Higher Education Transformation for Artificial Intelligence Revolution: Transformation Framework

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Rawan Ghnemat[1](✉), Adnan Shaout[2], Abrar M. Al-Sowi[3]
[1]Princess Sumaya University for Technology, Amman, Jordan
[2]The University of Michigan, Dearborn, Michigan, USA
[3]University of Jordan, Amman, Jordan
r.ghnemat@psut.edu.jo

Abstract—The field of Artificial Intelligence in Education (AIED) will change the shape of education in the future completely, current classroom environment management, collaboration with teachers, and development of AI-based technology platforms. The intelligent adaptive transformation of learning and teaching in higher education required the emergence of all educational process structures. This paper presents a revolutionary educational process called AI-based learning, Which involves technologies within universities, cultures, practices, goals, and communities. This transformation reduces the gap between higher education's outcome and industry's needs, by producing lifelong learners. The proposed framework illustrates the full structure, the development steps, and the implementation benefits. The proposed framework also provides connections of scattered scientific research work in different related domains. Using AI competency-based learning will let students achieve the course outcomes easier and faster and increase student engagement by solving real-life industrial problems in different application domains. The paper also presents implementations phases, benefits and provides a comparison after applying the framework.

Keywords—artificial intelligence, personalized learning, educational data mining, smart education, active lifelong learning

1 Introduction

For centuries professors transfer knowledge and experience to allow students to achieve a list of predefined learning outcomes through a direct lecturing process in classrooms and assess them using some performance indicators such as lecture attendance, exams, homework, and projects.

This learning method in the twenty-first century is suffering from a real problem which is "student disengagement". According to statistics in the European Union, one out of ten students is not pursuing education after high school as shown in Figure 1. Early leavers from education and training may face considerable difficulties in the market like low lifetime earnings. Many studies have shown that the problems of disengagement and difficulties in the market are on the rise worldwide [1].

Artificial intelligence (AI) is being applied in education to improve learning and educators' performance. The adoption of AI innovations for 21st-century education and its effect on classrooms and human development have been discussed by [2].

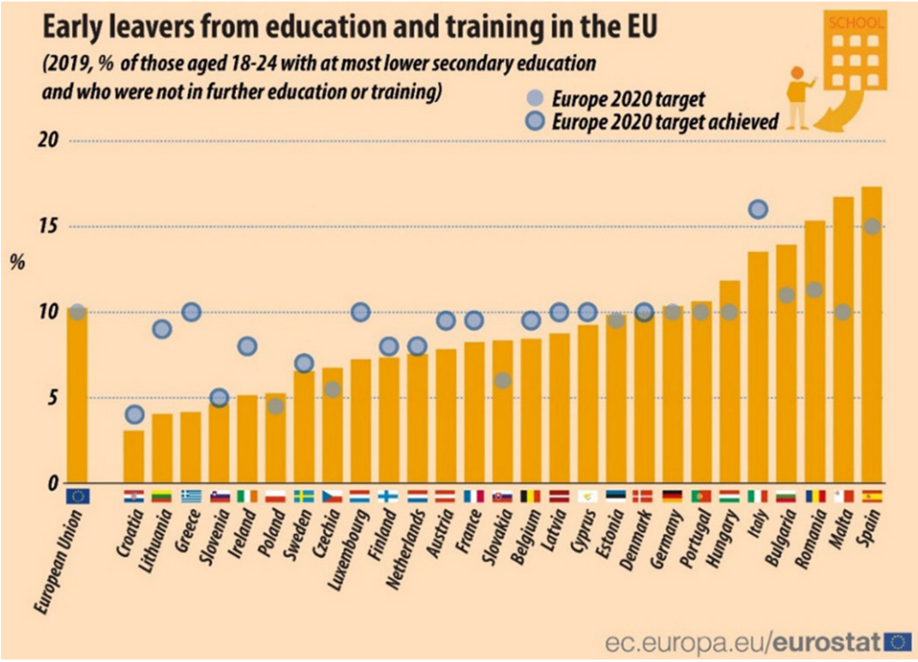

Fig. 1. Percentage of early leavers from education and training in the European Union (EU), (https://ec.europa.eu/eurostat/statistics-explained/)

One of the most efficient solutions to the problems in the educational system is to be able to adapt to the changes in technology. In a survey of American college students in 2015, it was found that students have used digital devices for non-class activities for over 20% of class time, which were an increase over a similar survey in 2013 [3].

