

AUTOMATED ASSESSMENT AND LEARNING FRAMEWORK FOR COMPETENCY-BASED TRAINING IN TEVT INSTITUTIONS OF SINDH, PAKISTAN

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ABSTRACT

Competency-Based Education (CBE) is a globally recognized instructional approach that emphasizes the achievement of demonstrable skills and knowledge rather than time-based progression. In Sindh, Pakistan, Technical Education and Vocational Training (TEVT) institutions traditionally rely on manual assessment methods that are time-consuming, subjective, and resource-intensive. This research introduces a web-based automated assessment and learning framework designed to improve the accuracy, efficiency, and reliability of Competency-Based Training (CBT) evaluations. The study involves data collection from multiple TEVT institutions, analysis of existing manual procedures, and development of an automated Decision Support System (DSS) using ASP.NET Core and C# programming. The framework digitizes assessment workflows, manages evidence records, and enables real-time performance monitoring for learners and assessors. Results demonstrate that the proposed system significantly reduces assessment time and enhances feedback quality. The system architecture ensures transparency, scalability, and adaptability to diverse vocational domains. This automation initiative marks an important advancement toward modernization and digital transformation of TVET education in Sindh.

1. INTRODUCTION

Education is a vital component of national development. The resources that are created through education are among the most important factors that drive a country's development. A study conducted by Curle in 1966 found a strong correlation between a country's attitude towards education and its rate of

development. In another study by the same author, it was found that countries that invest more in education tend to have a higher rate of economic growth as compared to countries that spend less on education.

It has also been emphasized that work-oriented education should be recognized as an effective means of fulfilling individual needs and employment requirements. Gordon's study in 1971 points out that work-oriented education can equip individuals with the necessary skills to secure employment and to contribute to the growth of the economy.

Technical education needs to be connected to other sectors of society so that it can educate and train the necessary technical personnel and skilled workers required for socio-economic development. With society changing rapidly, technical education needs to enhance its linkage with the world of work to meet the changing demands. Moreover, to cope with the evolving nature of the workplace, it is crucial to develop the skills needed for a job through lifelong education.

Sustained socio-economic development requires more than mere capital investment. To increase capital investment, it is crucial to have a skilled scientific and technical staff. A mix of skilled workers, artisans, technicians, engineers, researchers, and designers trained in subjects connected to industrial demands and national development needs are necessary for rapid economic growth. The Government of Pakistan stressed the need of investing in human capital in this statement from 1998 when discussing socioeconomic growth.

Quaid E-Azam Muhammad Ali Jinnah, the founder of Pakistan, made it very apparent to the attendees of the First National Education Congress in 1947 how important it was for students to have an education in science and technology. The shift from general education to a more specialized agriculture technical education was given priority in the Pakistani government's education strategy from 1972 to 1980.

The relevance of technical education as one of the primary educational goals was also acknowledged in the National Education Policy of 1978. A detailed development strategy for technical education in Pakistan was presented in a 1953 study by the Technical Education Commission.

Schooling is crucial for national development, and technical learning plays a significant role in creating the human resources necessary for socio-economic development. Governments need to invest in education to enhance the skills of their citizens and to ensure that they can contribute effectively to their country's progress. Professional tutoring must be related to other segments of society, and to adapt to changing requirements, there has to be a close connection with the workplace. Finally, scientific and technical education is essential for reinforcing capital investment and creating a workforce that is skilled and ready to meet the needs of the industry.

1.1 Competency-Based Education (CBE) In Sindh

Competency-based education (CBE) is a term used to describe a wide range of educational activities, from individual learning modules to total graduate programs. However, there is still confusion regarding what CBE really is and debates over its value. CBE can be perceived as a broad concept used as a framework for a total curriculum or interpreted narrowly as a framework for an individual unit of instruction. CBE involves an auto assessment method that uses well-designed performance criteria to cover a range of skills and knowledge. However, research studies on automated assessment in technical education in Sindh are still scarce.



Fig. 1: Competence Diagram



Fig. 2: STEVTA INSTITUTE

Technical education after Sindh gained its independence, engineering institutes began to provide education, accepting roughly 350 students annually across three engineering specialties (civil, electrical and mechanical). the Government, the original technical university. The United States' Ford Foundation helped establish the Karachi Institute of Technology (GCT) in 1955.

CBE is gaining attention from federal and state policymakers, foundations, and colleges as a form of higher education that provides credit based on student learning rather than credit or clock hours. One of the promising features of this model is its potential to lower college costs and provide flexibility for adult students. Vocational education is currently being reformed worldwide to provide young people

with access to the world of work or as an alternative to purely academic education. However, high youth unemployment can result from economic, social, and related policies in technical education, leading to skills shortages, mismatches, and inadequate qualifications. In some cases, economic restructuring can also contribute to skills shortages and mismatches in many countries.

1.2 Technical Education and Vocational Training (TEVT)

As of now, there are a total of 252 TEVT institutions spread across the province. However, until recently, the TEVT administration in Sindh was fragmented and controlled by three different departments: Education & Literacy (182 institutes), Labour (34

institutes), and Social Welfare (16 institutes). This lack of coordination resulted in overlapping functions, particularly in the area of vocational training, and ineffective control, without proper alignment to Federal/Provincial Policy Framework. Furthermore, the infrastructure of these institutions, including buildings, equipment, machinery, and faculty, did not meet national and international standards, leading to proficiency gaps in trained manpower that were not acceptable to local and international labor markets.

To address these issues, the Sindh government established Sindh TEVTA to manage and undertake TEVT institutions in the province, in line with the scheme of reorganization adopted by other provinces. The STEVTA Board, consisting of eminent professionals from the public and private sector, representatives from leading industries and universities, was entrusted with the task of policy making to extend complete autonomy and effective management. As of February 28, 2009, the administrative control of all TEVT institutions in the province was entrusted to STEVTA by the Sindh Cabinet.

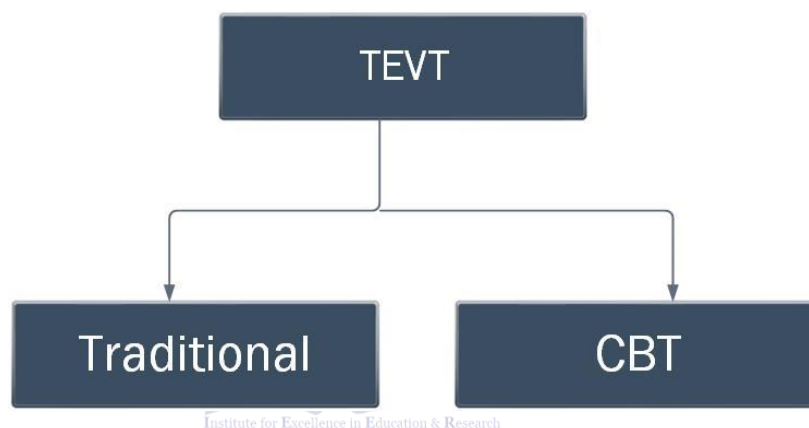


Fig. 1: Teaching System of TEVT

1.3 Manual CBT Assessment

Competency-based training brings a fresh, active analytical and experiential focus. The mysticism, romanticism, religious fervor, and indisputable traditions that previously dominated the thinking of educators have been displaced thanks to his analytical and empirical orientation, and new epistemological foundations have emerged. is created [2].

Though, the manual assessment often used in competency-based education in TEVT and many institutes in Sindh, Pakistan and the world. Although, the other method can be used on the place of manual assessment wherein there is no any human involvement. This method mainly based upon automatic assessment process. The method involves the very small use of resources during assessment. The automatic assessment is easier, accurate, reliable and valid than the earlier one. The result through this method may be more accurate, fast and less biased

than the manual assessment. Since, the manual assessment is fully performed by the human involvement. Therefore, this method takes too much time in assessing and declaration of the result but the result in automatic assessment is given very quickly, accurate and reliable after completion of the test.

1.4 Motivation

Modern Technologies have impacted several fields which also include Education system such as virtual universities which provide distance learning programs. Due to emerging technology, modern concept is emerging for enhanced education system which provide competency-based trainings, according to recent studies South Africa, Australia and Germany are adopting this advanced model of distance education.

