Original Article

Gap Assessment and AI-Based Quality Enhancement in Medical Curriculum: CIPP Framework

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Abstract

Objective: The current study aims to evaluate and redesign the curriculum of one of Pakistan's leading medical institutes by identifying its strengths and gaps and designing a more robust corrective plan.
Methodology: The CIPP model (Context, Input, Process, Product) was used as the main evaluation model in the present study. It incorporated Harden's SPICES principles and the famous eleven steps of the Integration model. The current study identified gaps in the 5th year MBBS curriculum of UHS and further proposed an artificial intelligence (AI) based quality enhancement tool to bridge this gap.
Results: The study has found the need for regular use of AI assistance for the evaluation of curriculum and quality enhancement. We identified that the curriculum of UHS is suffering deficiencies at the levels 6 and 7 (Harden's 11-step integration model) and recommends for employment of AI synchronization model for more vigorous improvement in integration throughout the curriculum.
Conclusion: A comprehensive curriculum evaluation should be performed for the incorporation of the latest high-tech advances in medical education. An artificial intelligence-based AI synchronization model proposed in the current study could efficiently and effectively improve teaching, learning, and assessment.
Keyword: Artificial Intelligence (AI), Curriculum Evaluation, Context, Input, Process, Product (CIPP model), Level of Integration

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Introduction

A well-designed curriculum is the backbone of every medical institute as it aligns the learning outcomes with teaching strategies. The curriculum also frames the desired academic clinical knowledge, attitudes, assessment, and evaluation procedures. It also tries to meet minimum quality benchmarks to fulfill the institutional and social accountability in accordance with the health needs of the population.

Erstwhile literature on curriculum integration and development emphasizes that organized content, assessment, and the learning environment enhance student learning and formation of professional identity, a robust curriculum design must shape individual competence by supporting program evaluation, accreditation, and iterative reform essential for producing effective physicians. [1, 2]

Curriculum evaluation in medical education is an organized assimilation and thorough review of content to judge how well a curriculum achieves its intended outcomes and to inform decisions about improvement. It examines alignment between mission, outcomes, and content, teaching and assessment strategies, resources, and the real-world performance of learners. Robust evaluation serves multiple functions as it provides evidence for accountability and accreditation, diagnoses strengths and weaknesses, guides quality improvement, and ensures graduates meet societal and health-system needs. This role of evaluation is

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emphasized in global standards and guidance (WFME) and in core medical education frameworks that link curriculum aims, learning outcomes, and assessment to continuous improvement.[2] In this context, medical schools commonly use established program-evaluation frameworks with established evaluation benchmarks (what and when). In this context, one widely used framework is the CIPP model (Context, Input, Process & Product) proposed by Daniel L[3], which explains the institutional perspective, goals, and objectives to fulfill its needs, identify system ability, and implementation of strategies, thus facilitates in designing procedures and measures to carry out strategies and schedules programme.[4,5]

The Hardens' 11-step integration ladder is a model for organizing curriculum from subject-based to fully integrated learning. Harden steps range from Isolation where subjects are taught separately, to Trans-disciplinary, where learning transcends traditional disciplines. As one moves up the ladder, the focus shifts from individual subjects to collaborative learning with 11 steps of integration, including isolation, awareness, harmonization, nesting, temporal coordination, sharing, correlation, complementary, multidisciplinary, interdisciplinary, and trans-disciplinary approaches. The Harden's SPICES model includes six educational strategies (Student-centered, Problem-based, Integrated, Community-based, Electives, and Systematic) developed for reforming the curriculum of medical schools. This curriculum development framework advocates shifting from traditional teaching methods towards a more flexible, relevant, and learner-focused approach. Earlier studies emphasized the use of structured teaching and assessment methodologies for the enhancement of the learning environment, which could be achieved by synchronizing an artificial intelligence model using teaching methodologies, data & infrastructure (LMS + E-Portfolio + analytics),[6, 7] use of AI assistant for student and faculty support, [6, 8-11] mobile apps, and gamification.[9,12] While studies also emphasize simulation and AR/VR (skills, communication, assessment) [7, 13, 14] as effective teaching and assessment methodologies.

