

Enhancing the quality of technical and vocational education in Saudi Arabia through the use of artificial intelligence and machine learning

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Abstract

The main problem for Saudi youth is that the skills they learn in technical and vocational courses do not match the job market requirements. The problem is more serious in the case of women. Many factors at various levels contribute to this problem. A qualitative review using 37 papers revealed many important findings towards solutions to this problem. One solution is that educational institutions and employers collaborate to ensure job-relevant skills with some practical experience through apprenticeships in the industry for students of technical and vocational courses. The use of AI and ML methods in teaching and learning may solve the problem of providing the required skills and enhancing its quality. However, evidence for concrete suggestions on which tool to use for which purpose is scarce. This is due to very few papers available on directly relevant aspects. Hence, more research on specific applications of AI and ML in specific areas of technical and vocational teaching and learning needs to be done.

Keywords: Technical and Vocational Education, Saudi Arabia, Artificial Intelligence, Machine Learning, Academic Failure, Trainee Dropout, Performance Improvement.

Introduction

According to Arab News (2023) the quality of vocational and technical education in Saudi Arabia ranked first in 2022 citing Global Knowledge Index 2022. Technical and Vocational Training Corp (TVTC) was able to attract 28% of high school graduates into vocational and technical courses in 2021. There was a stigma in favour of white-collar jobs in Saudi Arabia. This was broken by technical and vocational education and training (TVET). A key role in this was the socioeconomic strategies implemented by the Saudi government as a part of Saudi Vision 2030. TVET perceptions are related to gender, parental education and family income (Aldossari, 2020).

Self-assessment can help technical institutions to benchmark with other national and international institutions. In a brainstorming study, Alzamil (2014) found that many Saudi technical institutions were reluctant to implement self-assessment standards as they feared exposure to their weaknesses. However, if top management supports, these institutions are motivated to implement self-assessment standards.

Many organizations like the Technical and Vocational Training Corporation (TVTC), are now implementing smartphone applications as a part of their services. Hail College of Technology (HCT) launched a smartphone application called “Tahseen App” to improve the quality of practices in technical education. An evaluation of its effectiveness by Alshamari and Aichouni (2020) through a survey of 95 participants revealed some good features which can impact on quality improvement of technical education. Leadership was a key institutional factor in its success.

Thus, although Saudi technical and vocational education ranks first in the global ranking, many issues affect the quality of this education. This review aims to investigate methods to enhance the quality of technical and vocational education in Saudi Arabia using AI and ML methods. It is hoped that the review will lead to identifying how the use of AI and ML methods can address academic failure and improve trainees' results, trainee dropout, and trainee performance. Thus, the main review question is-

How can AI and ML methods be used to improve the quality of technical and vocational education in Saudi Arabia?

Some sub-questions from these are-

- a) What is the status of the quality of technical and vocational education in Saudi Arabia?
- b) Is it possible to use AI and ML methods to improve the quality of Saudi technical and vocational education?

Methodology & Results

Methods

A qualitative search of five pages of Google Scholar was done to identify full-text papers in English. No specific inclusion or exclusion criteria were used to select the papers. Only the relevance of the content to any of the research questions was considered. Using this method, 37 papers could be identified. These are discussed in the sections below.

Results

Despite reforms in vocational education and Saudisation by the Saudi government, private-sector employers perceived the continued existence of skill gaps in work ethics, generic skills and specialised knowledge. Technical education does not provide adequate vocational training to meet the skill demands of the job market (Baqadir, Patrick, & Burns, 2011).

Bahrain has socioeconomic factors similar to those of Saudi Arabia. TVET regulates and controls technical and vocational education in the country. Technical and vocational education aims to provide a planned programme of vocational skills development and work practice for a student, to assist the student in career exploration and selection of a career focus, to relate teacher skills to students' career focus, to connect school-based learning and work-based learning, to teach foundation skills like positive work attitudes and interpersonal skills, to provide opportunities for students to participate in structured workplace learning and to apply vocational skills and knowledge gained in the school-based programmes. However, there are challenges in achieving these aims. They include enhancing the achievement level of technical vocational schools from current to higher levels leading to outstanding levels, improving the student's ability to convert theory into practice, shifting from traditional teaching methods to modern methods, improving the effectiveness of teaching and learning, improving English language skills and assessment methods, improving infrastructure and opportunities for students to work together. The Ministry of Education has implemented several reforms to address these challenges. Two examples are the introduction of a General Secondary Vocational Educational Certificate (GSVEC) program adapted and modelled from Holmesglen Institute and the Victorian Certificate of Applied Learning from Australia (Al-Mahdi, 2014).