In Pakistan competency-based approach is negligible only few institutes are trying to partially implement

this modern technique. Advance countries prefer to automate the repetitive tasks in order to minimize human resources. Examination assessments, feedbacks and complaints are prime examples of automation in education system unfortunately in Pakistan there is lots of human resources used to perform these tasks

Hence, we are interested and motivated designing and Competency Based training in TEVT Institutions in Sindh.

1.5 Problem Statement

It has been observed through various institutions that the assessment and learning modules in competency-based education in TEVT mainly focused at manual assessment therefore there is a need to introduce a method of assessment that is automated assessment computed based assessment of CBT.

Assessment based on sometimes tracking devices or the trust only which may overcome by computer-based assessment.

1.6 Research Aim and Objectives

The aim of the Research is to provide the automated methods that could help assess the CBT trainees in TEVT sector Sindh.

The main objectives of the proposed study are:

- To identify the factors of assessment for the trainees in CBT based courses.
- To provide the automated assessment of CBT based courses.
- To suggest a scheme designing a framework assessing competency-based training (CBT).

1.7 Research Scope

The research aims to design a framework to automate technical and educational processes in Sindh. The potential for utilizing new technologies in an automated assessment system has also been explored. Teaching and learning experiences are also enhanced. It has also been emphasized that the teacher should not be limited to a specific style of presenting assessment material while applying Competency-Based Training (CBT). In turn, software package has also been developed. It facilitates the management of

programming assignments. Work of students can be submitted safely. In response, evaluation of the work against predefined criteria, including unit tests, using a user-friendly interface to provide feedback and marks can be performed automatically by teachers. The software package incorporates support for software metrics and unit testing. It enables a thorough software engineering-based approach. It utilizes novel technologies to simplify the administrative aspects of the process.

1.8 Research Outcomes

- A framework for automated assessment of trainees in CBT based courses.
- Web based application for providing automated instruction-based decision support system for CBT courses.
- To provide minimum human intervention by proposing a modern framework which supports cross platform and cross device in Sindh for assessment of the competency-based training (CBT).

1.9 Organization of the Paper

An introduction to Competence-Based Education (CBE), Technical Education and Vocational Training (TEVT), and CBT Assessment in Sindh is provided in Section 1 of the thesis' framework. The goals, issues, and advantages of the research are also presented in this section. For good reason, we have included the objectives, findings, and contributions of the research. In Section 2, a literature search is offered. The study approach and my primary contributions are described in Section 3. Suggested automated training and learning in database decision support systems, automation frameworks, and CBT analysis. The structure and approach that are suggested in Section 4 are also described, along with the analysis' findings. Section 5 concludes by outlining the paper's recommendations and next steps. References are included at the conclusion of the essay.

2. LITERATURE REVIEW

This section discusses several ancient and contemporary technical techniques. Study undertaken by several researchers in the field connected to competency-based training and

evaluation at his TEVT Institute in Sindh. The frameworks of similar investigations and parallel variations of completed studies are also examined.

2.1 Technical and Vocational Education and Trainings (TVET)

The TVET (Technical and Vocational Education and Training) system is an educational approach that focuses on providing training in various trades to individuals for a duration ranging from three months to three years. This training is offered by both public and private sectors and is available in all UCS areas across all districts in Sindh. The TVET system is comprised of 3-tiers of practical tutoring, vocational preparation and technical training which are facilitated through the utilization of technical colleges, vocational teaching centers, technical institutes, UC wise development sectors, and private institutes and training facilities.

Instilling technical and vocational skills into the workforce of Sindh, developing human resources, and fostering human capitalism are the primary goals of the state vocational education system. The National TVET Policy was introduced in 2015 with its eight objectives to support skill development in Pakistan. These objectives also apply to the state workforce, with a focus on helping Sindh's unemployed young improve their skill sets. State vocational education authorities, directors and departments promote technical and professional progress, develop manpower, create employment opportunities, reduce unemployment, and train skilled youth towards major projects and economic corridors. Prepare They also aim to spread skills to those who do not have them.

The Balochistan Government (2011), P-TEVTA (2018), Khan and Khan and Ahmed, NAVTTC (2018), Labor Force Survey (2015-16), and Khan and Khan are all part of the Sindh TVET system (2018). Such. The administration and promotion of the VET system, collaboration of his VET system with linkages to the labour market, and many other things are among the key goals of the VET system. In the long run, Sindh's TVET system will help to increase productivity, sustain economic growth, improve job prospects, upskill and retrain employees, and export skilled workers while satisfying the need for skilled workers on the labour market. Intends to accomplish.

2.1.1 E-Learning / Distance Learning

Started in two thousand eleven, the in-house capacity building initiative was carried out by 19 nationwide e-Education Facilities. More than 90 e-trainers were first educated to educate other teachers. The prime supervision was carried out by "National Vocational and Technical Training Commission", these e-Learning Centers continue to inter linked operations through provincial capacity building education,

TEVTAs and PVTC (NAVTTTC). Four Staff Training Institutes (STIs) are now operating under STEVTA's increase on as part of the European Union-funded TVET Reform Support Programme (TRSP). The STIs facilities are upper Sindh Larkana and Sukkur including Hyderabad and Karachi. The In-Service Trainings (Pedagogy) utilizing Blended Learning approach under the TEVET Reform Support Program (TRSP) were initiated during 2014 for Sindh Government for capacity building of 2400 professional tutors. More than thirty lead professional tutors from Sindh TEVTA were educated through German Experts to distribute the training, and GIZ (German Society of International Cooperation) created web based online learning systems (with the support of technical and modern equipment and furnishings) for Sindh Government on all four STIs.

2.1.2 Modern Skills Development

Fukuyama (1995) argues that organizations, rather than individuals, are responsible for most economic and commercial activities. These organizations require high levels of cooperation to promote social cohesion, Common standards of conduct, expertise and collaboration reflect the company's entire human resources. However, fundamental deficiencies in the proper preparation of teachers, lack of parental support for education, coordination and gender bias in decisions about sending children to school and training them for work, all contribute to government inertia. It leads to organizational and social coherence, which is a metaphor. Therefore, proliferating technical and vocational schools is essential for economic prosperity.



Yang (2004) suggests that students' understanding should be improved through particular encounters and sensitive stability to identify reality objectively. For this purpose, institutions should create an organized and well-designed learning process, and accumulating abilities across vocational colleges is imperative. While the development of "human capital" emphasizes the accumulation of cognitive talent as well as the acquisition of broader knowledge and skills, non-cognitive qualities also play a role in the development. Efficiency of human capital and can be affected by external learning. Human and social capacities and their development are prerequisites for effective policy-making, and policies should consider the well-being of society as a whole, not just individuals. Policy interventions should be holistic and address issues such as gender disparity, dowry, and early marriages to open up new opportunities for growth and prosperity. According to Rosen (1999), human capital is the investment people make in themselves to become more productive.

In 2007, Frank and Bemanke provided a definition of human capital that includes several factors that influence workers' marginal product value, such as education, experience, training, intelligence, vitality, work habits, reliability, and creativity. Other researchers also define human capital as "human knowledge, skills, talents, and characteristics that contribute to personal, social, and economic well-being" (Rodriguez and [18]). Psacharopoulos and Arriagada (1986) propose that the average number of years spent in education can be used as a measure of human capital. Therefore, the importance of higher education and engineering should not be underestimated.

Therefore, investing in education and skills development is crucial for individual and societal growth and prosperity. The acquisition of skills through vocational colleges is imperative, as it leads to the accumulation of human capital and the development of cognitive and non-cognitive skills. It is important to note that the development of human capital is influenced by cultural settings and external learning experiences.

Additionally, the fair policymaking requires development of human and social capacities. Policymakers need to take a holistic approach. It guarantees policy development and to ensure the overall well-being of a society. It encompasses to check the devastating effects of gender inequality, curse of dowry, and issues of early marriages. It is really a litmus test for speaking government actions to open new opportunities for proper education, especially for girls. It can be gauged from the fact that countries that have invested in education have undertaken successful journey in every segment of the society. They have touched the pinnacle of growth and improvement to maintain the quality and standard of life for their masses.

Human capital is a set of characteristics that affect the marginal value of output of workers, including intelligence, energy, work habits, reliability, and initiative. It also includes the information, abilities, skills and characteristics of people that help build their own personal, social and economic well-being. Since the average number of years of schooling is a useful indicator of human capital accumulation, it is often used to estimate human capital stock.

Education and skills development are crucial for individual and societal growth and prosperity.