In view of the above literature, the current study performs curriculum evaluation for the University of Health Sciences Lahore (UHS) 5-year MBBS program, which is the parent institution for all the undergraduate medical institutions in Punjab, Pakistan, the most populated province of Pakistan. This evaluation report aims to give a snapshot of the current structure of the UHS curriculum document (Year 2023) using the CIPP (Context/Input/Process/Product) model via incorporation of the Harden SPICES and 11 steps integration model for development and evaluation of the level of integration in the curriculum, respectively.

In this context, an artificial intelligence-based curriculum Innovation called 'Artificial Intelligence Synchronization Model'(AIS), a structure inspired by Precision Medical Education (PME) is employed to transform the curriculum into a flexible, evidence-based, and globally relevant program as it personalizes AI, Augmented Reality/Virtual Reality, gamification, programmatic assessment, and equity with hidden curriculum monitoring. PME focuses only on individualized learner pathways, while AIS implemented by the current study stipulates the ecosystem of digital technology, AI assistance, and simulation. This revised curriculum aims to prepare graduates who are clinically competent, digitally literate, ethically grounded, and globally competitive. [11, 15]

Methodology

The current study uses a variety of models and data. Key details of the methodology are summarized as follows:

- The study uses the CIPP framework (Context, Input, Process, Product) to evaluate the curriculum.
- Integration Assessment: It incorporates Harden's SPICES model (Student-centered, Problem-based, Integrated, Community-based, Elective, Systematic) and Harden's 11-step integration ladder to evaluate the depth of curriculum integration.
- AI Proposal: As the initial search has identified gaps in existing curriculum structures, at the levels 6–7 on the integration ladder, these gaps can be effectively bridged by synchronizing Artificial Intelligence (AI) to enhance teaching, learning, and assessment.

Results

The current study evaluates the MBBS (5-year) curriculum (year 2023) of the University of Health Sciences (UHS) Lahore and found room for rejuvenation and targeted up-gradation to meet contemporary practice and educational standards. The evaluation through the CIPP model found the UHS curriculum at 6-7 steps on the integration ladder (Table I) with gaps such as data-driven personalization, simulation capacity,

consistent faculty development, equity safeguards, and defensible programmatic assessment in the integration of curriculum.

The current study incorporates a new Artificial Intelligence Synchronization Model (AIS model), a learner-centered, data-driven, ethically governed curriculum that uses AI assistants, mobile learning/gamification, enhanced simulation, Augmented Reality/Virtual Reality (AR/VR), automated scoring and analytics, robust faculty development, and explicit strategies to surface/mitigate the hidden curriculum. This AIS model, inspired by Precision Medical Education (PME) principles and in view of Harden's SPICES model, advances the program toward integrated, competency-based, and precision education.

Table I: The proposed structure of the course includes 6 modules with each blended module of around 8–12 hours in total.