The National Commission for Academic Accreditation and Assessment of Saudi Arabia was established in 2004 for accreditation and quality assurance of post-secondary educational institutions. Based on some international frameworks, the Commission developed a 3-stage accreditation and quality assurance system. The system was implemented gradually with increasing acceptance. Within its 11-item areas of programmes and activities, a national qualifications framework specifies generic standards of learning outcomes, supporting materials like key performance indicators, student surveys, self-evaluation scales, templates for programme plans and reports and handbooks of quality assurance processes in detail with the support of the British Council through an Excellence in Higher Education project (Darandari, et al., 2009). Post-secondary education covers technical vocational education also. Hence these points apply to them.

The importance of the Technical and Vocational Education and Training (TVET) strategy and key policy to meet the skill needs of Saudi job markets was discussed by Ahmed (2021). There is an increasing need to qualify the Saudi youth in technical and vocational skills for industrial development. To achieve this, there is a need for a policy framework and direction and a transformation from the current design and delivery approach. For this purpose, the inclusion of Competency Based Training (CBT) in the TVET curriculum design and delivery at all levels of TVET institutions was suggested by the author. There are 176 TVET institutions in Saudi Arabia all with upper secondary level as the entry qualification. Out of 176, 52 are for male students and 36 are for female students. Of 176, 24 are strategic partner institutions and 64 are industrial secondary institutions. Student enrolment in male colleges was about 12400 and female colleges was about 31000. The other two categories accounted for about 9600 student enrolment. Thus, the potential number of students released to the job market is about 250000 per year. Although this number may be adequate to fill all job vacancies in technical and vocational jobs, the mismatch between the skills acquired by these students and those required for jobs leads to many of them out of jobs causing high unemployment rates. This means, that by solving the mismatch problem, unemployment among the Saudi youths can be reduced significantly. This can be considered as another way of Saudisation. This has been incorporated into the Saudi Vision 2030 documents. The challenges of TVET implementation and the role of TVTC in the TVET reform are gender equality in TVET programmes, increasing enrolment, improving the training environment using external guidance, incorporating ICT in TVET and developing suitable curricula.

Despite the Electronic Portfolio Management System (EPMS) importance, its adoption and implementation are quite low in Saudi technical and vocational institutions. This is because the end-user rejects it. The adoption of EPMS by TVTC organisations requires an effective framework. Alshahrani, Mohamed, Mukhtar, and Asma'Mokhtar (2023) used the Technology Acceptance Model (TAM), IS model and Technology-Organisation-Environment (TOE) model to explain the results of a survey of 375 TVTC institutions. The second-order factors of technology, organization, and environment, had positive effects on EPMS adoption. There was a substantial relationship between EPMS adoption and the performance of academicians and managers with the entire first-order factors accounting for 43% of the variations in EMRS adoption. EMRS explained 39% of the variations in employee performance.

A significant relationship between teachers' technology integration, teacher training programmes, accessibility to technical resources/equipment and the mission and vision of the technical and vocational institutes was obtained by Owais, Alabidi, Hatamleh, and Hussein

(2020) in the technical and vocational education context of the UAE. The three relationships were based on three models developed by the authors.

In Gulf states, TVET of female students faces an identity crisis. There are many problems in increasing the enrolment and employment of women in technical and vocational areas. Saudi Arabia and Bahrain, have been using TVET as a key element of educational policy for many years. However, other GCC nations are latecomers in this area. Women's participation in technical and vocational education is quite low in the GCC countries. Female students' percentage of total TVET enrolment in 2013 was 62% for UAE topping the list. In some technical education programmes, more female than male students enrol. This is because the societal and job market factors provide only a narrow selection of TVET programmes. Some GCC countries offer only very few courses for women. To increase women's enrolment in TVET programmes, improvements in its governance, accreditation, access to women for more courses and expansion of job opportunities for women are required (Khan, Aradi, Schwalje, Buckner, & Fernandez-Carag, 2017).

UN SDG (UNO, 2024) Target 4.1 connects SDG with education without gender discrimination, "4.1 By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and Goal-4 effective learning outcomes." Target 4.3 is specific to technical and vocational education, "4.3 By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university." The entire Target 5 deals with eliminating gender bias in technical and vocational education, thus, "5.1 End all forms of discrimination against all women and girls everywhere."