Policymakers need to take a holistic approach to policy development to ensure the overall well-being of society, and investing in education is a key factor in achieving this goal. The accumulation of human capital through the acquisition of skills and knowledge is an essential component of economic growth and development.

2.2 STEVTA

In 2009, the government of the Pakistani province of Sindh established STEVTA, which consisted of representatives from various government sectors, the private sector's legislative body, leading businesses such as Siemens and Engro Company Limited, and worked with the Chamber of Commerce & Industry. Currently, in 2017, Stevta was operating more than 251 Technical Education and Vocational Training (TEVT) institutions, which employed over 2000 teaching staff. These institutions offered a diverse range of technical programs, such as Bachelor of Technology, Bachelor of Science in Industrial Technology, Associate of Engineering Diploma, Diploma and Certificate in Business, Technical School Certificate (equivalent to the Metric Diploma), Diploma, Certificates, and Short Courses in Information Technology, as well as Vocational Diploma, Certificate, and other certificate programs (Stevta, 2017).

IN-SERVICE TRAINING (IST) PROGRAMMES

STEVTAAs part of the TVET Reform Support Program, STEVTA implemented a novel strategy for providing in-service teacher training programs for TVET teaching staff. Unlike traditional classroom-based training that follows a teacher-centered approach, this innovative training program utilized a blended learning model supported by IT, where trainees were required to use the internet and develop lesson plans. The training provided participants with both educational theories and practical tools to enhance their course delivery skills. The program consisted of a four-week instruction period, which included two weeks of self-learning during which participants were required to complete specific tasks. (Uwaifo and Uwaifo, 2009).

IN-SERVICE TRAINING AND TEACHER'S PERFORMANCE

Samupwa (2008) suggests that teacher training can positively impact teacher performance in the classroom, leading to improved behavior and outcomes for students. Schunk, Meece, and Pintrich (2002) also argue that in-service training programs can greatly contribute to the improvement of the educational system. It has been suggested by Zimmerman, Boekarts, Pintrich, and Zeidner (2000) that qualified teachers are more successful while creating effective teaching strategies for their students. In-service training programs can also help teachers to develop a greater awareness of their role. It makes them to become more inclusive practitioners. In sum, as per Kazmi, Pervez, and Mumtaz (2011), in-service training programs can provide teachers with systematic and methodical approaches for conducting their classes.

The following in-service teacher training outcomes Programmes has been proposed by Sim (2011) proposes:

- Improve instructors' expertise
- Foster a culture of optimism
- Improve teaching techniques

2.3 Competency Based Training (CBT)

Competency Based Training (CBT) is a training approach that emphasizes the ability of learners to perform tasks in the workplace. After completing a training program, it enhances the intellect of the teachers. CBT focuses on practical application of knowledge and skills, rather than just theoretical understanding. These training programs are designed to identify the required level of competence for different levels of performance within a specific work function. It means that learners are evaluated through their ability to transfer and apply the acquired knowledge and skills to new situations and environments.

CBT is a comprehensive learning approach that integrates assessment. It is a vital component that determines whether a learner has achieved the specific learning outcomes. It analyses the outlined aims and objects in the learning unit specifications for each course. Assessment in CBT is the process of collecting evidence. In turn, performance of learners is determined whether they have met the requirements

of the learning outcome specified in a particular unit. The assessment process measures whether a learner is competent or not competent, and if they are not yet competent, they develop their skills and knowledge further before being assessed again.

To ensure emphasis on performance, the assessment process in CBT uses different approaches, including observation, product, and questioning. The content material of the education is connected especially with the talents and competences needed to carry out the process, and the characteristic school materials are designed to aid the purchase of understanding and abilities. When entering this system, individuals' understanding and abilities are assessed, and those with first-rate know-how and talent may additionally skip training or skills already achieved.

CBT encourages self-paced learning and time to understand a competency is not always a critical element. This approach includes flexible learning approaches that consist of large group techniques, small group sports, and man or woman tours with the augmentation of supporting materials such as print, audio-visual, and simulation. Successful completion of education is based on the success of all distinctive abilities.

Advocating CBT, however, comes with challenging situations. These challenging situations consist in identifying the exact talents and abilities in the extraordinary ranges for each profession, in the development of educational requirements (curriculum), in the development of competency study materials (school materials) and in their continuous evaluation. CBT implementation can be managed with the help of external experts and donor assistance, which can present challenging situations, especially in the financial and political context of several international locations.

CBT is a training approach that emphasizes practical application of knowledge and skills in the workplace. Assessment is an integral part of CBT, and learners are evaluated based on their ability to transfer and apply acquired knowledge and skills to new situations and environments. The implementation of CBT can be challenging, but the benefits of this approach can result in highly skilled and competent workers who can adapt to changes in the workplace. CBT has become an increasingly popular training approach in recent years, and organizations can benefit from

implementing this approach to develop highly skilled and competent employees.

2.4 Automated Assessment

Assessments serve as a valuable tool in supporting student learning by helping them identify areas where they need to improve in order to achieve their studying targets [11]. The valuation strategy method begins by selecting the mode of assessment that aligns with the purpose of the review. Appropriate evaluation settings and types of competences are then evaluated primarily on the basis of the ratio between the fee and the benefit in the phrases financial price and testing time. The evidence-based assessment framework suggests that examinations must begin with clear information about whether the assessment will focus on testing the understanding or abilities of undergraduate students, as indicated in the general content of the material. Teachers must then offer a method to theoretically or almost theoretically test university students [12]. Currently, professional educators emphasize the use of opportunity tests along with portfolios, assignments, quizzes, reviews, and practical assessments to measure the information or abilities of undergraduates. Providing alternative assessments for professional subject students is a progressive coaching and learning technique that is focused on making sure that inexperienced individuals expand the capabilities they want in the administration center. The concept of alternative assessment, using innovative, revolutionary and more modern strategies, was proposed by [13]. It is primarily based on the need to align tests with the cognitive types of 21st century students.

Digital alternative assessments have several advantages over traditional assessments while using it. Digital assessments can be more efficient and cost-effective. It eliminates the need for printing and distributing paper-based assessments. Quicker and more accurate scoring is also allowed. The potential for human error is reduced. More personalized feedback to students also comes under the umbrella of digital assessments. As identification of areas where students need to improve are highlighted.

Simulation-based assessment can be an example of a third-generation digital assessment. A real-world scenario for application of student's skills and knowledge is given. These assessments are highly

engaging. A more realistic experience is provided to students. Immediate feedback can be availed through smart tutoring applications. Learning experiences are personalized. The difficulty level and pace of instruction to match the needs of individual learners are adjusted.

In digital assessments, Artificial intelligence remains crucial. Data is analyzed. Information of instruction is identified. Learning outcomes of students are ameliorated. Performance of students through given set of data, while employing, AI algorithms can be quoted as remarkable example Personalized learning activities are identified. Struggle to address these areas is done.

Implementation of digital alternative assessments also invited daunting challenges. These challenges may be using of appropriate technology and infrastructure. Accessibility and equity is ensured for all pupils. Concerns regarding data privacy and security are also addressed. These challenges must be read between the lines by educators and policymakers. Potential benefits of digital alternative assessments are fully realized. Student learning mechanism is supported.

Automated Assessment: A New Frontier in Education

In evaluation of learning outcomes of students, assessments play a crucial role. Instructional decisions are informed. In contemporary era, new assessment methods of technology have been used. Greater flexibility, efficiency, and accuracy in evaluating student performance have been accomplished. Automated assessment is worth-achieving innovation in this area.

Automated assessment is defined as the use of computer software to evaluate learning outcomes of students. In this field, algorithms and machine learning techniques are utilized. Responses of students to question are recorded. Immediate feedback on performance of the students is evaluated. A wide range of learning outcomes is elaborated through automated assessment. Knowledge, skills, and attitudes are also covered under this scheme.

Innumerable benefits are offered by the virtue of automated assessment. Firstly, in evaluation process, greater efficiency is offered. It automates the grading of assignments and tests. Time is saved and workload is reduced on teachers. At the second step, provision

of immediate feedback to the students is ensured. Areas of improvement are also identified. Their learning strategies are adjusted. Eventually, engagement and motivation in learning process of the students is also guaranteed. At last accuracy and objectivity of automated assessment is highly responded and elimination of the potential human error and bias in the grading process are also discouraged.