1.Programmatic Assessment	(Online 4 hours + Workshop 8 hours)
Learning Outcomes:	Explain PME, design low-stakes assessments and interpret dashboards.
Activities:	Case studies create WBA schedules for a rotation, portfolio, review and simulation.
Assessment	Create a blueprint and WBA rubric for one rotation.
2.AI Literacy for Educators	(Online 6 hours + Workshop 6 hours)
Learning Outcomes:	Understand AI capabilities/limitations, human oversight and bias mitigation.
Activities	Hands-on with UHS-Coach sandbox and bias audit walkthrough.
Assessment	Short reflective portfolio and AI-use SOP.
3.Simulation & Debriefing	(Hybrid for 2 days)
Learning Outcomes	Run high-fidelity simulations, structure debriefs and use simulation data in assessment.
Activities	Facilitation practice, micro-teaching, debrief grading.
Assessment	Demonstrate debrief using structured checklist.[28]
4.Augmented Reality/Virtual Reality & Procedural Skills Pedagogy	1 online session + 1 workshop
Learning Outcomes	Integrate AR/VR sessions, design pre-brief/ practice/ transfer steps.
Activities	Co-design one AR module; pilot practice.
Assessment	Module plan and demonstration.
5.Inclusive Pedagogy & Hidden Curriculum	(Online + Workshop)
Learning Outcomes:	Recognize hidden curriculum, design inclusive cases, run climate surveys.
Activities:	Role play, incident reporting training.
Assessment:	Design remediation & reflection workflow.[29]
6.Entrepreneurship & Assessment Design	A 2-Day symposium and events including online sessions.
Learning Outcomes:	Teach healthcare innovation basics, assessment of projects, and ethics of commercialization.
Activities	Student pitch, judging simulation, ethics and roundtable discussions.
Assessment:	Panel-judged project.

The proposed AIS demand Structure of Assessment as follows:

- Low-stakes (daily/weekly): Mobile quizzes, simulated cases, reflective logs, mini-quizzes.
- Medium-stakes (end rotation): OSCE stations (including simulation + communication), DOPS, structured long cases, portfolio checkpoints.
- High stakes (annual): Blueprinted written exam with aggregated portfolio review by the competence committee.
- Progress testing: Annual cohort tests measuring long-term retention.[27]

Frequency and Timelines divided into a rotation of 8 weeks, including;

- Mini-CEX: 4 per student (every 2 weeks)
- DOPS: 2–3 sessions per student for procedural rotations
- CBD (case-based discussion): 2 per student
- Simulation OSCE: 1 integrated station

- Online adaptive quizzes taken weekly (6–8 per rotation)
- Portfolio checkpoint at mid & end of rotation[27]

Implementation roadmap (high level) (GANTT CHART) & KPIs

Phases: Quick Wins (0 months–6months) ⇒ Medium (6months–18months) ⇒ Long (18months–36months).

Top KPIs:

- Number of modules with mapped outcomes
- WPBAs completed per student per rotation (target ≥8)
- The percentage of faculty development programs completion

Table II: Harden 11 steps of Integration.

Module	Current Level	Evidence
Foundation Module	Step 7: Correlation	Joint sessions between Anatomy & Physiology
CVS Module	Step 9: Multidisciplinary	Shared case weeks
MEU Skills Course	Step 3: Awareness	Subject experts aware but not collaborating

- OSCE reliability (Cronbach α > 0.75 per station battery)
- Equity gaps identification
- Uptake of AIS Framework interactions per student/week

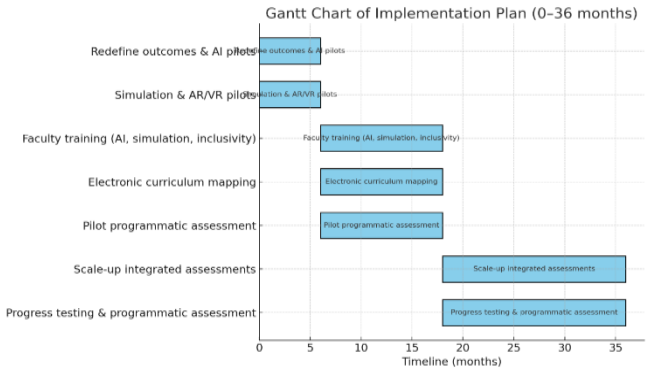


Figure 1. Implementation plan for 0-36 months.

