Integrated of Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology of Mathayom 1 Computational Science

Jaruwan Karapakdee
Srinakharinwirot University, Thailand, *jaruwanka@g.swu.ac.th*

*Corresponding author E-mail**:** jaruwanka@g.swu.ac.th

Received: July 22, 2025; Revised: September 9, 2025; Accepted: October 10, 2025

Please cite as: Karapakdee, J. (2025). Integrated of Hyflex learning model using artificial intelligence to enhance innovation technology of Mathayom 1 computational science. *International Journal of Educational Communications and Technology*, *5*(2), 11–23.

ABSTRACT: *An Integrated of Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology of Mathayom 1 Computational Science subject has the following objectives: (1) To integrate an Integrated of Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology of Mathayom 1 Computational Science. (2) To compare the outcomes of technological innovation projects created by Mathayom 1 Computational Science. (3) To assess student satisfaction with the use of An Integrated of Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology of Mathayom 1 Computational Science. This study was conducted in a sample group of 90 Mathayom 1 students of Ongkharak Demonstration School, Srinakharinwirot University, Computational Science subject, academic year 2024. The participants were selected through purposive sampling. The research instrument used was a satisfaction assessment questionnaire on the implementation of the Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology.*

The findings revealed that the Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology projects were rated at the highest level of appropriateness. The overall effectiveness of cognitive technology in supporting technological innovation projects was also rated at the highest. The average innovation assessment scores of students using An Integrated of Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology were higher than those of students in the traditional learning group, with the experimental group scoring at the highest level compared to the control group. Additionally, student satisfaction with the Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology projects was rated at the highest overall level.

Keywords: Hyflex Learning, Artificial Intelligence, Innovative thinking skills, Innovation

1. Introduction

Education in the 21st century is undergoing profound transformation as a result of technological advancement, globalization and the rapidly-evolving demands of the knowledge-based economy. Traditional models of instruction which emphasize uniformity and teacher-centered approaches, have become insufficient when it comes to addressing the diverse needs of modern learners. Instead, there is a need for contemporary education to focus on developing competencies that extend beyond the acquisition of factual knowledge, with an emphasis on critical thinking, creativity, collaboration, problem-solving, and digital literacy (Trilling & Fadel, 2009). These competencies are essential not only for academic achievement but also for effective participation in an increasingly complex and technology-driven society. In response to these demands, Hyflex Learning has emerged as a pedagogical model that emphasizes flexibility, learner autonomy, and inclusivity. This model integrates face-to-face, synchronous online, and asynchronous learning modalities, enabling learners to select formats that best suit their individual contexts, preferences, and capabilities (Beatty, 2019). Rooted in the principles of lifelong learning and andragogy, Hyflex Learning reflects the recognition that learners—particularly adolescents and adults-possess diverse prior experiences and require adaptive learning pathways that align with their goals and interests (Rosen, 2021). The adaptability of this

model is especially pertinent in the context of rapid social and technological change, where the cultivation of self-directed learning skills has become indispensable.

Parallel to the development of flexible learning models, Artificial Intelligence (AI) has emerged as a transformative force within education. AI technologies, including natural language processing, machine learning, and intelligent tutoring systems, have demonstrated significant potential when it comes to enhancing learning environments by providing personalized feedback, supporting data-driven decision-making, and fostering interactive engagement (Chaiyarak & Wannapiroon, 2020). The integration of AI into educational practice aligns with global efforts to leverage digital innovation for the purpose of improving instructional quality, learner outcomes, and educational equity. Within the domain of secondary education, particularly in Computer Science, the application of Hyflex Learning in conjunction with AI assumes critical importance. Computational Science at the lower-secondary level serves as a foundation for cultivating logical reasoning, systematic problem-solving, and computational thinking—skills that are central to innovation and indispensable for navigating the digital age (Amelink et al., 2013). By combining flexible pedagogical frameworks with AI-driven instructional tools, educators can establish adaptive, student-centered environments that not only support knowledge acquisition but also foster creativity, innovation, and future-oriented competencies. In the context of Thailand, these educational imperatives are of particular urgency. Despite ongoing reforms under the Thailand 4.0 policy framework, significant challenges remain, including disparities in access to quality education, limitations in technological infrastructure, and uneven digital literacy among students and teachers (Office of the National Economic and Social Development Council, 2017). The COVID-19 pandemic further magnified these issues, exposing the vulnerability of traditional classroom-based instruction, and underscoring the need for resilient, flexible learning models. Consequently, the integration of Hyflex Learning with AI represents a strategic response to both global and local challenges, offering pathways to enhance equity, efficiency, and innovation within the Thai education system.