The problems faced by Saudi higher education are the increased unemployment due to a mismatch between some courses offered and what is required in the job markets, a lack of coordination between higher education institutions and job markets and non-recognition of shared value among all external parties. The results of a survey of students and graduates validated four hypotheses related to cooperative learning, input-output quality relationship, quality of Saudi graduates and job market requirements relationship, and the university's role in integrating the scientific reality of female graduates qualifying for job markets (Ibeaheem, Elawady, & Ragmoun, 2018).

To diversify the economy towards Vision 2030 targets, Saudi Arabia needs to reform its education sector. The reform should include training of teachers in modern methods of teaching including digital technology, listening to teachers' voices and development of skills like critical thinking among them. An educated citizenry, trained in several disciplines, and with the required skills will achieve progress toward a knowledge-based economy (Allmnakrah & Evers, 2020).

Many technical and vocational education institutions suffer from weak outcomes in qualifying their graduates to match industrial skill requirements leading to a negative impact on employment rates. Esmail and Khan (2024) tried to match the technical requirements for the jobs of technicians and plant operators advertised by industrial companies with the outputs of courses and training programs in technical and vocational education institutions. A sample of 50 advertisements was compared with the courses and training programs in one institution. Three main required tasks identified were operate, monitor, check and record data of the equipment, comply with safety rules and regulations, follow safety procedures and ensure the safety of personnel and plant operation, conduct operation activities, check the operational parameters and troubleshoot plant operation. The drivers of each task with course requirements were tabulated.

The results confirmed the compatibility of courses and training offered by the institute with the job requirements of the industry.

Three problems in technical and vocational training were noted by Alzu'be (2012). They were the inflexibility of the curriculum to match the changes in job market demands, the requirement of Saudi workers for better skills and higher productivity, the absence of proper coordination for human resources planning between the government and the industry and inadequately qualified Saudi graduates in the market having a negative impact in the job market.

In a review Raji (2019) noted that despite all the encouragement and initiatives of the UAE government, the uptake of technical and vocational education has been slow. The newly implemented computer-assisted education in TVET was a commercial success while contributing to the reduction of unemployment.

Esmail (2024) assessed the consistency of strategic planning in technical and vocational institutes and training companies (TVITC) in Saudi Arabia and the objectives of Vision 2030. The vision, mission, strategic goals, and common values of TVITC were measured from 2016 to 2023. A mind map, an affinity diagram, a thematic analysis, and other analysis tools were used. The strategic objectives and other elements of the strategic plan of TVITC were found to be consistent with the objectives of the Kingdom's Vision 2030. The expansion of TVITC over the past years matched the employment of TVITC graduates.

There are five dimensions of a knowledge economy. They are strategy, technology, institutions, knowledge environment and knowledge cycle. Saudi higher education institutions face local and global challenges in all these dimensions. The Ministry of Higher Education addressed these challenges through many short-term, flexible and long-term policies and strategies. Out of the many initiatives of the MoHE, seeking support and recruiting outstanding international faculty and Nobel prize winners seems a good strategy. Many of them teach and supervise post-graduate and doctoral research in Saudi universities. After the above discussions, Al Ohali & Al Aqili (2010) proposed some recommendations to the MoHE for further improvement.

The survey of 396 undergraduate students by Singh, Singh, Alam, and Agrawal (2022) showed a significant impact of education, training and e-learning on sustainable employment generation and social empowerment of Saudi society. Government policies moderated these two relationships. National culture impacted social empowerment. The theory of constructivism supports the learners' active role in constructing knowledge for both individuals and society, the validity of constructed knowledge and its representation in the real world.

In an overview of education systems in GCC countries, Maroun, Samman, Moujaes, Abouchakra, and Insight (2008) observed a low return on investment in education. The Education Development Indices for 2021 according to World Population Review (2024), are 0.86 for UAE, 0.82 for Saudi Arabia and Bahrain, 0.80 for Oman, 0.76, 0.68 for Qatar and 0.67 for Kuwait. An action plan for education reforms in Saudi Arabia was suggested by the Saudi MoE. This plan consists of an expansion of education facilities with the growing demand, the production of individuals with higher skills to create and achieve social goals, integration of globalisation into educational reforms for the enhanced global competitiveness of the country, curricula fitting the modern technological trends, protection of national cultural and traditional identities. The authors recommended the use of a transformational approach for incremental reforms, division of big projects into smaller ones, ensuring ownership and consensus among all stakeholders, and a transparent socioeconomic environment regular monitoring and review of the

outcomes and identification of accountability. Saudi universities have implemented many reforms successfully.