Automated assessment tools can be categorized in several versions. Online quizzes, computer-based simulations are its examples. These are also called adaptive learning software. In today's world, online quizzes have gained popularity. Through this, teachers create multiple-choice questions. They also provide instant feedback to students. Automated assessment can also be displayed in Computer-based simulations. Interaction of students is also done in simulated environment. It receives immediate feedback performance of students. Automated assessment can be displayed in its advanced form of Adaptive learning software. Machine learning algorithms are used. It personalizes the learning experience for each student. This experience is based on their individual merits and demerits.

Automated assessment counters both advantages and disadvantages challenges. These need to be addressed. The main challenge is to ensure the security and integrity of the assessment process. Computer software is the foundation of automated assessment. The risk of hacking and cheating cannot be overlooked. For this reason, use of secure and reliable assessment software is made. Close monitoring of the assessment process to mitigate this risk is also essential. As usual implementation also remains a formidable issue.

2.5 Summary

Automated assessment is significant and prominent tool for evaluation of the effectiveness of computer-based training (CBT) programs. This fact is shown in a literature review. In fact, the design of automated assessment for CBT trainings is critical for success.

Designing of automated assessment for CBT trainings selection of suitable evaluation settings and deployment of proficiency categories is also important. The design process should be assessed through denervation of test, knowledge or skills. The

content standard should also be kept in mind. Vocational instructors also use valuations such as collections, assignments, quizzes, tests, and functional tests. It encourages the determination of expertise and abilities of students.

Digital option assessments are emerging and rising trends. Their design is more innovative, novel and up-to-date. The latest technological advancements are put into practice. There are three generations of Digital assessment. Each generation offers distinguished designs, characteristics and features. The paper-pencil assessments are features of the first generation, while web-based responses, automated item builds, and automatic scoring are characteristics of the second generation and the third generation incorporates development of simulations, smart teaching products and artificial intelligence.

CBT trainings have many pros. The foremost benefit is immediate feedback to students. Identification and address of areas are improved. Automated assessment is reliable. It is consistent than that of human grading. Certain factors such as bias and subjectivity influences to this phenomenon as well.

Some potential challenges are also there for designing of automated assessment for CBT trainings. Assessment creation is evidence of it. Measurement of complex skills and abilities are performed accurately. In addition to this, automated assessments become unable to gauge certain aspects of student learning such as creativity or critical thinking.

Careful consideration is the prerequisite of overall designing of automated assessment for CBT trainings. Settings and competency are also necessary. In this regard, latest technological advancements are required. Immediate feedback, reliability, and consistency are challenges of this approach. In short, it is vital for evaluation of student learning in CBT programs.

3. RESEARCH METHODOLOGY

3.1 Introduction

This research undertakes several tasks. These tasks involve obtaining of datasets from TEVT institutions, analyzing and refining of the collected manual

assessment data, gathering of outcome data from government and non-governmental organizations while comparing historical frameworks from literature review and modern manual assessment methods from various sources. an online web portal to perform statistical analysis of the collected data, and developing an automated process framework for learning and assessment using C# language and .Net framework has also been used. In order to meet the research objectives, such activities have been proved crucial.

3.2 Research Study on Automation of Assessment

This study utilizes a baseline survey methodology that involves various activities including fieldwork, desktop surveys, and content analysis of available policies and skill development documents at both national and provincial levels. To conduct the fieldwork, personal visits were made to different TVET departments, provincial authorities for TVET, NAVTTC regional and apex offices, and subject matter experts of TVET were consulted for brainstorming discussions. In addition, contacts with TVET diploma and certificate holders working in local labor markets were established. The desktop survey involves browsing internet sources related to TVET sectors and TVET affiliated departments/institutions, both working at national and provincial levels in the province. Furthermore, content analysis of official TVET documents, TVET acts and rules and regulations, and TVET policy papers are conducted to critically analyze the SWOT analysis of TVET system for HRD via TVET system in Baluchistan. To achieve this, the study follows the research conventions laid by Grundy (2006), Halcomb and Davidson (2006), International Labour Organization (2003), Hsieh and Shannon (2005), Schulman et al. (1989), Tuckett (2005), and Khan and Ahmed (2018).

This section presents a technique for integrating automated competency assessment with a modern framework using web technologies. The web-based approaches will be employed to classify and extract CBT results. The entire methodological process is depicted in Figure 3.1 using a flowchart.

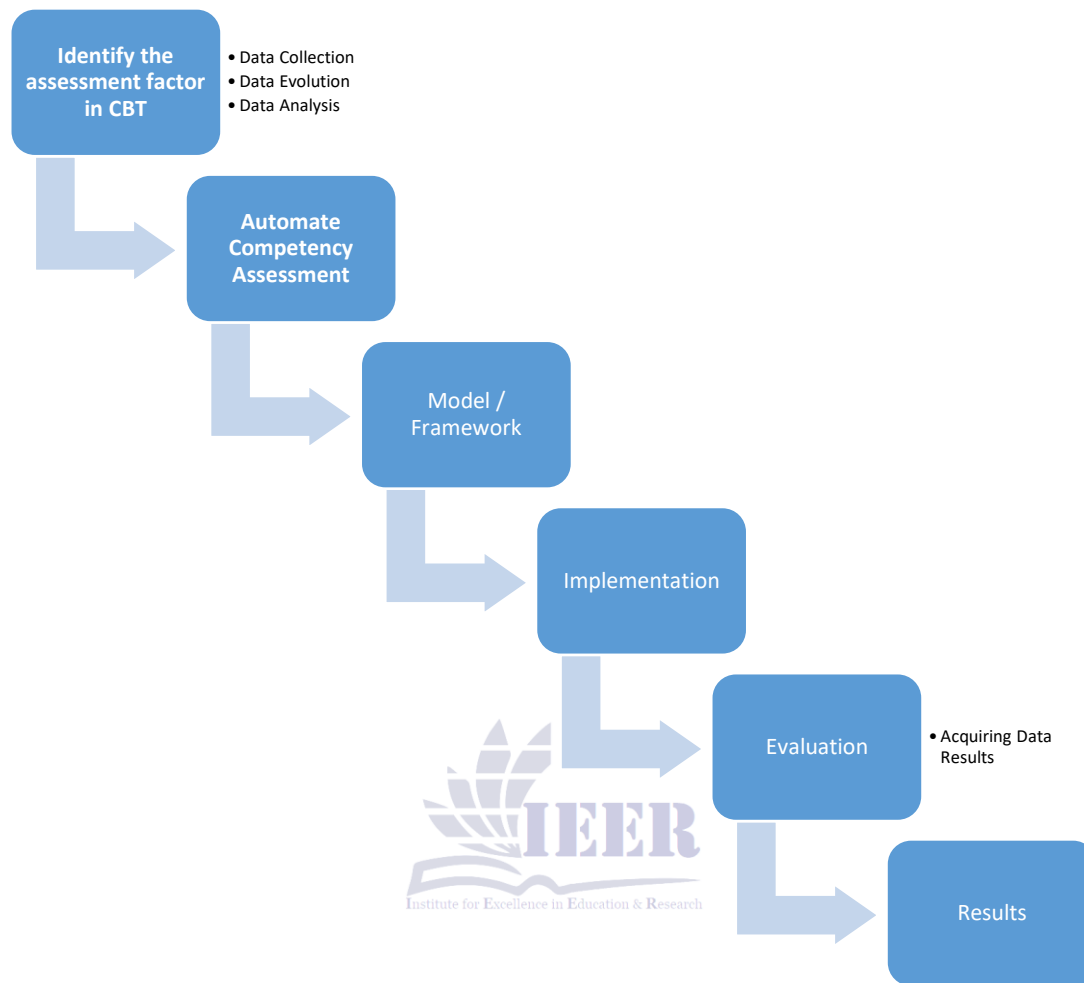


Fig. 2: Research Methodology.

3.3 Identify the Assessment Factor In CBT

In Sindh TEVT institution are mostly based on human tractional / conventional methods due to manually performing of assessment it consumes lots of time. it also produces lots errors.in modern age the repetitive tasks are mostly performed on computers. In this study we may acquire data in raw documents and perform generic analysis to find pattern to automate and provide statistical results based on input data.

3.3.1 Data Collections

The main goal of digitizing data gathered manually using evidence guides is to create datasets for analysis and create decision-based systems based on the obtained data. Raw Data from different technical and vocational institutions in Sindh's competency-based training (CBT) and teaching learning materials (TLM) were digitalized to enable statistical analysis and the development of visualization web portals to help with highlighting the trainees through various national assessors registered by NAVTTC (National vocational technical training commission).