There are countless opportunities for our society to evolve with the digital era and with the great advances in AI techniques [4]. One of them is education. With AI there is the potential for personalized learning experiences for people of all ages and challenges. If we create environments that deeply understand us, then we can personalize learning according to our needs. This can be the future of the educational system.

In the age of computing power, AI and machine learning are now able to learn a human task, which may need years to learn, in two days or less [5].

In the early digitalization stage, the technology was put into a working domain, and it did work properly after the testing phase. However, for AI systems, it needs many iterations between developing and learning before the testing phase [6]. This is a continuous process that involves working with human experience and data to design technology to support human values like education.

Future students would work in a cognitive adaptable environment that meets their needs under the teacher's supervision. This environment would include real-world problems where students come up with solutions and are responsible for the consequences of their decisions to complete the learning process.

Students would understand the problems, design solutions, come up with several patents and act as a breeding ground for start-ups. The students, scientists, and business partners become stakeholders on campus; instead of just using technology they would also learn how to design new technology.

The contribution of the work in this paper is to propose a comprehensive framework for the future of the higher education system with AI. The proposed framework will be used to transform university campuses into cognitive campuses from all aspects; learning environment, teaching material, artificial intelligence licenses, and research centres that adapt to the national priority (industry, agriculture health, banking, etc.). The proposed framework process will be explained from the following aspects:

- Framework aim and outcomes.
- Framework inputs and outputs.
- Framework components.
- Framework development steps.
- Framework transformation Benefits.

Some preliminary demonstration of the proposed framework will be provided, which is based on the computer science bachelor's degree program at Princess Sumaya University in Jordan.

The rest of the paper is organized as follows: in section 2, we will classify the major accomplishments in this domain and give a literature review of each one; section 3 explains how the proposed framework can be performed, the benefits of the experience, and discuss the results obtained; and, finally, in section 4 we will present the conclusion. Writing a new document with this template.

2 Literature review

AI applications in education have improved different fields of research and applications from theoretical contributions to technological developments [7] and implementations [8]. The major accomplishments in this field can be classified into four categories. The first is the empirical studies and analyses of higher education systems that used AI technologies. Empirical studies are usually implanted to evaluate students and process performance based on real case studies that could be different according to countries' educational policies [9]. The second is the current intelligent educational system descriptions and evaluation which addresses mainly the performance of intelligent web-based educational systems [10]. The third is the modeling approach for new smart educational systems [11] and the fourth is the learning theories using AI [12]. Sections 2.1 to 2. 4 will explain the main achievements in each field.

2.1 Empirical studies and analyses field

Empowerment is the "process by which individuals and groups gain power, access to resources and control over their own lives. In doing so, they gain the ability to achieve their highest personal and collective aspirations and goals" [13].

Different AI methods have been used in education empowerment which is as follows:

The authors in [14] have used machine learning methods in supporting the context of human learning and teaching. They proposed a conceptual framework using machine learning based on empirical findings gleaned from the work on open learning models.

In [15] machine learning has been used to build a recognition system to support higher education student performance, embedded in the online learning platforms. They proposed to predict the final score of students before participating in the final examination and detect students at risk. They improved the failure rate in examinations with almost half of their case study.

Emotions of learners were addressed in many research articles like in [16] which have addressed the measurement of emotions experienced by students while using video-based e-learning materials for the interaction design course for higher education. The research has proven that emotions like motivation and fun are crucial in e-learning, specifically in video-based e-learning. While [17] empirically has addressed whether the use of visualization tools may affect students' emotions while they learn to program and found that the use of the visualization system has decreased students' negative emotions.

Another research was conducted on professionally motivated learning analysis [18] has studied the internships in higher education and the measurement of practical outcomes to facilitate students' transition from higher education to industrial work. The authors in [18] have aimed at the strength of internships and how education can maximize the internship experience to improve the employment effect.

Research that has analyzed the structure of internships using statics on graduate unemployment and outcomes from two Australian universities is provided in [19].