Vocational training in Saudi Arabia has grown rapidly enhancing the skills of the Saudi youth. A survey of 330 individuals employed in the higher education sector by Bhatti and Alshiha (2023) revealed that entrepreneurship culture and innovation directly influenced vocational training. The relationship between entrepreneurship culture and vocational training was mediated by entrepreneurship development programmes. The relationships should have been reversed according to common logic. Vocational training should influence entrepreneurship culture or development programmes, not the other way.

Community-based vocational instruction (CBVI) has several benefits. It is highly useful to train intellectually disabled (ID) children on skills required in the job market. A survey of 81 special education teachers who are involved in CBVI by Almalky (2018) revealed a positive attitude of these teachers on CBVI for ID students. However, some barriers were also listed by the teachers. The ranked barriers (1 to 16) are a lack of administrative, support, non-cooperation of employers with the schools, lack of cooperation between schools and external agencies, liability issues, lack of work opportunities for ID students in the community, pressure to focus on the academic curriculum, challenges of aligning standards with vocational goals., challenging behaviour of students, the severity of disabilities, limited experience in CBVI, lack of preparation time, funding and transportation, safety concerns, concerns of parents and inadequate staff. The sample size of 81 for the survey affects the validity and generalisability of the findings.

The private sector is playing an important role in improving the quality of the Saudi educational system. To accelerate educational reforms and achieve Vision 2030 goals, the Saudi government needs to promote increased investment in the private sector. Technical and vocational training is one area where there will be immense benefits due to increased public-private participation. Aseery and Aseri (2024) used analysis of Vision 2030, the Public Investment Fund (PIF) and the National Transformation Programme (NTP) in this study.

In the Saudi educational system, technical and vocational courses are offered to post-secondary students (Fig 1).

