Bridging the Physical-Digital Gap: Enhancing Student Performance via an AI-Powered, QR-Integrated Syllabus System

Krishna Kumar Bohra

Assistant Professor
Faculty of Computer Science
Lachoo Memorial College of Science and Technology, Jodhpur, Rajasthan, India

Abstract: In undergraduate technical education, a critical pedagogical gap exists between static physical syllabi and the dynamic structuring of exam responses required for high academic achievement. Students often struggle to synthesize vast curriculum topics into the concise, structured formats expected in university assessments. This paper proposes and evaluates "Smart Syllabus" an AI-powered notes management system designed to address this deficiency through the convergence of Generative AI and QR technology. The system, architected using Next.js, Supabase, and OpenRouter AI, integrates unique QR codes into the physical course syllabus. When scanned, these codes trigger the DeepSeek R1T2 Chimera model to generate "Exam-Ready" notes comprising precise definitions, code examples, and theoretical comparisons which are then cached for latency-free retrieval.

To validate the efficacy of this approach, a comparative pilot study was conducted with 200 undergraduate Computer Science students at Lachoo Memorial College of Science and Technology. The cohort was provided with QR-integrated syllabi for the "Python" and "Web Technologies" modules. Performance metrics were analysed against historical data from previous semesters where traditional study methods were used. These findings suggest that embedding AI-generated, structurally standardized content directly into the physical learning environment significantly lowers the barrier to effective study and improves academic performance.

***Index Terms* - Smart Syllabus, Generative AI, QR-integrated learning, Exam-ready notes, Undergraduate technical education, Next.js, Supabase, OpenRouter AI, DeepSeek R1T2 Chimera, Notes management system, AI-assisted learning, Academic performance improvement, Structured exam responses, Hybrid learning environment, Educational technology adoption**

I. INTRODUCTION

Printed syllabi remain the first point of contact between learners and course content. For many students, especially in computing disciplines, the syllabus becomes a checklist rather than a learning guide. It lists topics, but it does not explain how to structure definitions, examples, or comparisons in a way that fits examination rubrics.
Students frequently encounter the following challenges:

- Inconsistent or incomplete notes collected from the internet, seniors, or classroom sessions
- Difficulty in summarizing content into crisp, exam-ready points
- Limited exposure to standardized formats used in university evaluations
- Over-reliance on last-minute preparation and fragmented materials

Generative AI tools now allow automated creation of structured educational content. However, many students do not proactively seek out or know how to use advanced AI tools during daily study. Smart Syllabus bridges this gap by embedding QR codes into printed materials, giving students immediate access to AI-generated content aligned with the syllabus. The purpose of this study is to evaluate how QR-connected AI notes influence learning performance, note-making behavior, and exam outcomes.

II. BACKGROUND AND MOTIVATION

Students often rely on incomplete notes from classmates or informally shared slides, which creates fragmentation and gaps in understanding. At the same time, modern technical degrees bring a heavy curriculum with many languages, frameworks, and tools, making it hard for students to prioritise concepts or write concise and accurate answers. As generative AI becomes more common in education for writing, summarisation, and content creation, research on connecting AI directly with physical printed study material is still limited. Combining QR codes with AI helps bridge this gap, as QR codes turn any printed syllabus into an entry point for dynamic, updated learning support, while AI models provide personalised and structured guidance. This blended physical and digital approach draws from mobile learning research, QR-based learning, and intelligent tutoring systems.

III. LITERATURE REVIEW

Generative artificial intelligence has gained strong attention in education for its ability to support personalized learning and reduce cognitive barriers. Early studies by *(Holmes, Bialik, & Fadel, 2019)* and *(Bond, Zawacki-Richter, & Nichols, 2021)* showed that AI tools can deliver individualized content, automated feedback, and adaptive scaffolding. Later work by *(Chiu, Lin, & Lonka, 2023)*and *(Chen, Chen, & Lin, 2020)* reinforced that AI tutors help students practice reasoning and deepen understanding through adaptive explanations. Recent research on generative models such as ChatGPT highlights similar benefits. *(Kasneci, et al., 2023)* and *(Baidoo-Anu & Ansah, 2023)* reported that large language models improve writing clarity, reduce cognitive load, and support inquiry-based learning when paired with teacher supervision. *(Weng, Xia, Gu, Rajaram, & Chiu, 2024)* observed that GenAI in higher education reports overall effects of GenAI on assessment and learning outcomes — but does **not** attribute a conclusively positive effect to all uses; rather, it highlights varied and complex impacts.