2.2 Current system description and evaluation

This research discussed the use of AI in teaching and learning in higher education and evaluates the use of technological solutions such as 'learning management systems or IT solutions in the era of artificial intelligence as follows:

The authors in [20] studied the impact of AI on teaching and learning in higher education by exploring AI solutions that help in automating some teaching and learning tasks. They also reconsidered the teacher's role as well as pedagogies and list a set of challenges such as privacy and plagiarism. They also stressed the need for research on the ethical implications of the current development of AI.

The research in [21] proposed restructuring the current higher educational institutes by strategically employing the trending technologies to prepare students and educators with the right set of skills based on knowledge.

What happened to the education system in the era of the industrial revolution 4.0 (IR 4.0) was presented by authors in [22]. The authors have indicated that information management is the most challenging issue faced by many organizations in developing countries and building a comprehensive strategic plan should cover both ethical and constructive steps. [23] proposed a complete strategic plan after studying three countries which are China, India, and Russia in AI development areas.

2.3 Modelling approach

Many modeling approaches using AI address different problems in the current higher educational systems. The following are some of the modelling approaches:

1. **Building new** models using an ontological approach for curriculum semantic modelling in higher education. Authors in [24][25][26] have purposed organizing knowledge areas and subjects for each discipline using a syllabus classification scheme as well as learning ontologies. Based on the assessment category which is skills, knowledge, and attitude, the model builds the syllabus automatically.
2. **Modelling teaching quality.** The authors in [27] have developed a model to unify perspectives for the entire e-learning for the instructors and they gave a comprehensive systematic approach that measures the importance of continuance satisfaction for sustaining the use of e-learning in higher education institutions. Bidirectional relations between factors related to e-learning continuance satisfaction were one of the successful methods that have been implemented. [28] have addressed the quality of education issue by a structural equation modelling approach. The proposed structural model found that there is a significant relationship between the ten selected evaluation criteria practice and the performance which have steered up the academic quality in all aspects, resulting in an excellent performance.
3. **Assessment modelling.** [29] have addressed the problem of assessments in online education and have proposed a model using AI techniques like Immersive Virtual Environment (IVE) [30][31]. AI systems are designed to interact with the e-learning platform through capabilities, such as speech recognition, and intelligent behaviors. The proposed model does suffer from some ethical issues like sharing data and privacy, but it does have a major social impact by delivering knowledge to people from different economical levels.

2.4 Learning theories developed for AI

The learning theories developed for AI have been reported by many authors. The authors [32] have focused on converting the educational system into smart adaptive and customized systems according to student needs. This has minimized the problem of disorientation and cognitive overload. The proposed tools to achieve this goal use AI techniques to detect students' learning styles. [33] have recommended the use of gamification in online learning for medical domains, which assists students to learn through game-like elements and the platform, to engage in learning outside the classroom. Gamified learning is believed to be more effective to render collaborative and competitive learning in medicine. The work by [34] has emphasized the computational thinking transformation into a process of learning using AI. They proposed to use AI to fill the gap between practical skills and knowledge theories by applying an experiential learning model. Tables 1 and 2 illustrate the main contributions in each field with limitations and methods used and goals.

Table 1. First comparison between related work in artificial intelligence research in education: description, examples, and research goal

Research	Description	Examples	Research Goal
Empirical Studies and Analyses	Analyzing case studies using different statistical and machine learning techniques for data collected from specific higher education institutes.	– Open Learner Modelling using machine learning [14] – Early recognition System with Machine Learning to support Students' Success [15]. – Analysing the influence of a visualization system on students' emotions [17]. – The influence of Work-Integrated Learning and paid work during studies on graduate employment and underemployment [18].	Enhanced students' engagement and students' learning performance.
Current System Description and Evaluation	Study the link between higher education and developments of new technologies and computing capacities of AI.	– Exploring the impact of AI on teaching and learning in higher education [20]. – Education system in the era of the industrial revolution [22], [23].	Reconsiderations of teacher's role emergent pedagogies. Highlighting ethical implications of the current developments of AI.
Modelling Approach	Modelling different problems in the current higher educational systems approaches using AI approaches.	– Syllabus classification scheme [24] – Systematic approach that measures the importance of the use of e-learning in higher education institutions [27], [28]	Finding the key factors affecting students' and instructors' satisfaction in higher education.
Learning Theories	Developing new learning theories based on AI.	– Detecting students' learning styles and determining the most suitable learning environment [32]. – Gamification in online learning [33]. – Experiential learning model [34].	Determining the best teaching environment and style.
Transformation Framework (our proposed approach)	Create a model for a sustainable complete framework that used new learning theories based on AI, linking the new digitization process to analyzing adaptive evolving process.	–	Connect the AI with the learning process in a sustainable way that would increase student engagement and decrease industrial practical qualification shortage and create an economical solution using applied research.