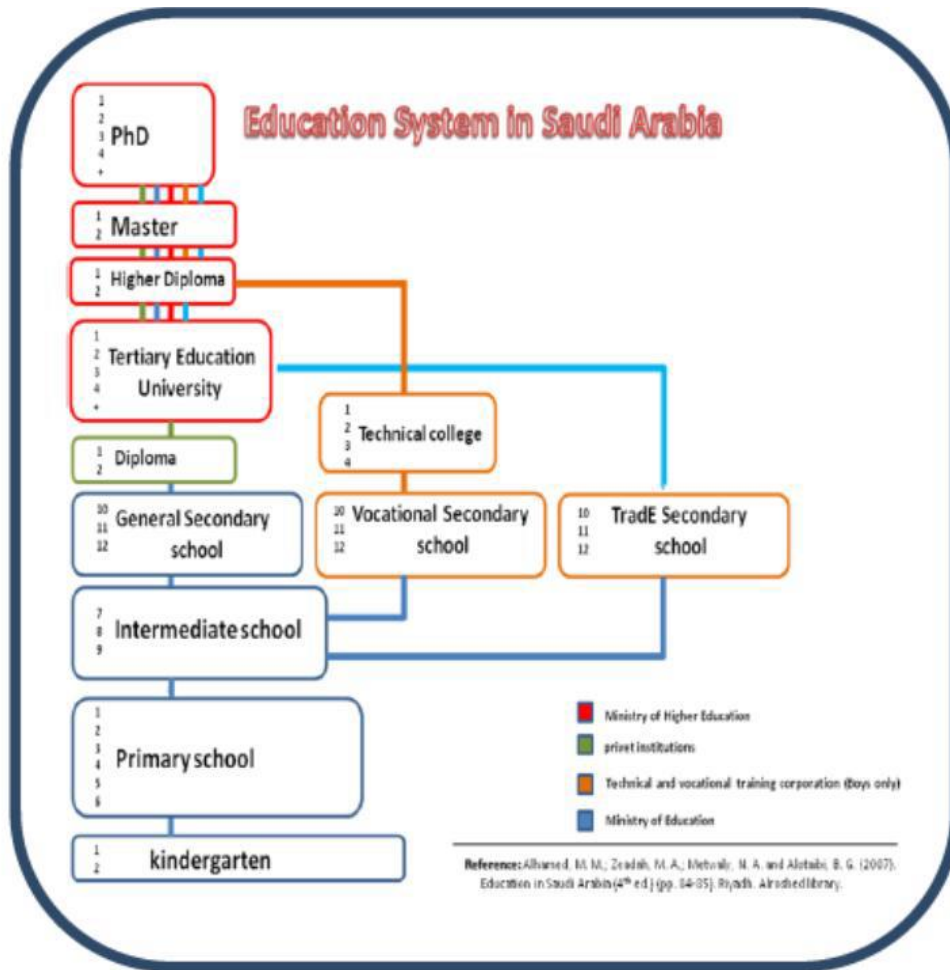


Figure 1 Education system in Saudi Arabia (Abouelnaga, et al., 2019).

In Saudi Arabia, the onset and integration of technical and vocational courses occurred during the 1950s. The General Organization for Technical Education and Vocational Training (GOTEVOT) was established in 1980 to address the technological education requirements at the college level to develop high-quality workforces. Further development in technology adoption for education led to e-learning and now smart learning environments are being developed (Fig 2).

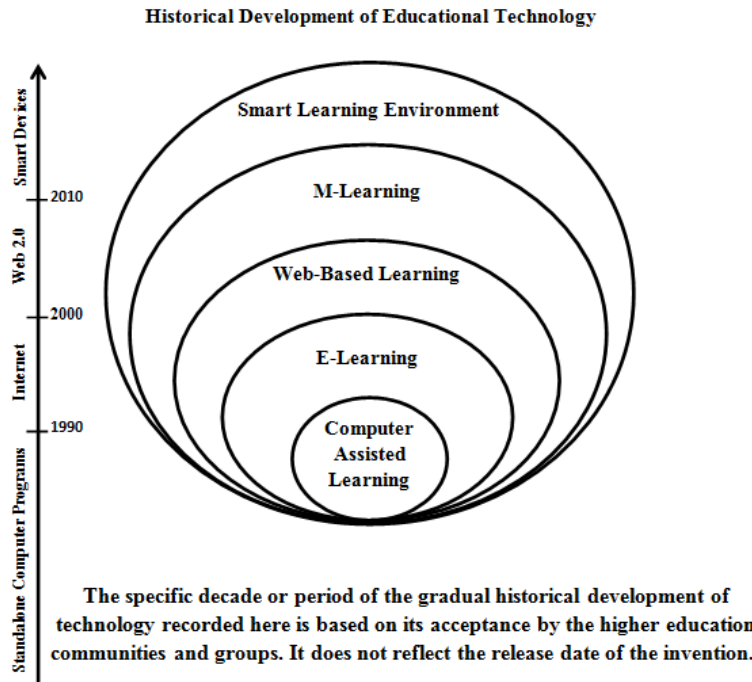


Figure 2 Historical development of educational technology in Saudi Arabia (Abouelnaga, et al., 2019).

All these technological developments enhance the effectiveness of teaching and learning, especially in technical and vocational training (Abouelnaga, et al., 2019).

From a survey of people in the Al-Qassim area, Ibeaheem, Ragmoun, and Elawady (2017) concluded that some of the current skills do not match market requirements. There is a lack of coordination between higher education institutions and employers. The principle of shared value is not recognised by external agencies. Qualities of inputs and outputs match skill requirements in job markets. The level and quality of Saudi graduates are related to current job market requirements. Universities have an important role in women's employment. There are many barriers to the implementation of cooperative training.

AI and ML methods to improve the quality of technical and vocational education in Saudi Arabia

According to the results obtained by Melweth and Alkahtani (2024) from a survey of 50 secondary school teachers, the teachers were confident about basic technology skills, but cautiously optimistic about the potential of AI technology to improve quality and reduce routine workload through automated grading, administrative tasks, and personalized tutoring. The results demonstrated the need for teacher-centred integration of policies and limited automation using AI, improving the technological skills of teachers for digital transformation not limited to tests and scores, but a holistic approach towards digitalisation of the Saudi education system.

Based on a systematic review of the literature, Alotaibi and Alshehri (2023) concluded that AI is in a nascent stage in the Saudi education system. It is developing rapidly and hence will become a reality for higher education institutions shortly. AI can help to address learning challenges. Both teachers and students need to acquire the skills for its proper use. The use of AI can accelerate the progress towards Vision 2030.

