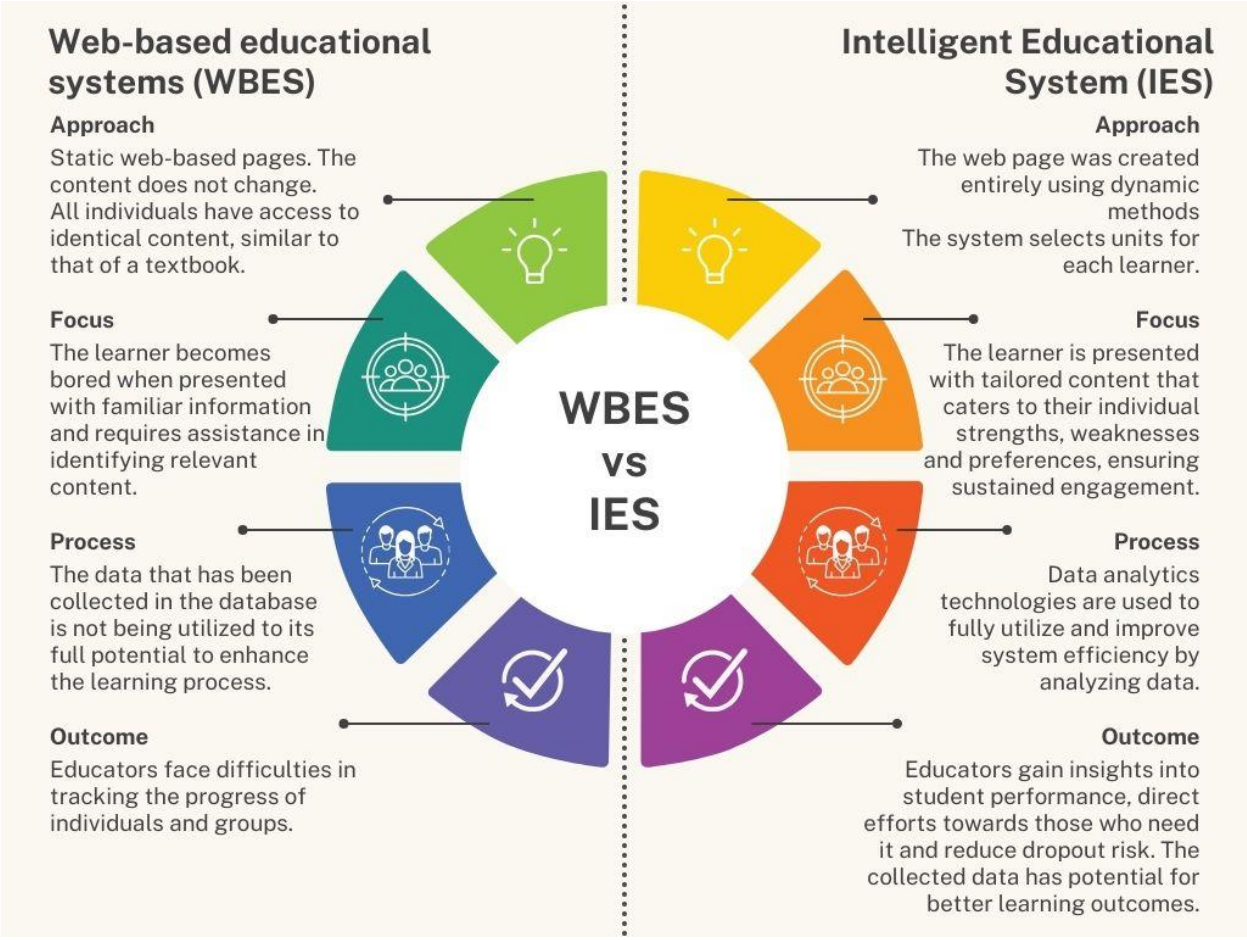

Fig. 1. Comparison of web-based educational systems and intelligent educational systems.

Advantages of Intelligent Education Systems: Educator's Perspective

Educators also benefit from using IES, as they offer more flexibility and options with the tools provided. For example, such a system can streamline some administrative work, such as automating grading and attendance, given appropriate hardware. The educator decides what grade each student receives, but the system is ready with a suggestion. Just like a traditional web-based educational system, IES also offers educational content. They can give basic statistics to the educator, such as visits per page, time spent, frequency of access, user activity for the month, or predictions for the grades. The statistics can be visualized so that the educator can spot patterns for the student group in the courses they are teaching. Understanding the group being taught is especially important in distance learning, where it is very difficult to determine.

In addition to statistics, which may prove insufficient in today's age, IES leverages all available data in the database by utilizing technologies such as data mining, data analytics, artificial intelligence, and neural networks to make insights and predictions for each individual student. IES can determine their future performance and alert the educator if there are any anomalies, such as problems encountered by the student, the risk of becoming a dropout, sudden changes in the usage activity, diminished motivation, and others. Educators can use this information to take appropriate pedagogical action towards the student and prevent undesirable outcomes before the problem takes

place. The educator can use the performance prediction to determine whether or not the students follow the path the educator wants them to take. IES can group students' responses and reactions to a pedagogical strategy. This gives honest course feedback to the educator, which in normal settings is hard to receive. IES can extract information about common misconceptions held by the students, which the educator can create content to rectify. The enhanced feedback received by the systems helps educators improve their instructional design and pedagogical strategies. IES have a great advantage in utilizing the data and providing information that is difficult to notice with any other means.