Digital transformation in higher education has changed the structural, contextual, and temporal inefficiencies; Increasing higher education's ability to manage this change effectively; reformulation for higher educational systems is needed.

Dealing with different parts of the higher educational systems separately have been done in most of the previous works; authors have dealt with one or more part of the educational system separately which have created problems like data dependency, and generalization difficulties and have made a comparison between different contributions difficult. In this paper, the main contribution will be dealing with a transformation framework that will connect all the higher education elements; students, instructors, the learning process, and future employers.

Applying the proposed framework will unify the reformulation in a progressive sustainable way. It will address and connect the four main aspects: the instructor's teaching and research, the teaching process, the evaluation and quality management, and the industrial involvement.

Table 2. Second comparison between related work in artificial intelligence research in education: used methods, benefits and contributions, and limitations

Research	Using Methods	Benefits and Contributions	Limitations
Empirical Studies and Analyses	– Machine learning algorithms – Quasi-experiments – Partial least square analysis. – Statistical analysis.	– Deliver a universal machine learning framework that supports human learning. – Propose an Early Recognition System for an adaptive learning environment. – Propose a visualization system that will decrease student negative emotions. – Empirical understanding of the relative benefit of different forms of practical experience on graduate employment and underemployment.	– Statistical result validity strongly depends on the validity of the method and the data distribution. – Machine learning model is data driven model and related directly to specific university data and difficult to be generalize.
Current System Description and Evaluation	Statistical data analysis	Pinpoint some challenges for institutions of higher education and student learning in the adoption of these technologies for teaching and exploring a new direction in this domain.	Propose a strategical solution without a given framework for it.
Modelling Approach	– Semantic modelling – Structural modelling – Immersive Virtual Environment.	Development of automated adaptive knowledge structure.	– Ethical issues like sharing data and private violence. Research considers students in education but less consideration for the instructors and the whole education process.

(Continued)

Table 2. Second comparison between related work in artificial intelligence research in education: used methods, benefits and contributions, and limitations *(Continued)*

Research	Using Methods	Benefits and Contributions	Limitations
Learning Theories	– Data analytics – Experiential learning – Computational thinking	Proposed a framework of tools to achieve adaptive smart learning using AI.	Difficulties in comparing different learning theories which are diverse and data dependent.
Transformation Framework (our proposed approach)	– Machine learning algorithms. – Data analytics – Computational thinking. Modelling.	– Create a system that will be sustained on its own and achieved educational economical practical goals simultaneously. – It's not data driven model.	Difficulties in comparing it to other systems because the new approach combines all existing systems.

3 The proposed framework for AI and educational technology relation

Our proposed higher educational transformation framework reformulates the structure of educational institutes as well as proposes a direct influence of the industrial partners on the research centres' projects as shown in Figure 2.

The aim of the proposed framework is to provide intensive comprehensive knowledge, skills, and experience for students in the applicative domains like engineering and information technology. As a result of the framework, the students will be able to develop their products and be evaluated by a panel from the industry and the university which will eventually reduce the gap between universities' output and market needs.

The framework will be used to transform the university campus into a cognitive campus by building a learning environment (halls, labs, and material), preparing a training program for AI license, and establishing data/research centres connected to the national priority (industry, agriculture health, banking, etc.) and using this framework to accelerate the country's economic growth by choosing applicative research problems. The transformation process from inputs to outputs is explained in the framework as shown in Figure 2.

In this section, we will present the framework's essential components, development steps with process actions, and how this transformation will change the education process.

3.1 Framework components

The following are the framework components for the proposed system:

A. **(E-Learning) centres:** using digital learning platforms and Massive Open Online Courses (MOOCs) platforms and customizing these tools to do mining for the data that is generated through devices and learning management systems. These centres will offer teachers and students a virtual campus that is personalized and customized.