Table 1: Evidence Assessment from Primary Data.

Written	Observation	Oral	Portfolio
Objective Type	Scaling	Does	Resume / Curriculum vitae
Short Type Questions	Task Monitoring	Does How	Position descriptions
	Observing Periodically	Shows How	Training journals / Work journals / Diary entries
		Knows How	References
			Industry certificates
			Project reports
			Photos / Videos

3.3.2 Data Evaluation

The data analysis and collection can be performed manually by the administration from different sources and then merged into a single entity. The data can then be transferred in the desired format using custom or third-party addons, as illustrated in Figure

3.13. A specially designed web-based application provides stakeholders with a graphical interface to display the data. The web-based application-based data analysis enables multi-user data comparison through the use of controls to group data of different types.

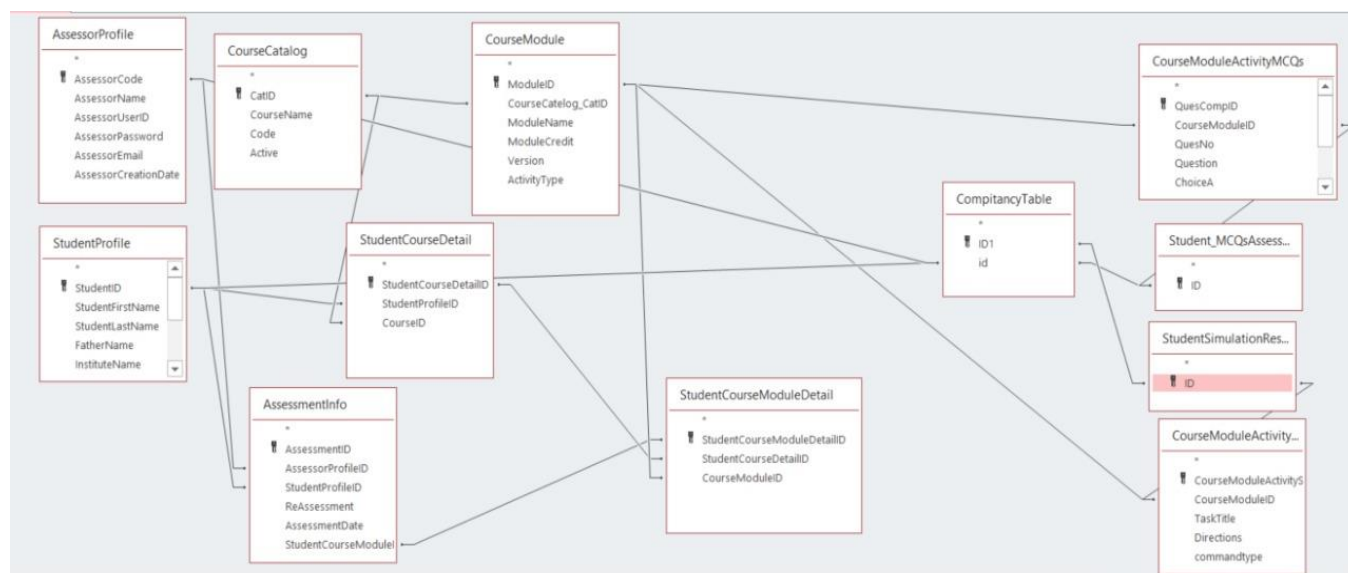


Fig. 6: Database ERP Diagram.

The web-based portal was created utilizing the C# programming language, the .NET Core framework, and ASP.NET. As seen in Figures 3.14 and 3.15, a database for storing CBT data was designed and developed using Microsoft Access. It has a lot of customizability and data filtering tools and is very compatible with Microsoft Excel. It can import and export data while retaining data integrity. These two

programming tools are effective and provide a decent user interface. Consequently, using this system is practical.

3.3.3 Data Evaluation

Excel files have been generated from scanned data and logical conditional analysis is performed for data conversion to DSS system. Database decision support

system also provides other forms of diagrams with the detailed filtered information by date. Which were achieved by developing custom macros for generation, transformation and visualized of generic data. The reporting tools allows users to access the data and generate insights or decision-making support reports for CBT tables.

3.4 Automate Competency Assessment

The information gathered for providing proof of competency is called evidence gathering. It can take

many forms and be collected from a number of sources including Written, Observation, Oral and Portfolio.

In STEVT currently ADDIE model is implemented for manual assessment in CBT based model diagram is shown in Fig 6. however, our proposed model will focus on automation of completed process providing the stakeholder a web platform to submit and perform there CBT courses.

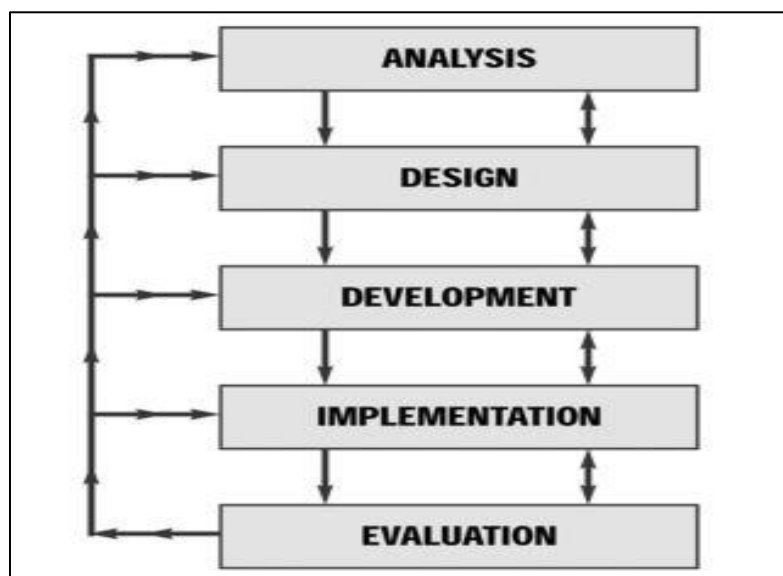


Fig. 7: ADDIE Model.

3.5 Model / Framework

Table 2: Proposed System for Automation and Database Decision Support System.

Modules	Description
Registration and authorization	This is the interface where learners access the system using unique identity and only the authorized users have access. The learner register him/herself.
Account database	DBMS (Database Management System) is used for automated competency exams.
Decision support system (DDS)	Context aware algorithms are used to automate assessment of exams using modern techniques
Traversing and retrieval	Instant search method is used to retrieve simulation or MCQs based requirements

Scheduling and filtration methods	Contextual time-series based exclusion system is implement for exams type separations
Profiler	Holds Contextual information such as preference, activity, family background, social context etc.
Learning portfolio	Learning statues, progress, Achievements, performance and other information about learning process.
learning sequence guidance	Customizes the representation of learning resources and activities to each learner.
Learning materials	Consists all learning resources such as books, notes, video, audio, rhyme, test papers

3.6 IMPLEMENTATION

In implementation we use pervasive computation methods for pattern recognition using following modules which also shown in Fig 8.

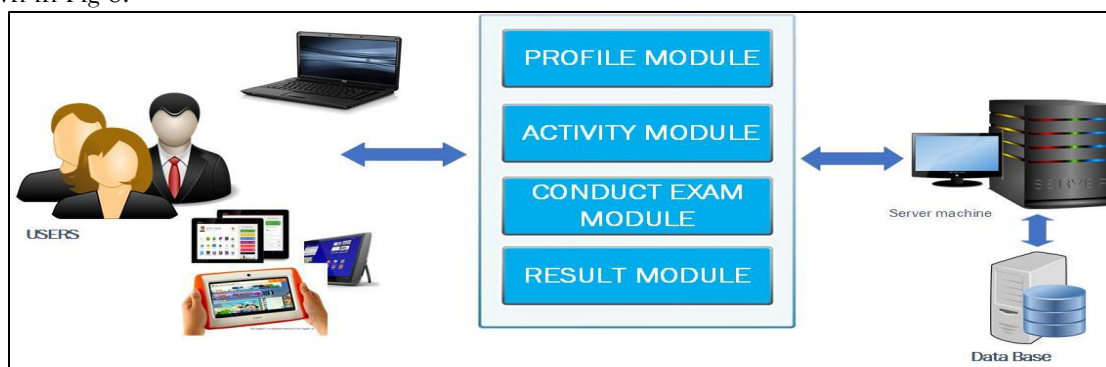


Fig. 8: System architecture for implementation of pervasive computing

- **Profile Module:** Profile of the Users (i.e. Candidate and Assessors)
- **Activity Module:** Activity of the candidate and activity of assessor.
- **Examination Module:** This section shows the competency-based task of their relevant trade.
- **Results Module:** Results will show competent status.