IES provides web-based access for educators to monitor students through their access to discussion forums for questions, assignments, and group projects. It also generates automated AI feedback, allowing students to learn or request assistance. The systems can sort and group students based on similar characteristics (Romero, 2008; Dutt, 2017) which helps educators tailor their efforts on a group basis. It could detect and report student misuse of forums (Romero, 2008).

Much of the benefits for educators are also shaped to better support the students and focus the educator's efforts to engage with the students. IES provides benefits for educators to further improve their courses and educational content within the system.

Advantages of Intelligent Education Systems: Students' Perspective

IES, combined with educators and the content they produce, primarily offer advantages to students. IES are typically web-based systems that are accessible over the Internet. Every student can access them at any hour and location, not just at class, from their personal device. The student can do practical workshops, home assignments, or study additional content with the help of the system in their free time (Wuttke, 2009). This way, IES can assist the student without the direct need of the educator. Chatbots or other virtual assistants can privately guide the student through the learning material. Questions can provide hints or explain a solution. Interactive workshops can offer immediate feedback, which helps speed the transfer of knowledge to practical skills where appropriate. Assignments or exams can be done within the IES system, creating a central study repository for the students to visit and minimizing the amount they have to track. A discussion forum to connect with other students or educators is accessible within the IES.

During the class, if the classroom is smart, it can be viewed through a smartphone with augmented reality (AR). Insights and data from the IES can be shown to students. Laser projection systems placed in the smart classroom can function as AR displays (Terzieva, 2021). Physical interaction assists the learning process while in class.

IES is an adaptive system, and its educational content is personalized to the needs of the student. The system displays appropriate content based on the skills and performance of the student. This creates a personalized learning journey where the book isn't just a textbook that is typical for traditional web-based systems but is adapted and unique to each individual. This reduces boredom and helps to boost their motivation and engagement as it focuses on relevant content that they need to learn. IES are multimodal as they offer a choice to the learner to select their preferred learning style (auditory, video, text-based). The systems can include a recommender system in which educational content is recommended and displayed to the student for further study and pursuit given their interest, motivation, and performance.

These systems are better suited to developing 21st-century skills in students. Students may be digital natives, but it is paramount to have high levels of digital literacy nowadays. Utilizing such a system ensures that they have the necessary competencies. In addition, such systems can prepare them for future collaborative projects at work in which they must work in a multicultural environment across countries. IES makes use of its data and groups students accordingly, forming balanced teams without students feeling left-out (Dutt, 2017). IES can further enhance essential 21st century skills among the students', such as critical thinking, communication, analyzing abilities, perception, making decisions, and problem solving (Chrysafiadi, 2013; Dutt, 2017).

The ability to think critically, adapt, and learn independently is highly valued for students to develop. These abilities can be boosted through the improvement of an individual's metacognitive skills. They focus on personal understanding of the individual, such as their learning process,

regulating their own thinking, discerning information for decision-making, and a solution approach to problems. Specifically designed IES can enhance metacognitive skills such as self-regulation, self-explanation, self-assessment, and self-management (Chrysafiadi, 2013). IES could engage learners to be aware of metacognitive skills and further stimulate their improvement. Enhancing students' learning resources, such as metacognitive skills, increases their chances of succeeding in their educational and personal goals (Peña, 2011).

The benefits for educators are many, and for students, they are numerous. This section is not an exhaustive listing of them, but it has focused on practical benefits for students.

Potential Implications of Integrating Intelligent Educational Systems

While IES offer many advantages compared to traditional education or web-based systems, they are not without a flaw. Some implications need consideration.

To work sufficiently well, the systems need to be designed well (Terzieva, 2021), and the students must also be motivated. Their attitude towards the system is detrimental to its efficiency. They have to experience challenges and interest in the field. This work relies on educators to be conscious of this, exert the necessary control over the students, and keep learning alongside them. For the effective transfer of knowledge, content, and gamification to students, educators need to have experience with the technology (Terzieva, 2021).

There is an overreliance on technology, which may have health concerns that may not be known yet. Students may become indecisive in their judgment on their own by relying too much on the AI to make the decisions for them instead.

Due to data collection, there are some privacy concerns, such as anonymization of data, data longevity, explicit consent, and transparency. In addition, depending on the used case, some monitoring devices can stress students too much because they are constantly monitored or judged, creating a negative educational effect in the individual rather than a supportive one.

The advantages listed in this paper consider a theoretical IES used in practice based on the experiments done throughout the years. Such a system could be costly to produce and could mean further expenses for the HEIs. For example, some smart devices may have insufficient longevity or become obsolete and require major replacements.