B. **Intelligent educational recommendations systems:** using machine learning, data analytics, and business intelligence solutions for personalized learning and student behavior or performance. This will help in improving student retention and reducing student dropout rates. Personalization of content will also match different learner styles, preferences, and needs to maximize and speed up the learning process. Another unique feature of educational recommendation systems is the dynamic curriculum design using AI for both undergraduate and graduate levels with the right measurement tools for the certificate outcomes.
C. **Quality management centres:** classroom monitoring and collaborative learning process will identify the best quality management policies. This can be done based on various technologies and multimedia tools designed for instructional and behavioral management strategy analysis for research income and industrial goals.
D. **Research centres in AI:** supporting data collection, technical investment, legal and ethical issues and focus on industrial problems that are related to the curriculum with defined educational and business outcomes.

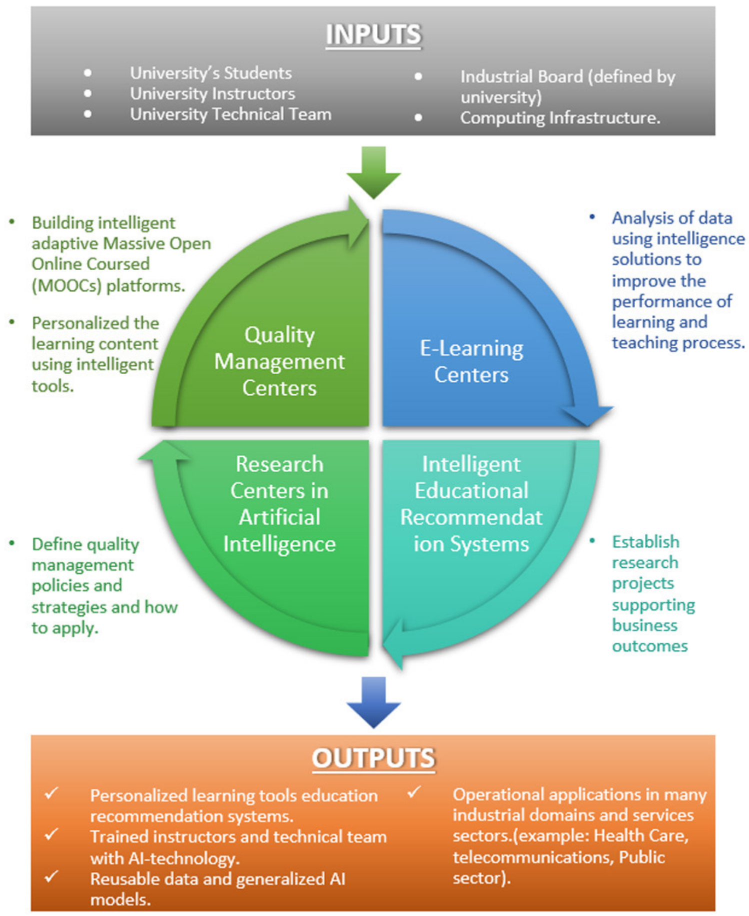

Fig. 2. The proposed higher education transformation framework

3.2 Development steps

This section explains the details for implementing the transformation components; the Establishment of (E-Learning) centres, educational recommendation systems, quality management centres, and intelligent research centres.

A. **Establishing an (E-Learning) centres:** these centres should work on developing three types of task learning management system platforms customized with multimedia tools, learning content keeping content in tune with the diversity of the learners, and assessment tools connected with the content. This step needs the collaborative work of the academic and the technical team.
B. **Establishing an educational recommendation system:** The recommendation system will provide a mechanism to connect learners' profiles with the different digital content to achieve a certain outcome in order to make better recommendations. This can be achieved using different factors such as interaction time, ordered list of contents, direct feedback, number of iterations, and time of completion.
C. **Quality management centres:** Classroom monitoring and visual analysis using a different kinds of sensors in order to use the best quality management strategies using AI methods. With smart sensors and wearable devices, methods can be implemented with learning analytics and machine learning algorithms. The aim of this monitoring task is to predict and enhance the final student scores ahead of their final examinations.
D. **Research centres in artificial intelligence:** Each university is supposed to take one domain and established its research projects in its domain (data, human experts, application, industrial products, etc.). Here are some possible domains:

- Healthcare [35]
- Agriculture Bots [36].
- Cognitive computing systems [37].
- Computer vision [38].
- Natural language processing [39].
- Smart Mobility and Transportation [40].
- Education [41].