Accordingly, the present study proposes the development of an Integrated Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology of Mathayom 1 Computational Science. This initiative represents a targeted effort to strengthen foundational digital skills, address existing gaps in educational access and quality, and prepare Thai students for effective participation in a rapidly-changing global society.

2. Objective

1. To integrate a Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology of Mathayom 1 Computational Science.
2. To compare the outcomes of technological innovation projects created by students of Mathayom 1 Computational Science.
3. To assess student satisfaction with the use of an Integrated Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology of Mathayom 1 Computational Science.

3. Hypothesis

1. The students who used this approach as part of Mathayom 1 Computational Science demonstrated significantly higher technological innovation performance than those who learned through traditional methods.
2. The technological innovation performance of students in the experimental group after the intervention was significantly higher than before the intervention.
3. Students expressed a high degree of satisfaction with the Integrated Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology.

4. Research scope

The sample group used in this research consisted of 90 Mathayom 1 students enrolled in the Computational Science subject at the Ongkharak Demonstration School of Srinakharinwirot University in the first semester of the 2024 academic year. The students were selected through purposive sampling.

5. Method

The research involved the development of an Integrated Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology with regard to the Mathayom 1 Computational Science subject. The research is

categorized as Research and Development (R&D) and was divided by the researcher into five phases. Each phase was carefully designed to ensure academic rigor, practical feasibility, and reliability of outcomes.

Phase 1: Designing the Architecture of Cognitive Technology to Enhance Technological Innovation Performance

This phase focused on the conceptual and theoretical foundation necessary to build a robust learning system.

1. A literature review and needs analysis were conducted to identify the importance and feasibility of applying cognitive technology in secondary-level computational science education.
2. A survey of relevant tools, including AI-powered software (e.g., adaptive learning platforms, intelligent tutoring systems) and hardware (e.g., IoT devices, smart classroom facilities), was carried out to determine practical integration methods.
3. The researcher analyzed system components such as knowledge representation, reasoning mechanisms, and machine learning algorithms to align with innovation performance enhancement.
4. The suitability of the designed architecture was evaluated against educational standards, technological readiness, and scalability.
5. The results from expert reviews and preliminary analysis were summarized, leading to a finalized architecture design.

Phase 2: Developing the Hyflex Learning Model Using Cognitive Technology to Enhance Technological Innovation Performance

This phase involved the transformation of the theoretical architecture into a functioning learning model.

1. The prototype system was developed by integrating AI-driven cognitive functions into the Hyflex model, enabling the creation of synchronous and asynchronous learning pathways.
2. Initial trials were carried out with a small pilot group to refine user interface design, accessibility, and instructional flow.
3. System performance was evaluated by three purposively-selected experts with more than five years professional experience. Their evaluations used a validated performance assessment instrument focusing on effectiveness, efficiency, and adaptability in enhancing technological innovation.

Phase 3: Comparing the Technological Innovation Performance of Students

This phase aimed to assess the impact of the developed model on student innovation.

1. Orientation sessions were conducted to ensure students understood the learning objectives, usage guidelines, and expectations.
2. A pre-test innovation performance assessment was administered, using authentic tasks requiring students to design solutions to real-world problems.
3. A 5-week experimental implementation of the Hyflex model was conducted with the sample group. Learning activities emphasized computational problem-solving, creativity, and innovation-driven projects.
4. A post-test assessment was conducted using the same validated instrument to measure growth in innovation performance.
5. Collected data were statistically analyzed (e.g., paired t-test, effect size) to measure the significance of observed improvements.
6. Findings from the comparison were synthesized to determine the effectiveness of the model.