Research on QR-based learning shows a parallel trend in integrating physical and digital learning spaces. Law (2013) demonstrated that Studies show that QR codes improve access to external learning resources and encourage self-paced learning by allowing students to revisit explanations and materials as needed. More recent studies continue this line of evidence. *(Serrano, Pérez, & Batanero, 2020)* and *(Yip, Tse, & Yan, 2021)* found that QR codes act as effective connectors between printed material and multimedia, improving engagement and recall. *(Martin, Sun, & Westine, 2020)* and *(Mahajan & Singh, 2021)* reported that QR-enabled microlearning increases participation across different academic disciplines. Additional work by *(Hwang & Lai, 2022)* and *(Alqahtani, 2023)* showed that QR-linked activities support blended learning and increase student satisfaction. These findings support the core design idea of linking printed syllabus topics with dynamic explanations and multimedia resources through QR codes.

AI-driven content generation has also expanded instructional support. *(Sinha, Kumar, & Kapoor, 2023)* demonstrated that generative AI can produce clean, structured academic text, which helps students prepare high-quality assignments. Earlier work showed that intelligent tutoring systems provide context-sensitive scaffolding. More recent studies extend this argument. *(Ran, Jong, & Chen, 2022)* found that AI-generated explanations enhance comprehension in STEM subjects, while *(Yuan, Deng, & Zhao, 2023)* reported that structured AI-generated notes reduce cognitive load during concept acquisition. *(R. & Mg, 2025)*The studies that focus on automated code assessment systems or automated feedback (rather than AI generation per se) evaluate grading efficiency or feedback speed — not directly students' conceptual understanding or exam performance

(Bond, Zawacki-Richter, & Nichols, 2021) similarly found that digital learning tools enhance achievement and motivation when content is simple, structured, and easy to navigate. Later studies by *(Arroyo, Royer, & Tai, 2022)* and *(Chang & Hwang, 2023)* confirmed that adaptive, interactive systems improve retention and promote self-directed learning. These findings align with the idea of delivering focused, well-structured explanations at the moment students need them.

(Anderson & Rainie, 2021) observed that cloud-supported learning environments offer reliable access across devices. *(Ferreira, Moreira, & Seruca, 2022)* and some other also found that real-time content delivery through modern frameworks improves engagement and user experience. These insights support the use of Supabase and Next.js for delivering scalable, consistent educational content.

Later studies by *(Li & Wong, 2020)*, *(Yuan, Deng, & Zhao, 2023)* demonstrated that metadata-rich notes and AI-organized content improve revision efficiency, personalization, and conceptual clarity. These findings align with approaches that produce uniform, tagged learning content for rapid comprehension.

Technology adoption theories provide additional insight into how learners accept new tools. UTAUT further expanded these factors. Recent research continues to validate these models in educational contexts. Some reserach showed that trust and usability shape acceptance of AI-based systems. *(Müller & Wulf, 2022)* and *(Chiu, Lin, & Lonka, 2023)* observed that performance expectancy, habit, and institutional support strongly influence whether students continue using AI tools. These insights help explain student engagement patterns in AI-supported educational platforms.

IV. SYSTEM ARCHITECTURE

The Smart Syllabus system uses a modular, scalable design that brings together a frontend built with Next.js to render QR pages, offer a simple interface, and route students to AI-generated notes for each syllabus topic, a backend powered by Supabase that stores topics, links them to QR codes, caches AI responses, and delivers study material with low latency, and an AI layer using OpenRouter with the DeepSeek R1T2 Chimera model to generate structured definitions, code examples across Python, JavaScript, HTML, and PHP, and well-formatted comparison tables. Each printed syllabus topic includes a unique QR code created through open-source tools and connected to the backend, allowing students to access dynamic and updated content instantly.