Establishing a framework to apply AI in universities and to all relevant enterprises is the new smart way to achieve efficient business goals. Figure 3 shows the process of research evolution in education. These steps can vary in sequence and often occur simultaneously.

3.3 The process of research evolution in education

Many benefits can be obtained by applying AI transformation like industrial application, knowledge and reusable data storage, applicative research work, and achieving more efficient educational outcomes.

The concept of connecting both academic and business organizations by transforming education into problem-based education is a very effective method for advances in both domains. Applying the research of experts that offers the best techniques to achieve success in business objectives will achieve excellent performance for both the educational and business communities.

The computer science bachelor's degree program at princess Sumaya University in Jordan will be used as a transformation case to demonstrate the proposed framework and show the contribution of this proposed work. The program is a four-year undergraduate program that is fully accredited by the Accreditation Board for Engineering and Technology (ABET). Table 3 lists the Program Educational Objectives (PEOs) and Student outcomes (SOs), which have been measured by the following evaluation methods: projects, assignments, and exams.

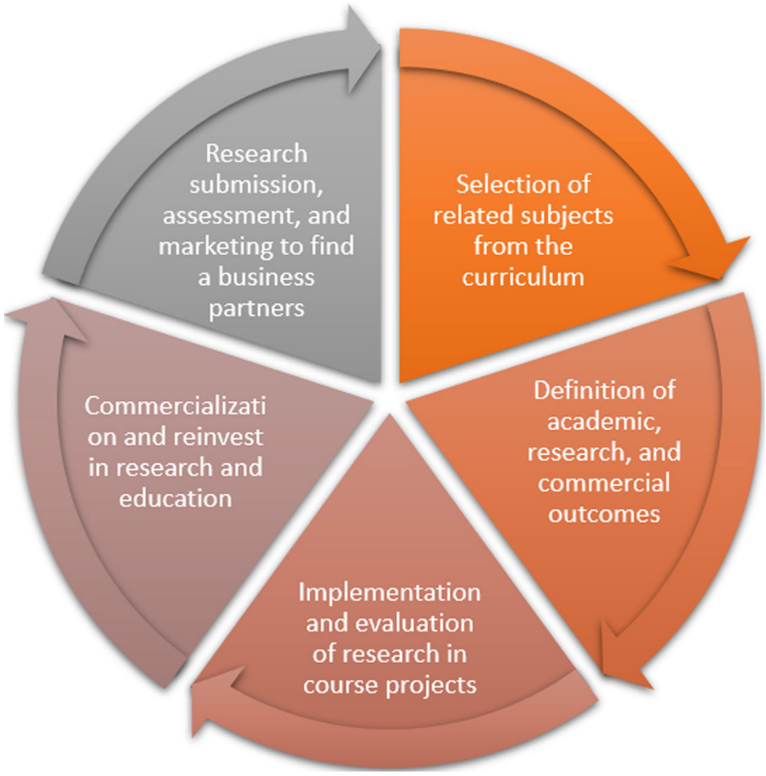

Fig. 3. The process of research evolution in education

Table 3. Computer Science PEOs and SOs (Revised in February 2012) (http://psut.edu.jo/)

PEO-1	Develop graduates' abilities in the applications of the necessary mathematical tools, scientific basics, and fundamental knowledge of Computer Science.
PEO-2	Yield graduates with robust problem-solving skills, professional practices, and ethical standards to meet the market needs.
PEO-3	Yield graduates are capable of using and developing high-quality computer systems and state-of-the-art tools and techniques to serve various sectors' needs.