Discussion

CIPP evaluation of context involves reimagining the UHS curricular mission of producing clinically competent physicians by explicitly addressing digital health literacy, equitable care, innovation, and entrepreneurship as competencies of graduates looking forward to AI-augmented practice and system-level challenges. For that very reason, the AIS model identifies gaps in the undergraduate curriculum framework and argues that learning outcomes incorporate data-driven and individualized learning goals inspired by the PME and Harden SPICES model. AIS reflects the CIPP context-based curriculum to prepare digitally literate, patient-centered, equitable clinicians with an updated mission for digital health readiness. [8, 11, 15]

INPUT:

The existing input design of the UHS curriculum uses modular structures, early clinical exposure, and OSCE-based assessments [7,13] with limitations such as underdeveloped simulation infrastructure, inconsistent use of learning management systems (LMS), limited AI-based analytics, and insufficient faculty preparation. The proposed AIS model augments AI-assisted LMS with adaptive feedback[8], gamified mobile applications,[16] AR/VR simulations for clinical skills[17,] and equity-focused infrastructure ensuring access across socioeconomic groups.[18]

PROCESS:

The current teaching processes of UHS are dominated by lectures with limited use of PBL, TBL, or a flipped classroom; hence, assessment remains largely summative and reduces opportunities for formative feedback. Under the AIS framework, processes are enhanced through AI tutors, adaptive testing, and simulation with patient-centered scenarios, workplace-based assessments (WPBAs), AR/VR anatomy, procedural rehearsal, and just-in-time mobile learning. Moreover, the incorporation of gamification would improve motivation with deliberate practice and repetition, enhancing cognition. [19] Programmatic assessment with frequent low-stakes exercises (quizzes, WPBAs, simulation metrics) should be assimilated for automated analysis and robust evaluation. [8-14,20]

PRODUCT:

The graduates under the existing curriculum have clinical competence but are underprepared for AI-augmented clinical decision-making, global innovation, and digital health integration. The graduates under the AIS model curriculum demonstrate enhanced clinical competence, critical thinking, and communication skills through adaptation of AI-enabled decision-making, entrepreneurial innovation, and equity-driven practice.

AIS also enables precise remediation and higher certainty in assignment decision.[15, 21]

RATIONALE (CIPP to AIS Model implementation)

The CIPP model evaluated the UHS curriculum, showing an efficient modular structure and assessment framework, but required stronger inputs via simulation, LMS analytics, and process changes with frequent formative data collection. The AI-enabled learning and the product can be rejuvenated via the augmentation of digital health literacy and entrepreneurship. Precision Medical Education (PME) emphasizes the use of continuous learner data and adaptive pedagogy for effective learning, which requires an environment to achieve that programmatic assessment, simulation, AI assistants, mobile learning, and equity safeguards, which is provided by the AIS model. The PME represents the next generation of medical training, shifting from the traditional approach of "one-size-fits-all" to a more personalized approach that aligns with the individual learner's needs and future patient care. The PME employs continuous learner data derived from EHR, assessments, and simulations, and uses the concept of adaptive pedagogy that helps to create a tailored, efficient, and effective learning environment. [22]

Core functions of the proposed Artificial Intelligence Synchronization (AIS) Model

AI inputs to the curriculum development are pivotal in the current era. AI has the potential to contribute to all aspects of the curriculum. Human beings should be in the loop as AI outputs are advisory only, and all stakes involve competent authority. Audits for bias control are required, including testing before deployment using local data. This will help in revalidation. Validation and quality Assurance are also mandatory. These will help to check the validity with a pilot run in 1–2 modules, including side-by-side human raters, user response surveys, and tracking outcome presentation of pilot results to stakeholders. [22-24]

Mobile apps and gamification follow the pedagogic principles of augmentation, including micro-learning for retrieval practice, spaced repetition, and gamification elements with rewards for formative engagement, e.g., badges for completed activities and WPBA with levels for spaced quiz streaks.[25] Minimum features required for engagement include offline coaching of cases with flashcards, push notifications for spaced quizzes and simulation bookings, secure login integrated with LMS with progress synchronization when online, clinical guidelines for quick-access and bedside use, and data analysis reflection to the AIS Model.[26] Gamification structure with development of difficulty levels, including mastery badges with learner profile visible to faculty, showing progress bars, completion of scenario streaks, and team-based leader boards for in-class activities.[25]