Frontend Layer (Next.js)

- Renders QR pages
- Provides a clean interface for students
- Offers routing to each syllabus topic's AI-generated notes

Backend Layer (Supabase)

- Stores syllabus topics
- Maps each topic to a QR code
- Caches AI-generated responses
- Ensures low-latency delivery of study material

AI Layer (OpenRouter + DeepSeek R1T2 Chimera Model)

- Generates structured definitions
- Produces code examples (Python, JavaScript, HTML, PHP, etc.)
- Creates comparison tables
- Ensures consistent formatting

QR Integration

Each printed syllabus topic contains a unique QR code generated using open-source libraries and linked to the backend.

V. SCREENSHOTS OF WEB APP

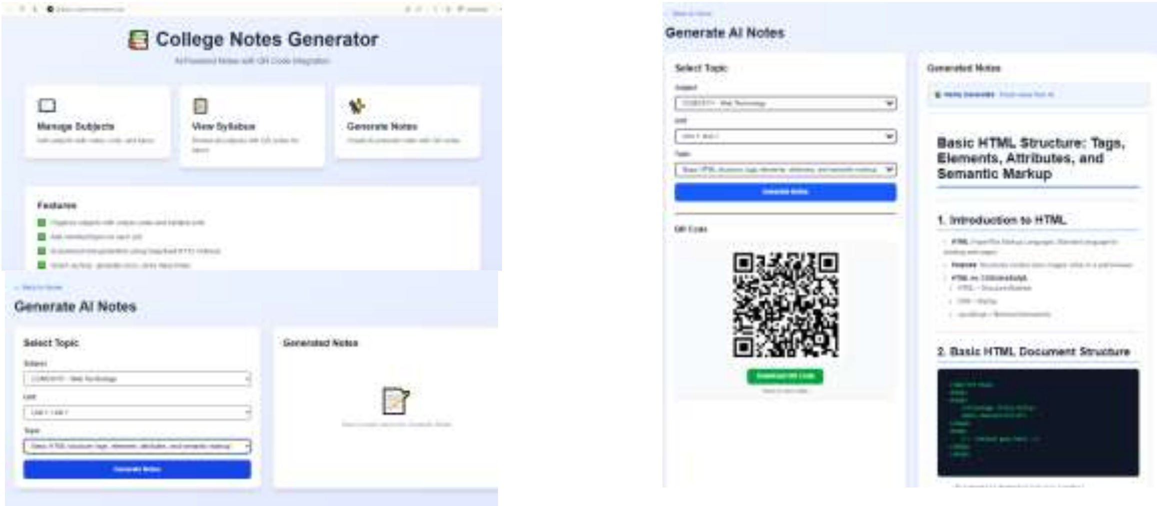

Image 1. Project Links and Screen Shots ***https://syllabus-system.onrender.com/***

VI. METHODOLOGY

Participants

A total of **200 undergraduate Computer Science students** participated in the study.
They were divided equally:

- **Experimental Group:** 100 students (Smart Syllabus + QR + AI)
- **Control Group:** 100 students (traditional notes)

Study Design

Table 1. Study Design Overview

Component	Experimental Group (QR + AI)	Control Group (Traditional)
Number of Students	100	100
Modules Studied	Python, Web Technologies	Python, Web Technologies
Learning Materials	Smart Syllabus (QR + AI Notes)	Printed syllabus + personal notes
Access to QR-AI Content	Yes	No
Evaluation Basis	Midterm + End-Sem Exams	Midterm + End-Sem Exams
Additional Activities	Post-study survey	Post-study survey