(Continued)

Table 3. Computer Science PEOs and SOs (Revised in February 2012) (http://psut.edu.jo/) *(Continued)*

PEO-4	Prepare graduates for successful teamwork and effective oral and written communication.
PEO-5	Prepare graduates for continually growing professional development.
PEO-6	Prepare graduates for research and to pursue graduate studies in Computer Science fields, supported with the best skills required for academic success.
SO-a	An ability to apply knowledge of computing and mathematics appropriate to the discipline
SO-b	An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution
SO-c	An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs
SO-d	An ability to function effectively on teams to accomplish a common goal
SO-e	An understanding of professional, ethical, legal, security, and social issues and responsibilities
SO-f	An ability to communicate effectively with a range of audiences
SO-g	An ability to analyze the local and global impact of computing on individuals, organizations, and society
SO-h	Recognition of the need for and an ability to engage in continuing professional development
SO-i	An ability to use current techniques, skills, and tools necessary for computing practice.

All outcomes are covered by multiple courses and evaluated by the following: current students, alumni, faculty members, and employers as stakeholders. PEO-6 is the only program educational objective that is mapped with all student outcomes as shown in Table 4 (1 indicates relation and 0 no relation).

Table 4. Relationship of student outcomes to program educational objectives

SOs / PEOs	SO-a	SO-b	SO-c	SO-d	SO-e	SO-f	SO-g	SO-h	SO-i
PEO-1	1	0	0	0	0	0	0	0	0
PEO-2	1	1	1	0	1	0	0	0	1
PEO-3	0	0	0	0	0	0	1	0	1
PEO-4	0	0	0	1	0	1	0	0	0
PEO-5	0	0	0	0	0	0	0	1	0
PEO-6	1	1	1	1	1	1	1	1	1

Same observation for the list of courses related to the outcomes; some courses match many outcomes and some match one or two courses only. Applying the proposed framework will change this and introduce a balance between program objectives and student outcomes. It also will merge one or more courses in the same outcome using the proposed industrial projects implementations and evaluations. Table 5 shows the transformation difference in PEOs and SOs relations, evaluations, outcome measurements, and other factors.

Table 5. Comparison results between the current educational model and the proposed framework

Comparison Factor	Current Educational Model	Proposed Transferred Model
PEOs and SOs relation	Imbalance relations.	Each SO is connected to all PEOs because all courses are connected with industrial problems and functional deliverables.
Program constituencies	Alumni, current students, employers, and faculty members.	Specialized business partners and faculty researchers.
Assessment of performance	End of each semester.	A long research project application process.
Type of educational contents	Static content.	Dynamic personalized content.
Learning deliverables	Knowledge and skills.	Knowledge, skills, competencies, and experience.
Structured	Semester time-based.	Research project-based cycle.
Research work	Not structured and individual-based.	Structured and project-based.

With all the digital online learning, artificial intelligence will assist in the higher education process and industries in many aspects. For example, it can increase AI Experts such as data scientists, machine learning engineers, robotic scientists, research scientists, and business intelligence developers.

Personalize Education system is a long-life education process that enhances problem-based learning and simulations. Furthermore, the research with Business goals will produce better results in both areas and create a useful reusable business model with data centres. This framework is generic and could be applied as a process transformation for graduate and undergraduate programs.

Table 6 shows the comparison between two modes of learning: The first is the traditional on-site learning and the second is completely online distance learning for first-year students at Princess Sumaya University in Jordan. The course has four outcomes that have been measured during the semester by the evaluation's methods: projects, assignments, and exams. The outcomes are as follows:

1. Deploy the syntax and semantics of the C programming language to build basic computing programs.
2. Analyze a computing problem and come up with the solution requirements to solve the given problem
3. Design and implement a solution using C programming language.
4. Express algorithms using C Programming Language.

The preliminary results showed a huge difference in students' engagements, project implementation, and outcomes measurements.

Table 6. Performance results for the different modes of offering for the course on structured programming online and on site learning

Comparison Factor	Onsite Learning	Online Learning
Semester	Fall semester 2019/2020	Spring semester 2019/2020
Course	Structured programming	
Total number of students	72	72
Lectures attendance percentage	67%	96%
Assignments submission percentage	52%	98%
Final exam average percentage	61%	76%
Final exam average results for outcome 1 percentage	71%	81%
Final exam average results for outcome 2 percentage	64%	70%
Final exam average results for outcome 3 percentage	59%	72%
Final exam average results for outcome 4 percentage	57%	71%

We used an artificial neural network (ANN) model to predict students' future performance in a course. The model was used to facilitate educational interventions and remedial actions in a timely manner. We conducted an empirical investigation and comparison of several data sources, using data from 500 learners (students) collected from the main institutional database.