Aljohani, Aslam, Khadidos, and Hassan (2022) noted an emerging big data and AI market in the Saudi technical market. About 50% of industries seeking applications are related to information and software technologies. The highest demand was for machine learning and data science skills. The authors recommend some jobs, certifications and soft skills suitable for job markets. The authors discussed some of the latest AI, ML, and learning analytics developments. In this respect, the authors proposed some novel, viable and innovative approaches for a sustainable framework for skills and competencies related to digital transformation in the Saudi economy. The authors demonstrated a methodological framework to predict future market needs for sustainable skills management for which, they used AI and big data analytics.

A model using Markov Chain and greedy algorithms for teacher-student interactions in virtual classrooms and labs was built by Fakeeh (2017) on a Deep Belief Network architecture as a novel approach for Energy and Wireless Communication courses in higher education. The author also developed a bio-inspired Differential Evolution algorithm for the virtual labs and virtual classrooms with specific learning requirements for the teacher-student interactions specific to this e-learning platform. There is no indication in the paper that the model was tested and validated.

An Arabic AI-powered web chatbot, Tayseer, for quick access to college information and communication between students and colleges, was developed by Alabbas and Alomar (2024). Tayseer was tested at the Technical College for Girls in Najran (TCGN) for technical and vocational courses. A sample of 210 students used Tayseer during the first semester, proving its efficiency in advising students with 90% precision identifying 50 types of questions from inputs. Thus, an advanced conversational agent was developed to help students in procuring information about the institution, courses and admission procedure. However, further improvements for specific challenges of negative responses and comprehensiveness of responses were noted.

The Maharat platform of Taif University has problems with variations in objectives, content, trainers' efficiency, online interaction and participation patterns, training strategies, evaluation tools, and feedback techniques. The achievement of standards had been low in dimensions of planning, curriculum design, leadership, online learning and training, technology, assessment, student support, continuous improvement, and evaluation. To rectify these defects, Alsubaie (2023) proposed a Machine Learning (ML) approach to predict the student's performance. This can help to enhance the quality assurance of online training programs via the Maharat platform at Taif University for online learning training based on the standards in Saudi Arabia. A survey of 208 faculty members of the University provided 93.2% accuracy for support vector machine (SVM) followed by 92.3% accuracy for Naïve Bias for academic achievement prediction. Items of platform leadership, standards for technology and programmes, design, interactions, justice and accessibility, measurements and evaluation were agreed or strongly agreed by the participants.

In their studies, Lakshmi, et al. (2023) noted that digital technology has a tangible impact on all aspects of higher education with the support of the institution. The organization plays a crucial role in the integration of digital technology into teaching and learning. There is a need to examine the evidence already available in the Collaborative Technical Education (CTE) organization to identify the potential effects of new digital technology. AI can make e-learning more interesting, efficient, and tailored to each learner. All these will contribute to better learning outcomes and wider access to technical education.

A survey of 60 UAE teachers by Jarrah, et al. (2024) showed that moderate challenges related to technological innovation in teaching vocational education. The challenges related to the use of technology, school capabilities and curricula were significantly affecting student outcomes. The authors recommended technological infrastructure in all government vocational schools. However, the small sample size of 60 can affect the validity and generalisability of the findings.

Using AI applications, teachers can identify poorly performing students and help them to improve on their weaknesses. This is more useful in an e-learning context. Each institution adopts e-learning methods as the primary way of learning. For social distancing, e-learning was adopted by most educational institutions during the COVID-19 pandemic. Despite being a creative solution for many problems, there are many challenges in e-learning adoption. They include the delivery of quality education, performance analyses, determining teaching strategies for performance and future goals, and career counselling for students. Based on a systematic review of various ML methods used in education, Shafique, et al. (2023) noted that very little research has been done on using these methods for implementing corrective measures when the current strategies do not produce the desired outcomes.

Despite computers becoming ICT tools for teaching and learning, educators are unable to incorporate them into their processes. This leads to students being inadequately skilled for the job market. Those who are employed perform poorly. In the case of TVET, this problem can be solved by determining its quality. Kanbul, Adamu, Usman, and Abba (2022) examined the literature on competence required by TVET teachers for the use of ICT in classroom teaching and learning using the technological pedagogical content knowledge (TPACK) model. A survey of Nigerian 60 TVET teachers revealed that they were competent in some technologies using computers. This competence was correlated with their teaching experience, but not with their gender. The sample size of 60 for a survey is inadequate for validity and generalisability.