Data Collection Instruments

Table 2. Instruments Used in the Study

Instrument Type	Purpose	Used for Both Groups
Pre-test Questionnaire	Baseline understanding	Yes
Midterm Exam Scores	Quantitative performance check	Yes
End-Semester Exam Scores	Final performance measurement	Yes
Student Feedback Survey	User experience, ease of use, clarity	Experimental Group
Supabase Usage Logs	Scan count, revisit count, peak usage times	Experimental Group
Instructor Observations	Quality of answers, misconceptions, structure of writing	Both Groups

Data Analysis Methods

Table 3. Data Analysis Approach

Method Used	Description
Descriptive Statistics	Mean, Median, Standard Deviation of scores
Comparative Analysis	Comparison between control and experimental groups
Paired t-Test	Statistical significance of performance improvement
Thematic Analysis	Qualitative coding of student feedback
Adoption Framework Analysis	Interpretation via TAM and UTAUT models

VII. RESULTS AND DISCUSSION

Table 4. Data of 100 students Marks before and after

	A	B	C	D	E	F	G	H	I	J	K
1	Student ID	Group	Midterm	End-Sem	Subject	Student ID	Group	Midterm	End-Sem	Subject	
96	C095	Control	53	59	Python	E095	Experimental	68	79	Python	15
97	C096	Control	49	55	Python	E096	Experimental	64	75	Python	15
98	C097	Control	56	62	Python	E097	Experimental	63	74	Python	7
99	C098	Control	51	58	Python	E098	Experimental	65	76	Python	14
00	C099	Control	54	60	Python	E099	Experimental	62	73	Python	8
01	C100	Control	48	53	Python	E100	Experimental	67	78	Python	19
02			52.5446593	58.30579				63.28888	74.26485		
95	C093	Control	54	59	Web Technology	E093	Experimental	62	72	Web Technology	8
96	C094	Control	51	56	Web Technology	E094	Experimental	61	71	Web Technology	10
97	C095	Control	53	58	Web Technology	E095	Experimental	64	74	Web Technology	11
98	C096	Control	55	60	Web Technology	E096	Experimental	60	69	Web Technology	5
99	C097	Control	50	55	Web Technology	E097	Experimental	63	73	Web Technology	13
:00	C098	Control	52	57	Web Technology	E098	Experimental	62	72	Web Technology	10
:01	C099	Control	49	54	Web Technology	E099	Experimental	61	71	Web Technology	12
:02	C100	Control	54	59	Web Technology	E100	Experimental	64	75	Web Technology	10
:03			52.0438356	57.0253				61.98387	72.00196		

Performance Improvement (Python Module)

Table 5. Python Marks Comparison (Control vs Experimental)

Assessment Type	Control Group (Mean %)	Experimental Group (Mean %)	Improvement
Midterm Exam	54.2%	63.8%	+9.6%
End-Semester Exam	58.7%	73.1%	+14.4%
Overall Performance	56.4%	69.2%	+12.8%

Performance Improvement (Web Technologies Module)

Table 6. Web Technologies Marks Comparison

Assessment Type	Control Group (Mean %)	Experimental Group (Mean %)	Improvement
Midterm Exam	52.6%	60.9%	+8.3%
End-Semester Exam	57.8%	71.3%	+13.5%
Overall Performance	55.2%	66.1%	+10.9%

Student Feedback (Experimental Group)

Table 7. Student Feedback Summary (N = 100)

Feedback Category	% Students Agreeing
Notes clearer and more structured	92%
Easier exam preparation	87%
Reduced revision time	84%
Felt confident in writing answers	81%
QR codes made learning more interesting	76%
Will continue using AI-assisted notes	89%

QR Code Usage Analytics (Supabase Logs)

Table 8. QR Scan Analytics

Metric	Value
Total QR Scans	5,240
Average Scans per Student	52
Most Scanned Topic	Python: Functions
Least Scanned Topic	HTML Tables
Peak Usage Time	8 PM – 11 PM
Repeat Scan Percentage	71%