3.7 Evaluation

In this proposed use case diagram authorized student have access to active course catalog and scheduled module for assessment. Students and Assessors will also be allowed to update their student profile before competency exam. Computerized Decision support

system will be implemented on the nature of exam. Web application will automatically pick suitable exam from databank. Automated reports will be generated for assessor and student which will highlight competency assessment.

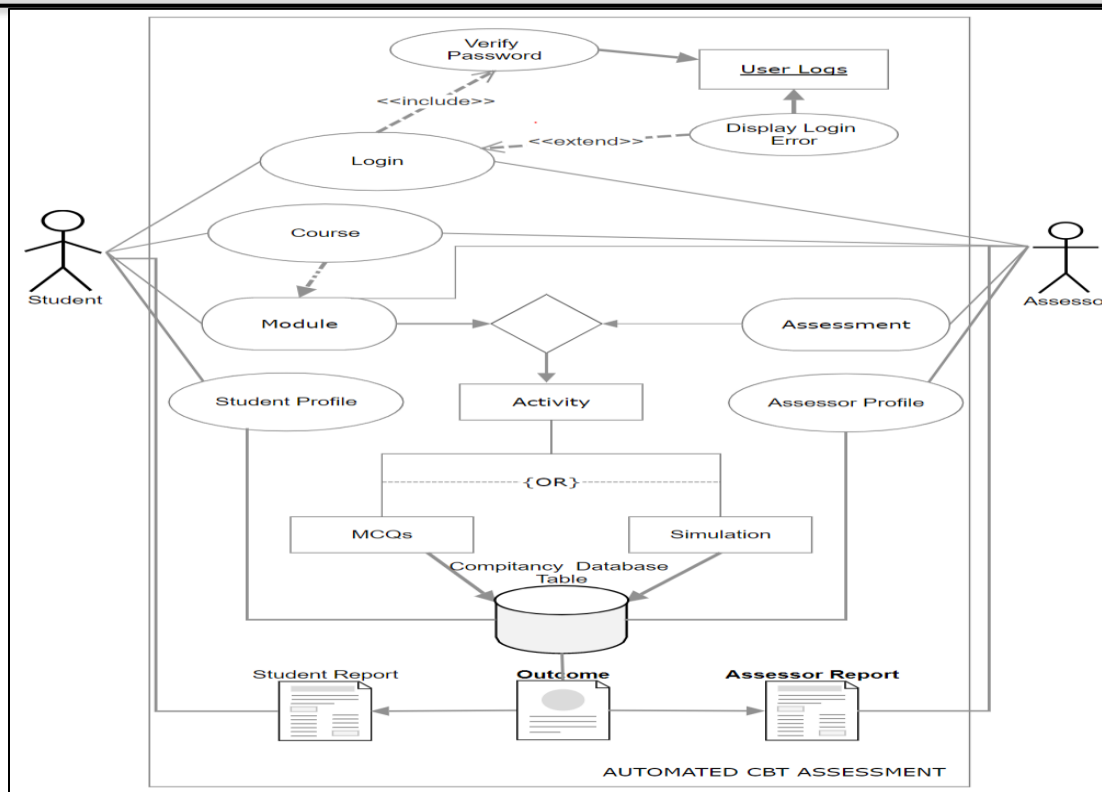


Fig. 9: Use case Diagram for Implementation and Evaluation Web Framework.

3.8 Results

Finally, empirical data obtained through Implementation and Evaluation techniques is compared and appraised with available data which is processed manually to get the truth about past, present and future assessment. As a remedy, the web application framework would be assessed to automate the process of assessment in CBT.

4. RESULTS AND DISCUSSION

The purpose of the Competency Based Training and Assessment (CBT&A) System is to assess an individual's performance against nationally approved competency standards that specify the necessary knowledge, skills, and attitude required for effective workplace performance, as established by employers and industries. The TVET Reform Support Program in Pakistan, with the technical support of GIZ, has introduced the CBT&A System. This system employs Training Packages developed by NAVTTC to deliver CBT curricula that equip trainees with the competence to demonstrate their knowledge, skills, and attitude effectively.

Competency Based Assessment (CBA) is the collection of evidence that demonstrates a trainee/learner's ability to perform according to approved competency standards. Assessment process is part of the learning process under the shadow of CBT&A System. Formative and integrated assessments have important role in CBA. The Internal Assessor conducts formative assessments. He is also called the instructor of the trainees. His role is to improve their performance. Internal Assessor also takes monthly tests. These are conducted to create evidence for knowledge, skills, and attitude. The role of the Trade Testing Board (TTB) is only Qualification Awarding Body. It conducts Integrated Assessments. It aims to verify the demonstration of knowledge, skills, and attitude achieved by trainees. TTB also deputes to assess trainees as soon as they complete the training course. The implementation of the CBT&A system in Pakistan is a step towards aligning TVET with the needs and requirements of the industries and employers. With the development of training packages and curricula, trainees are being

prepared to perform tasks according to nationally approved competency standards. The competency standards in the assessment process, focus on trainees are not just tested on their theoretical knowledge. However, their practical skills and attitudes, which are essential for effective performance in the workplace, are also analyzed.

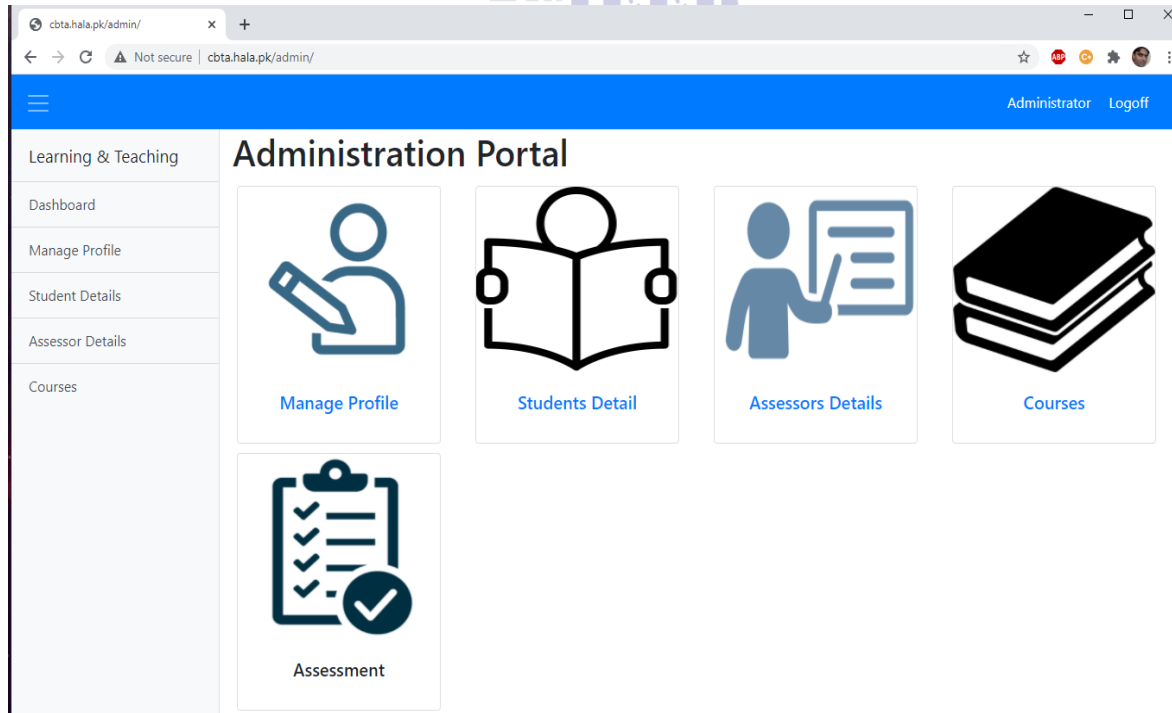
Assessment is not a separate process in the CBT&A system. However, it is integrated into the learning process. Both formative and integrated assessments are conducted to ensure continuous improvement of trainees and their performance. It meets the required competency standards. The role of the instructor as an internal assessor in conducting formative assessments is crucial. It identifies the strengths and weaknesses of the trainees. It provides them with constructive feedback. It also improves their performance. Monthly tests also serve as a formative assessment tool. It also provides an opportunity for trainees to demonstrate their knowledge, skills, and attitude. On the other hand, integrated assessments are conducted through Trade Testing Board (TTB). It is

the qualification awarding body. External assessors are deputed by the TTB. It also assesses trainees on the completion of their training course. It ensures that they have achieved the required competency standards. The holistic and integrated approach is adopted in the integrated assessment. It verifies that the trainees have not only acquired theoretical knowledge. It has also the practical skills and attitude that are required for effective performance in the workplace.