Phase 4: Studying Results of Model Implementation and Student Satisfaction

This phase focused on field testing and student perceptions.

1. The Hyflex learning model was implemented with 90 Mathayom 1 students at the Demonstration School of Srinakharinwirot University Ongkharak during the first semester of the 2024 academic year. The trial period lasted five weeks, incorporating project-based learning and collaborative innovation tasks.
2. Student satisfaction was measured using a researcher-developed questionnaire, covering dimensions such as content relevance, usability of the system, engagement, and overall learning experience. Quantitative data from the questionnaire were analyzed alongside qualitative feedback for a comprehensive understanding.

Phase 5: Maintenance and Continuous Improvement of the Model

The final phase emphasized sustainability and long-term effectiveness.

1. Feedback from expert evaluations and student satisfaction surveys was systematically analyzed to identify strengths and weaknesses.

2. Improvements were made in terms of instructional design, technological integration, and support mechanisms.
3. A maintenance framework was established to ensure the model remains adaptable to future technological advancements and changing educational needs.

6. Results

1. The results of developing an Integrated Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology on the part of Mathayom 1 Computational Science students.

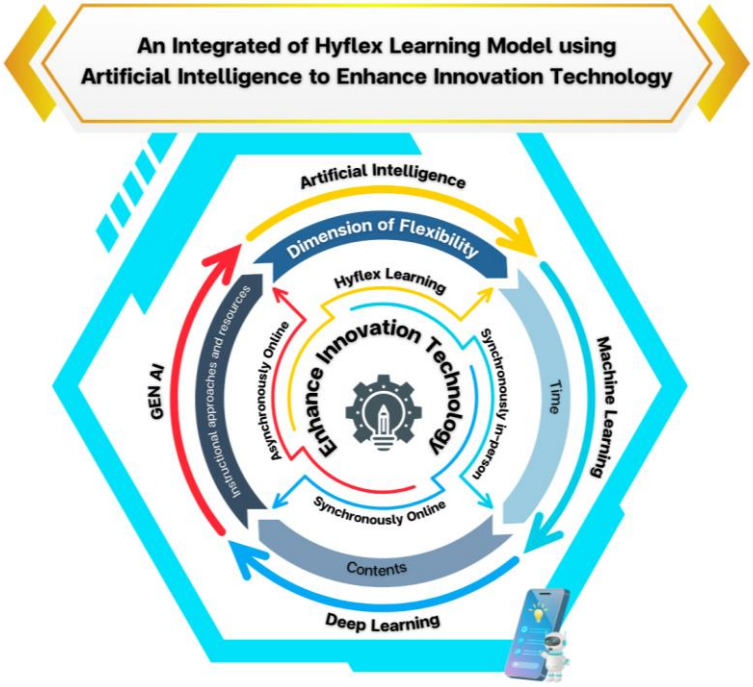

Figure 1. An Integrated of Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology

From Figure 1 we can see that the results of developing an Integrated of Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology on the part of Mathayom 1 Computational Science Subject students consists of the following components:

1. Dimension of Flexibility

This dimension includes three key aspects**:** Time, Content, and Instructional Approaches & Resources **(**Beatty, 2019; Trilling & Fadel, 2009**).**

1.1 Time

1.1.1 Started Learning – Establishing a fixed start time for each class or session helps students develop a sense of responsibility and readiness, reducing tardiness and improving instructional efficiency (Means et al., 2013).

1.1.2 Finishing Learning – Setting a clear end time for each session allows instructors to manage content and activities effectively within the given time frame, promoting time discipline (Garrison & Vaughan, 2008).

1.1.3 Tempo of Studying – Refers to the appropriate duration for learning activities that matches the content and teaching method, tailored to students' learning abilities. Efficient time allocation helps learners grasp concepts more effectively (Bonk & Graham, 2006).