Semi-structured interviews with 40 participants from the government, academia and industry in Saudi Arabia by Gadi (2021) revealed the willingness of cooperation between universities and businesses to help women for employment. These arrangements can increase the potential for increased female employment in the country. Academic institutions have adequate facilities for the vocational training of women. Based on these observations, the author recommended efforts to increase the participation rates of women in vocational education and training through incentives from the government. Employers can arrange workshops to create awareness among women on the importance of vocational education and training in digital technologies to get jobs.

The paper by Hemachandran, et al. (2022) highlighted the progressive research in identifying the opportunities of AI in the field of vocational courses. More specifically, AI tools can simulate one-on-one/mentor-mentee and supervised learning experiences to meet the needs of students in vocational education.

There is a high scope and potential for using AI to pay attention to the four pillars of education in Saudi Vision 2030. Vocational education and inclusive education are two of the four pillars (AlGhamdi, 2022).

Discussion

In Saudi Arabia and a few other GCC states, the situation regarding technical and vocational education is similar. UAE may be a bit ahead due to its economic status.

A serious mismatch between the skills required in the job markets and the skills possessed by the Saudi youth drives unemployment despite adequate job openings and this leads to the need for job-oriented technological and vocational education. The achievement level of technical and vocational schools needs to be upgraded to embrace modern technologies like AI and ML to improve quality. Although students passing from these schools possess theoretical knowledge, they do not know how to use them in practice. This limitation fails them in getting jobs. Foreign firms provide attractive jobs in technical areas. However, limitations of English language proficiency prevent Saudi youth from getting these jobs. Quality accreditation standards introduced by the National Commission for Academic Accreditation and Assessment of Saudi Arabia are being slowly accepted by technical and vocational schools. The mismatch can be addressed if there is collaboration between educational institutions and employers coordinating the job markets. This can lead to good compatibility between the courses offered by the institution and the job requirements of employers. The mismatch is also due to the inflexibility of the curriculum to match the changes in job market demands, the requirement of Saudi workers for better skills and higher productivity, the absence of proper coordination for human resources planning between the government and the industry and inadequately qualified Saudi graduates in the market having a negative impact in the job market.

There is a need for a policy framework and improvements in the design and delivery of courses. The challenges of TVET implementation and the role of TVTC in the TVET reform are gender equality in TVET programmes, increasing enrolment, improving the training environment using external guidance, incorporating ICT in TVET and developing suitable curricula. The adoption of the Electronic Portfolio Management System by technical and vocational schools is quite low. The technical and vocational institutes and training companies (TVITC) offer a good way to improve the scope of more Saudi youth getting jobs. Private participation in technical and vocational schools will enhance their quality.

Teacher training for better design and delivery of technical and vocational courses is important. They should also be trained in the use of digital technologies in education. Community-based vocational training can supplement classroom training and provide some practical experience to the students. Teachers have a major role in this. So, their training should include this aspect also.

In converting Saudi Arabia to a knowledge economy, technical and vocational education has an important role. The early plan of MoE consists of an expansion of education facilities with the growing demand, the production of individuals with higher skills to create and achieve social goals, integration of globalisation into educational reforms for the enhanced global competitiveness of the country, curricula fitting the modern technological trends, protection of national cultural and traditional identities. This plan is valid even today.

As vocational training promotes an entrepreneurial culture and innovation, those who pass vocational training courses can establish businesses instead of seeking jobs. This is another way of reducing unemployment.

Many of the above problems can be solved using AI and ML methods. A few research papers available on this aspect provide promising results. However, in the absence of an adequate

evidence base through research, specific AI tools for specific purposes cannot be suggested at this stage.

Conclusion

This paper aims to undertake a qualitative review of the status of technical and vocational education in Saudi Arabia and AI and ML methods as solutions.

The main problem for Saudi youth is that the skills they learn in technical and vocational courses do not match the job market requirements. The problem is more serious in the case of women. Many factors at various levels contribute to this problem.

One solution is that educational institutions and employers collaborate to ensure job-relevant skills with some practical experience through apprenticeships in the industry for students of technical and vocational courses.

The use of AI and ML methods in teaching and learning may solve the problem of providing the required skills and enhancing its quality. However, evidence for concrete suggestions on which tool to use for which purpose is scarce. This is due to very few papers available on directly relevant aspects. Hence, more research on specific applications of AI and ML in specific areas of technical and vocational teaching and learning needs to be done.

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