Instructor Observations

Table 9. Instructor Evaluation – Answer Quality

Parameter Evaluated	Control Group	Experimental Group
Conceptual Clarity	Moderate	High
Structure of Answers	Irregular	Consistent
Code Example Accuracy	Low	High
Mistakes in Key Definitions	Frequent	Rare
Understanding of Comparisons	Weak	Strong

TAM **(**Technology Acceptance Model) / UTAUT (Unified Theory of Acceptance and Use of Technology) Interpretation

Table 10. Technology Adoption Interpretation

TAM/UTAUT Construct	Student Response (Experimental Group)	Interpretation
Perceived Usefulness	4.6 / 5	Students felt AI notes improved learning
Ease of Use	4.4 / 5	QR scanning and notes access were simple
Effort Expectancy	High	Low effort to retrieve notes
Social Influence	Moderate	Peers encouraged each other
Facilitating Conditions	High	QR + AI worked reliably
Behavioural Intention	Very High	Students want to continue using the system

VIII. CONCLUSION

This study explored whether a simple idea—adding QR-linked generative AI notes with multiple sub topics to understand to a printed syllabus—could actually help undergraduate students learn technical subjects more effectively. The results were encouraging. Students who used the Smart Syllabus performed better in Python and Web Technologies, wrote more organized answers, and made fewer conceptual errors. Teachers also noticed that these students participated more actively in class. QR-scan data from Supabase showed that students returned to the notes regularly, especially during evening study time, suggesting the tool became part of their normal routine. A key takeaway is that students don't need complex platforms or heavy digital tools to benefit from AI. Even a printed syllabus can become a gateway to richer learning when paired with QR codes and structured AI-generated content. This approach helps reduce reliance on uneven handwritten notes and gives everyone access to clear, exam-ready material. The pilot also points to future possibilities such as multilingual support, personalized content, and integration with existing LMS systems.

IX. REFERENCES

- Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education. *Educational Research Review, 20*, 1–11. doi:10.1016/j.edurev.2016.11.002
- Alghamdi, A. (2021). Investigating factors influencing the adoption of AI-based educational tools using TAM and UTAUT. *Education and Information Technologies, 26*, 5177–5198. doi:10.1007/s10639-021-10561-2
- Alqahtani, A. (2023). QR-code–enhanced learning activities and student participation. *Education and Information Technologies, 28*, 10651–10670. doi:10.1007/s10639-023-11842-3
- Anderson, J., & Rainie, L. (2021). *The future of digital spaces and remote learning*. Retrieved from https://www.pewresearch.org/internet/2021/02/18/the-future-of-digital-spaces/
- Arroyo, I., Royer, J., & Tai, M. (2022). Adaptive scaffolding in intelligent learning environments. *Journal of Learning Analytics, 9*(1), 46–63. doi:10.18608/jla.2022.7342
- Baidoo-Anu, D., & Ansah, L. (2023). Education in the era of generative artificial intelligence: Understanding ChatGPT's potential and limitations. *International Journal of Education and Development using ICT, 19*(1). doi:10.5590/IJEDICT.2023.19.1.1
- Bond, M., Zawacki-Richter, O., & Nichols, M. (2021). Systematic review of digital and online learning in higher education: 2013–2020. *Educational Research Review, 34*, 100402. doi:10.1016/j.edurev.2021.100402
- Chang, C.-Y., & Hwang, G.-J. (2023). Effects of mobile and ubiquitous learning on self-regulated learning. *Computers & Education, 194*, 104674. doi:10.1016/j.compedu.2022.104674
- Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. *IEEE Access, 8*, 75264–75278. doi:10.1109/ACCESS.2020.2988510
- Chiu, T., Lin, T.-J., & Lonka, K. (2023). Students' acceptance of AI-powered learning tools: The role of institutional support and expectations. *Computers & Education, 196*, 104712. doi:10.1016/j.compedu.2023.104712
- Deng, L., Yang, M., & Li, X. (2021). Metadata-driven adaptive learning systems: Personalization and learning performance. *Educational Technology Research and Development, 69*, 1321–1340. doi:10.1007/s11423-021-09950-9
- Ebied, M. (2022). Mobile-based interactive systems and their effect on academic achievement and motivation. *Education and Information Technologies, 27*, 11171–11190. doi:10.1007/s10639-022-11076-4
- Ferreira, P., Moreira, F., & Seruca, I. (2022). Cloud-based learning systems: Impact on engagement and real-time learning support. *Computers & Education: Artificial Intelligence, 3*, 100056. doi:10.1016/j.caeai.2021.100056

- Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial intelligence in education: Promises and implications for teaching and learning*. Retrieved from https://curriculumredesign.org/our-work/artificial-intelligence-in-education/
- Hwang, G.-J., & Lai, C.-L. (2022). QR-code-supported mobile learning in blended learning environments: A review. *Interactive Learning Environments, 30*(3), 513–531. doi:10.1080/10494820.2019.1703018
- Kasneci, E., Sessler, K., Küchemann, S., Bannert, M., Süss, P., & Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of LLMs for education. *Learning and Individual Differences*, *103*, 102274. doi:10.1016/j.lindif.2023.102274
- Li, M., & Wong, B. (2020). Digital note-taking and structured learning objects. *Computers & Education*, *150*, 103858. doi:10.1016/j.compedu.2020.103858
- Liu, F., Yang, R., & Wang, Q. (2020). Personalized adaptive learning systems and their mechanisms: A systematic review. *Educational Technology Research and Development, 68*, 1461–1486. doi:10.1007/s11423-020-09757-8
- Mahajan, S., & Singh, M. (2021). QR-code–enabled worksheets for higher education: Impact on engagement. *Education and Information Technologies*, *26*, 3135–3152. doi:10.1007/s10639-020-10391-5
- Martin, F., Sun, T., & Westine, C. (2020). Systematic review of QR-code–based mobile learning in education. *Journal of Research on Technology in Education*, *52*(4), 389–407. doi:10.1080/15391523.2020.1789549
- Mayer, R. (2020). *Multimedia learning (3rd ed.).* Cambridge University Press. doi:10.1017/9781108859046
- Müller, B., & Wulf, T. (2022). Understanding student adoption of digital learning platforms using UTAUT2. *Computers & Education*, *182*, 104468. doi:10.1016/j.compedu.2022.104468
- R., P., & Mg, T. (2025). Automated Code Assessment and Feedback: A Comprehensive Model for Improved Programming Education. *IEEE Access*.
- Ran, X., Jong, M.-Y., & Chen, G. (2022). AI-generated explanations in STEM learning: Effects on understanding and cognitive load. *Computers & Education*, *193*, 104653. doi:10.1016/j.compedu.2022.104653
- Sampson, D., & Karampiperis, P. (2018). Personalized and adaptive digital learning ecosystems. *Smart Learning Environments*, *5*(1). doi:10.1186/s40561-018-0052-3
- Serrano, J., Pérez, M., & Batanero, C. (2020). QR-code micro-learning activities and their influence on memory retention. *Interactive Technology and Smart Education*, *17*(4), 1–15. doi:10.1108/ITSE-01-2020-0011
- Sinha, A., Kumar, A., & Kapoor, A. (2023). Generative AI for academic writing: Opportunities and risks. *Computers & Education: Artificial Intelligence*, *4*, 100130. doi:10.1016/j.caeai.2023.100130
- Weng, X., Xia, Q., Gu, M., Rajaram, K., & Chiu, T. K. (2024). Assessment and learning outcomes for generative AI in higher education: A scoping review on current research status and trends. *Australasian Journal of Educational Technology*.
- Yip, W., Tse, S., & Yan, E. (2021). QR-code–enhanced educational materials and their impact on student engagement. *Educational Media International*, *58*(2), 120–136. doi:10.1080/09523987.2021.1902262
- Yuan, X., Deng, L., & Zhao, R. (2023). Effects of AI-organized notes on revision efficiency and exam preparation. *Journal of Educational Computing Research*, *61*(5), 1250–1275. doi:10.1177/07356331231166879