The implementation of the CBT&A system in Pakistan is a significant step towards aligning TVET with the needs and requirements of the industries and employers. The focus on competency standards in the assessment process ensures that trainees are prepared to perform tasks according to nationally approved standards. The integration of assessment into the learning process through formative and integrated assessments ensures that trainees are continuously improving their performance and meeting the required competency standards.

4.1 Administration Web-Portal

ADMINISTRATOR PORTAL WILL PROVIDE OVERALL CONTROL TO IT PROFESSIONALS



(COURSE CATALOG AND MODULE MANAGEMENT)

Course Catalog Management

Course Name:

Code:

☐ Active

Catalog ID	Code	Code	Is Active	
1	Pre Engineering CBT	PE01	☐	Edit Delete
2	Computer Operator	CO01	☐	Edit Delete
3	Web Programming	WP01	☐	Edit Delete
4	IT Office	IT01	☐	Edit Delete
6	Application Development1	AD01	☐	Edit Delete

Course Module Management

Select Course Catalog:

Module Name:

Module Credit:

Module Version:

Activity Type:

Catalog ID	Name	Credit	Is Version	Activity Type	
1	Chemistry	3	1	MCQs	Edit Delete

(ASSESSOR PORTAL)

cbta.hala.pk/Assessor/

Not secure | cbta.hala.pk/Assessor/

Assessor : hussain Logoff

Welcome to Assessor Web Portal

Learning & Teaching

Dashboard

Profile Update

Reference Material

Announcements

Exam Results

Module Test Setting

Simulation Tests

MCQs Tests

Profile Update

Reference Material

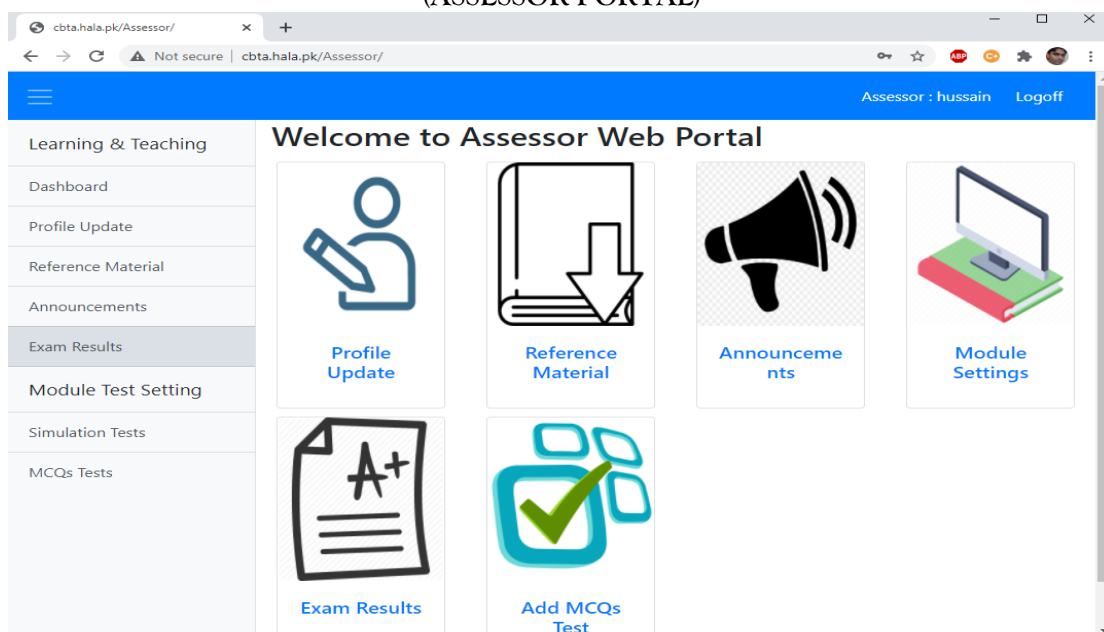
Announcements

Module Settings

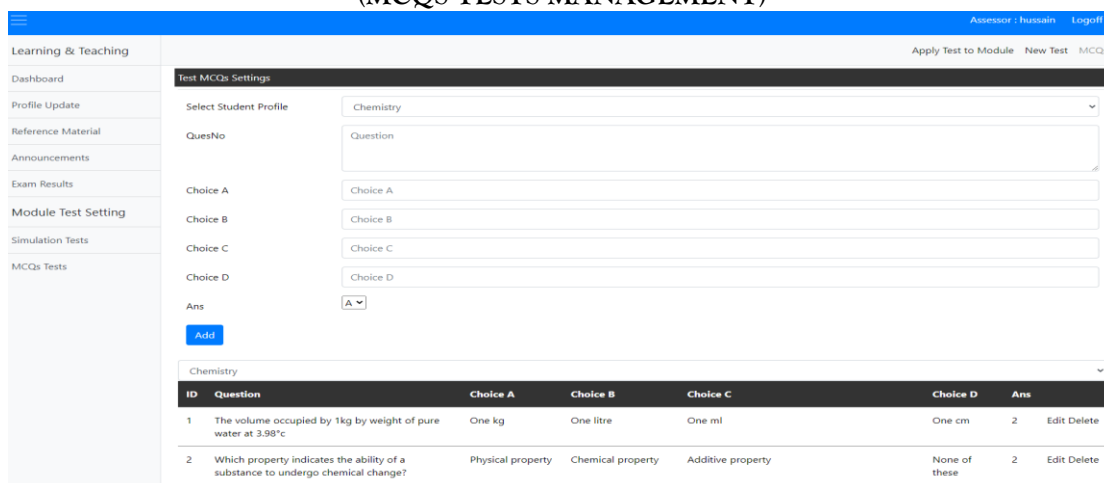
Exam Results

Add MCQs Test

(ASSESSOR PORTAL)

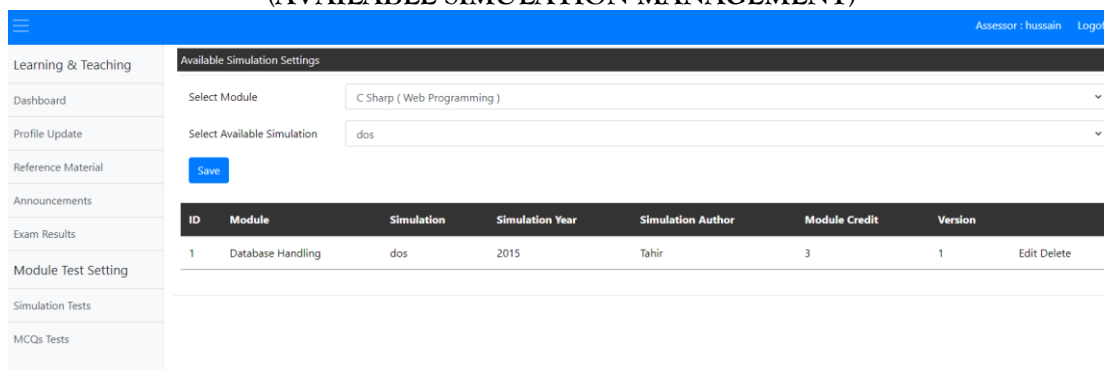


(MCQs TESTS MANAGEMENT)