The input attributes for the neural network are: (attendance, first quiz grade, number of course views per week, participation percentage in the lecture, number of questions during office hours, major, high school grades, and gender).

The ANN consists of 5 hidden layers; input, hidden1, hidden 2, hidden 3, and output layers. The training parameters are as follows: data was divided into 70% for training and 30% for testing.

The data were normalized between 0 and 1 and Levenberg –Marquardt (LM) learning algorithm was used with a learning rate of 0.001and a momentum rate of 0.95.

The activation or transfer function used in the hidden layers was log sigmoid or "logsig" while in the output layer it was mainly linear. The training would stop when the Minimum Square Error or MSE (shown in equation 1) was obtained, which is the minimum error between the targeted and the predicted.

$$\text{Mean Square Error (MSE)} = \left(\frac{1}{n} \sum_{i}^{n} (y_p - y_i)^2 \right) \quad (1)$$

We have obtained an MSE=0.0309 for the training data (for 500 students) and an MSE=0.0369 for the testing data. The neural network model could be generalized and used for different courses using larger training data.

4 Conclusion and future work

The future of higher education with the AI industrial revolution will replace the course work with exams by solving research and applicative problems. Solving medical or any industrial problem by combining one or more course outcomes will achieve great academic goals and will give the degree the industrial dimensions. This paper gives a detailed framework, transformation inputs outputs, and steps. It explains the relationship between the research and industry community and how to evaluate each role and shows some comparisons between the traditional educational methods and the proposed one with AI. The future is to apply this framework in higher educational institutions and measure the performance by comparing the traditional educational model and the new way. Many previous research has focused on modelling the online learning process or evaluation but this research work has focused on the whole transformation. The transformation from learning, teaching, measurements, and applicative approach was done by connecting all the transformation framework essential components from infrastructures and human experts and digital content. The transformation process will be time and effort-consuming and needs collaboration from all managerial levels as well as technical and academic levels including the industrial partners.

The future work of this framework is to apply the transformation process to one major at a university and study its impact on the education and industrial partners before and after.

Another future work is also to address the required descriptive tools and their effects on applying the proposed transformation. Higher education, and industrial partners, should decide where, how, and when higher education programs need to develop better pivoting that will maintain higher education's relevance and industrial growth.

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6 Authors

Rawan Ghnemat received her PhD in Computer Science, with distinction, from Le Havre University, France in 2009. Her study was funded by a French government scholarship. In 2009, she worked as assistant professor in the department of Computer Science at German-Jordanian University. She currently works as associate professor in the department of Computer Science at Princess Sumaya University for Technology. She has several scientific publications in artificial intelligence and data mining. Rawan Ghnemat has published on journal such as: international Journal of Bifurcation and Chaos, International. Journal of Interactive Mobile Technologies, Journal of Software Engineering and applications, International Journal of Computers & Technology, she is a strategic steering committee member in an artificial intelligence powered search engines firm (GETJo Inc.), http://gaset-gbset.com/Team.html.

Professor Adnan Shaout received his B. S., M. S. and Ph D degrees in 1982, 1983, and 1987 from Syracuse University respectively. Since 1987, he has been with the University of Michigan – Dearborn, where he is currently a full professor in the Electrical and Computer Engineering Department. His current research interests are in the areas of applications of fuzzy engineering applications, software engineering, computer design (hardware & software), intelligent Systems, and embedded systems. He hold the position of a visiting professor for Princess Sumaya University for the academic year 2015/2016. He has published in journals such as: the International Journal of Advanced Research in Computer and Communication Engineering, ACM Transaction on Software Engineering Methodology, the International Journal of Internet and Web Technology, the journal of intelligent & fuzzy systems – Applications in Engineering and Technology, The journal of Expert Systems with Applications.

Abrar M. Al-Sowi received her master's degree, with distinction, in Information System from the University of Jordan in 2021. She received the grant as a teacher assistance at the Computer Information System department between 2019–2020. Currently, Abrar, beside her full-time job in IT solution provider, focuses on the research of Artificial Intelligence, Machine Learning, and Data Mining. She has published in journals such as the Journal of Theoretical and Applied Information Technology.

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