Despite these implications and due to the many advantages of these systems, HEIs are encouraged to adopt IES in practice where feasible (Kabudi, 2021). IES are an investment worth pursuing and further fine-tuned by HEIs worldwide.

CONCLUSION

Intelligent Educational Systems offer personalized instruction and content tailored to individual students, leveraging technological advancements like artificial intelligence and data analytics. These systems help educators gain insights into student performance, direct needs-based efforts, and reduce dropout rates. IES harnesses collected data to predict grades and performance for each student, enhancing cognitive faculties and decision-making skills. Students benefit from tailored content, personal knowledge, experience, and preferred learning styles. Interactive and engaging workshop exercises provided by IES enhance the acquisition of practical skills. The system also provides immediate feedback to educators, enhancing the overall learning experience for teachers and students. Overall, IES offers numerous benefits for both educators and students.

If HEIs implement IES into their students' curriculum, graduates will be better prepared for the increasing demands of modern life. IES provides facilities for students to develop and improve their metacognitive and 21st-century skills, such as critical thinking, problem-solving, digital literacy, communication, and self-learning for life.

IES relies on educators to create and operate educational content, requiring digital literacy and experience in IES technologies. Accessible authoring tools for interactive content creation are crucial. Effective educational content creation relies on pedagogical skills, and IES relies on educators ahead of their students in digital literacy.

Despite the implications and challenges, HEIs are encouraged to pursue investment in such systems for practical use with students. IES offers numerous benefits, including personalized education preparing students for the changing world of tomorrow by leveraging its capabilities.

ACKNOWLEDGEMENTS

This paper is supported by project 23-FEEA-01 "Development of models and simulations with different application areas", funded by the Research Fund of the "Angel Kanchev" University of Ruse.

REFERENCES

Almasri, A., Ahmed, A., Al-Masri, N., Sultan, Y. A., Mahmoud, A. Y., Zaqout, I., Akkila, A. N., & Abu-Naser, S. S. (2019). *Intelligent Tutoring Systems Survey for the Period 2000- 2018*. 3(5).

Brusilovsky, P., & Peylo, C. (2003). Adaptive and Intelligent Web-based Educational Systems. HAL Portal Telearn, *International Journal of Artificial Intelligence in Education (IJAIED)*, 159–172.

Chrysafiadi, K., & Virvou, M. (2013). Student modeling approaches: A literature review for the last decade. *Expert Systems with Applications*, 40(11), 4715–4729. https://doi.org/10.1016/j.eswa.2013.02.007

Dutt, A., Ismail, M. A., & Herawan, T. (2017). A Systematic Review on Educational Data Mining. *IEEE Access*, 5, 15991–16005. https://doi.org/10.1109/ACCESS.2017.2654247

Guo, L., Wang, D., Gu, F., Li, Y., Wang, Y., & Zhou, R. (2021). Evolution and trends in intelligent tutoring systems research: A multidisciplinary and scientometric view. *Asia Pacific Education Review*, 22(3), 441–461. https://doi.org/10.1007/s12564-021-09697-7

Kabudi, T., Pappas, I., & Olsen, D. H. (2021). AI-enabled adaptive learning systems: A systematic mapping of the literature. *Computers and Education: Artificial Intelligence*, 2, 100017. https://doi.org/10.1016/j.caeai.2021.100017

Kahraman, H. T., Sagiroglu, S., & Colak, I. (2010). Development of adaptive and intelligent web-based educational systems. 2010 *4th International Conference on Application of Information and Communication Technologies*, 1–5. https://doi.org/10.1109/ICAICT.2010.5612054

Mousavinasab, E., Zarifsanaiey, N., R. Niakan Kalhori, S., Rakhshan, M., Keikha, L., & Ghazi Saeedi, M. (2021). Intelligent tutoring systems: A systematic review of characteristics, applications, and evaluation methods. *Interactive Learning Environments*, 29(1), 142–163. https://doi.org/10.1080/10494820.2018.1558257

Peña, A., Kayashima, M., Mizoguchi, R., & Dominguez, R. (2011). Improving Students' Meta-cognitive Skills within Intelligent Educational Systems: A Review. In D. D. Schmorrow & C. M. Fidopiastis (Eds.), *Foundations of Augmented Cognition. Directing the Future of Adaptive Systems* 442–451. Springer. https://doi.org/10.1007/978-3-642-21852-1_51

Romero, C., Ventura, S., & García, E. (2008). Data mining in course management systems: Moodle case study and tutorial. *Computers & Education*, 51(1), 368–384. https://doi.org/10.1016/j.compedu.2007.05.016

Terzieva, V., Ilchev, S., Todorova, K., & Andreev, R. (2021). Towards a Design of an Intelligent Educational System. *IFAC-PapersOnLine*, 54(13), 363–368. https://doi.org/10.1016/j.ifacol.2021.10.474

Wuttke, H., & Henke, K. (2009). Learning management systems: Coupled simulations and assessments in a digital systems course. *Interactive Technology and Smart Education*, 6(2), 97–107. https://doi.org/10.1108/17415650910968107