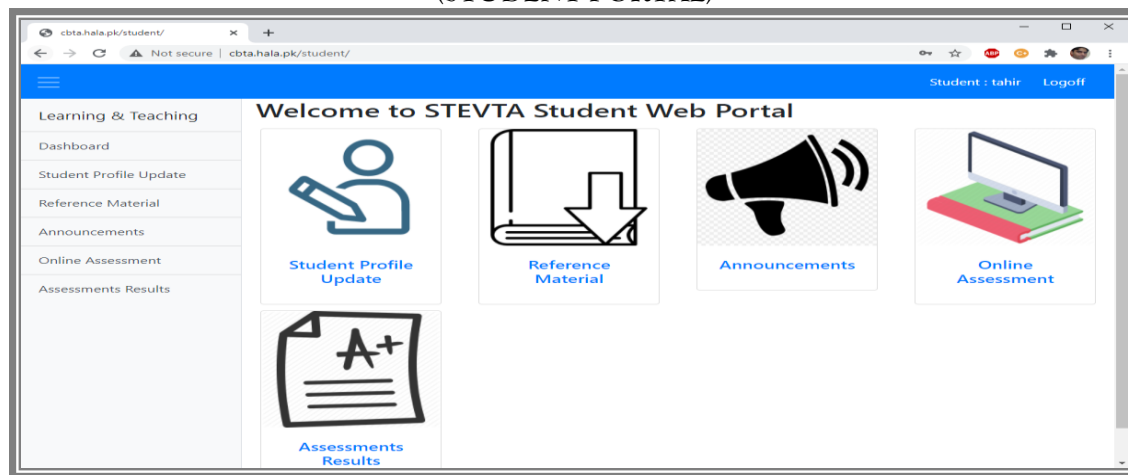
ID	Question	Choice A	Choice B	Choice C	Choice D	Ans	
1	The volume occupied by 1kg by weight of pure water at 3.98°C	One kg	One litre	One ml	One cm	2	Edit Delete
2	Which property indicates the ability of a substance to undergo chemical change?	Physical property	Chemical property	Additive property	None of these	2	Edit Delete

(AVAILABLE SIMULATION MANAGEMENT)



ID	Module	Simulation	Simulation Year	Simulation Author	Module Credit	Version	
1	Database Handling	dos	2015	Tahir	3	1	Edit Delete

(STUDENT PORTAL)



4.5 Results

Several assessments of the phases for developing Automated Assessment have been conducted for automotive student as shown as table 1. During this study, Automated Assessment underwent two

category process of evaluation by experts 1: Web based MCQs tests 2: Web based basic Simulation environment tests.

Item	Percentage of Student (%)	Threshold Value	(d) Fuzzy Score
MCQs	100%	1000	0.1
Simulation	70%	1000	0.7
Self-Assessment	10%	1000	0.01

Passed Users Are These										
Username	First Name	Subject	Number of Questions	Correct Answer	Wrong Answer	Pluse Score	Negative Score	Overall Score	Percentage	Remarks
ibrahim12	ibrahim	Math	15	12	4	48	4	44	73%	Passed
Failed Users Are These										
Username	Firstname	Subject	Number Of Questions	Correct Answer	Worg Answer	Pluse Score	Negative Score	Overall Score	Percentage	Remarks
ibrahim12	ibrahim	Physics	7	0	7	0	7	-7	-25%	Failed

5. CONCLUSION AND FUTURE WORK

5.1 Conclusion

This study successfully developed and validated an automated web-based framework for competency-based training assessment in Sindh's TEVT institutions. The system digitizes assessment processes, minimizes manual intervention, and increases accuracy. By incorporating DSS and pervasive computing principles, it ensures transparent, real-time, and scalable competency evaluation.

The framework supports sustainable modernization of TEVT education, aligning with Pakistan's digital transformation goals and enhancing workforce readiness for industrial demands.

5.2 Discussion

Automated Assessment in TVET has been gaining currency with passage of time. Several potential benefits of TVET cannot be overshadowed. The ability to provide instant feedback is its fundamental goal. Learners become abreast of identification of their weak areas. It takes corrective measures

immediately. It bears fruitful results in vocational fields. Automotive technology- where hands on experience and practical skills are critical components of the learning process is also useful.

Undoubtedly, many opportunities are offered through Automated Assessment for collaborative learning. Vocational colleges can also avail its fruits. Students can learn from each other. They may share their knowledge and experiences. They can develop their skills collectively. Automotive technology can use these advantages. It provides stage to students to learn from each other. Learning about the different steps encompassing the repair and maintenance of vehicles, experiment becomes easy. New and novel techniques are also created. Various tools are also explored.

The crux of the matter is that the effective learning can be accomplished through the use of Automated Assessment in TVET. It leads to produce outcomes for students in vocational colleges. The collaborative learning environment created through Automated Assessment can allow students to work together. It facilitates learning from each other. It develops their skills collectively. As technology continues to evolve and new tools become available, it is essential for TVET institutions to adopt innovative approaches. It helps them in teaching and assessment. In nutshell, Automated Assessment is one such approach that holds great promise for the future.

5.3 FUTURE WORK

Future studies should focus on integrating:

- Artificial Intelligence (AI) and Machine Learning (ML) for adaptive assessment.
- Gamified and simulation-driven learning environments.
- Cross-platform mobile compatibility for broader accessibility.
- Longitudinal analysis of student performance using national databases.

The integration of AI-based analytics can further personalize CBT and foster continuous improvement in skill-based education across Pakistan.

ABBREVIATIONS

CBE: Competency-based education

GCT: Govt. College of Technology

TEVT: Technical Education and Vocational Training.

STEVT: Sindh Technical Education and Vocational Training Authority.

CBT: Competency-based training.

CBTA: Competency-based training and assessment.

MIS: Management Information System.

DSS: Decision support system.

DBMS: Database Management System.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interest regarding the publication of this research work.

REFERENCES

- [1] Yang, J. "Holistic Human Capital Development in Vocational Education," Journal of Educational Policy and Development Studies, vol. 12, no. 4, pp. 233-248, 2004.
- [2] Fukuyama, F., "Social Capital and the Global Economy," Foreign Affairs, vol. 74, no. 5, pp. 89-103, 1995.
- [3] Rosen, S., "Human Capital: A Review," Journal of Labor Economics, vol. 7, no. 3, pp. 123-145, 1999.
- [4] Frank, R. and B. Bernanke, Principles of Economics, New York: McGraw-Hill, 2007.

- [5] Government of Pakistan, National TVET Policy, Islamabad: NAVTTC, 2015.
- [6] GIZ, Technical Education Reform Support Program for Sindh Province, Karachi: STEVTA-GIZ, 2014.
- [7] Uwaifo, V. and Uwaifo, E., "Training the Trainers: E-Learning in TVET," International Journal of Vocational Education and Training, vol. 11, no. 2, pp. 87-94, 2009.
- [8] STEVTA, Annual Report on Technical Education in Sindh, Karachi: Government of Sindh, 2017.
- [9] Psacharopoulos, G. and Arriagada, A., "Education and Development: A Policy Perspective," World Bank Research Observer, vol. 1, no. 2, pp. 121-139, 1986.
- [10] NAVTTC, Pakistan Skills Development Framework, Islamabad: NAVTTC, 2018.
- [11] Kazmi, A., Pervez, T., and Mumtaz, M., "Effectiveness of In-Service Teacher Training in Pakistan," Asian Journal of Education and Training, vol. 2, no. 1, pp. 15-22, 2011.
- [12] Sim, J., "Enhancing Teacher Performance through Training," Journal of Educational Psychology and Practice, vol. 18, no. 3, pp. 220-235, 2011.
- [13] MahdaviFar, S. and Ghorbani, A. A., "Application of Deep Learning in Cybersecurity," Neurocomputing, vol. 347, pp. 149-176, 2019.
- [14] Khan, A. and Ahmed, S., "SWOT Analysis of the TVET System for HRD in Pakistan," Journal of Technical Education Research, vol. 7, no. 2, pp. 101-112, 2018.
- [15] STEVTA, "Sindh TEVT Statistics," Provincial Technical Education Directorate Report, 2018.
- [16] Navarro, M. et al., "Automation in Educational Systems," Computers & Education, vol. 164, pp. 104-114, 2021.
- [17] Ahmed, R., "Integrating DSS in Learning Environments," Education and Information Technologies, vol. 28, no. 1, pp. 223-239, 2022.
- [18] Naylor, T., "Competency-Based Approaches in TVET," International Journal of Vocational Training Research, vol. 33, no. 4, pp. 432-450, 2020.
- [19] Ghulam, S., "Digital Assessment Tools for Technical Education," Journal of Modern Education Systems, vol. 19, no. 1, pp. 11-28, 2023.
- [20] Rabbani, M., "Automation and Assessment Models in Skill Development," Journal of Network and Computer Applications, vol. 151, p. 102507, 2020.