Faculty Development Programs (FDP**)** incorporate the micro-credential model. It must be practical, modular, and recognized with CPD credits for improving the weightage of the program. Blended delivery scales should be part of it and involve short online and face-to-face workshops. Though faculty development workshops dominate, follow-up and long-term support are required [24]

Structured WBA should be developed with evidence-based rubrics adapted for best practice (Mini-CEX, DOPS, CBD). Grading should incorporate a 1–5 entrustment/competency scale (1 = novice needs direct supervision to 5 = independent performance). Mini Clinical Evaluation Exercise (Mini-CEX)[27] Direct Observation of Procedural Skills (DOPS) and Case-Based Discussion (CBD). [27-30] In modern assessments, AI has the potential to serve as a transformative engine. AI has the ability to move beyond simple digitization to the more complex and highly desired personalization, efficiency, and deep analytical insight which are needed at all stages of the process of assessment.

Test scoring and evaluation workflows entail Item banks and quality maintenance including blueprint mapping, cognitive levels and routine analysis of item statistics with flagging are rectification of weak items.[30] Standard setting is mandatory for standardizing the whole process with various methods like Angoff for MCQs, borderline regression for OSCEs along with faculty calibration workshops.[30] Automated scoring via AI is dynamic process implemented by Automated MCQ/ SAQ marking starting from pilot AI scoring using structured pattern with responses and OSCE video to validate against human raters for inter-rater reliability. Standard OSCE/OSPE with digital checklists evaluating KR-20/Cronbach alpha for assessing station reliability and generalizability studies. The AI-assisted scoring system with pilot run via structured notes and video with human cross-validation.[24,30]

Equity should be maintained by allowing access to device loan schemes, subsidized data packages and offline application modes along with monitoring of the performance data on gender, socio-economic status and campus based for remediation via tutoring. Hidden curriculum mitigation implemented by Routine

educational environment surveys and facilitated reflection sessions in each rotation. Conducting Faculty workshops and explicitly disseminating the code of conduct, creating safe reporting channels for professional misconduct and remediation.[29]

For Faculty development the proposed AIS model delivers incentives for increasing engagement by the use of micro credentialing and badges along with CPD points encouraging via recognition in appraisal .Follow-up through peer coaching groups to streamline the process.[24] Programmatic Assessment Blueprint of AIS MODEL would include multiple low stakes exercises with ratings → robust decisions ,providing rich feedback → learning would be evaluated by competence committee for final decisions (Ottawa consensus).[20]

Evaluation and research agenda should be performed by pilot in 2 preclinical and 2 clinical modules with mixed-methods evaluation (analytics + qualitative). Publishing phased results to check AI efficacy and fairness.[24]

Competence committee should be established which should be multidisciplinary including a module lead, external assessor and student advocate performing quarterly reviews of logs and portfolios to make progression decisions for fairness and appeals.

Conclusion

The AIS Model offers a transformative reform pathway for UHS MBBS curriculum as it develops an AI-driven ecosystem incorporating simulation, AR/VR, gamification, faculty development, programmatic assessment, and equity/hidden curriculum strategies built upon PME personalization. Implemented via the CIPP roadmap with rigorous evaluation, this innovation could enable UHS to produce graduates who are technologically literate, ethically aware, and globally competitive.

Purpose of this model is to provide a supervised AI assistant that supports students, augments faculty and improves feedback timeliness thus it is not just a grader replacing humans but a facilitation tool.

Limitations of the study: The current study review curriculum document for recommendations but feedback for the same was not obtained due to time constraints.

Future recommendations: Longitudinal study is recommended for the future study to gauge impact of the proposed model.

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