1.2 Contents

1.2.1 Sequence of Content – Organizing content from basic to more complex levels help students understand progressively without confusion (Bruner, 1960).

1.2.2 Assessment of Background Knowledge – Evaluating students' prior knowledge before starting new lessons through tests, surveys, or interviews to ensure effective instruction (Shuell, 1996).

1.2.3 Additional Content – Supplementing core content with examples, case studies, or real-life scenarios enhances students' understanding and practical application (Jonassen, 2011).

1.3 Instructional Approaches and Learning Resources

1.3.1 Variety of Teaching Methods – Utilizing diverse techniques such as lectures, discussions, project-based learning, or hands-on activities to increase student engagement and creativity (Prince, 2004).

1.3.2 Motivation to Learn – Using methods like rewards, thought-provoking questions, or fun learning environments to stimulate interest and drive self-improvement (Deci & Ryan, 2000).

1.3.3 Methods & Technology for Learning – Integrating technology such as computers, the internet, online media, and educational apps improve learning efficiency and broadens access to information (Mayer, 2009).

2. Hyflex Learning Model

This model blends in-person and online learning, allowing students to choose their preferred mode—attending class physically, joining online in real-time, or engaging in self-paced learning. It includes (Beatty, 2019):

- Synchronously In-Person – Real-time, face-to-face instruction in a physical classroom where students interact directly with the teacher and peers through activities, discussions, or Q&A sessions (Garrison & Vaughan, 2008).
- Synchronously Online – Real-time online learning via platforms like Zoom, Microsoft Teams, or Google Meet. Students can participate from anywhere with internet access and interact through video calls, chats, or other digital tools (Moore et al., 2011).
- Asynchronously Online – Self-paced learning that allows students to access recorded videos, content, or exercises at any time. This promotes autonomous learning, letting students control their own schedule and pace (Hrastinski, 2008).

Chatbot Functions in Learning

- Q&A Assistant – This function of AI/chatbots helps learners resolve their questions, answer inquiries, and explain knowledge in an easily understandable way, supporting self-directed learning (Woolf, 2010).
- Learning Resource Recommendation – This function of AI/chatbots assists learners in searching for and accessing appropriate learning resources, enhancing understanding and enabling deeper knowledge development (Luckin et al., 2016).
- Assessment Support – This function of AI/chatbots helps evaluate learners' understanding in various formats and provides immediate feedback, fostering comprehension and improving learning effectiveness (Chen et al., 2020).
- Innovation Guidance – This function of AI/chatbots acts as a virtual advisor, offering guidance on ideas, methods, and tools to help learners systematically and effectively create technological innovations (Goel & Polepeddi, 2016).
- Conversational Interaction – This function of AI/chatbots allows learners to communicate and interact as if in real conversation, enhancing flexible learning, engagement, and motivation (Fryer et al., 2021).

Table 1. Linking Chatbot Functions with the Hyflex Model

Function	Application in the Hyflex Model
Q&A Assistant	Learners can ask questions both in the classroom or online. The system responds immediately, enabling continuous learning regardless of location.
Learning Resource Recommendation	The chatbot can suggest videos, documents, or websites to help learners continue studying, whether at home or in the classroom.
Assessment Support	Online quizzes or tests provided by the chatbot allow learners to assess their understanding instantly, supporting Hyflex learning in any setting.
Innovation Guidance	The system provides guidance on project development and feedback via text or voice, allowing both online and in-class learners to access advice equally.
Conversational Interaction	Creates two-way interaction, so learners feel as if they are communicating with a teacher or classmates, maintaining the engagement with Hyflex learning.

Chatbots serve as a tool that enables the Hyflex model to support learning anytime, anywhere, and at any level of understanding, while maintaining interaction and motivation, and facilitating the development of students' technological innovations, similar to a traditional classroom experience.

Table 1. Results of the Development of an Integrated Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology as part of Mathayom 1 Computational Science

An Integrated of Hyflex Learning Model using Artificial Intelligence to Enhance Innovation Technology	**Expert opinion**		
	M	***SD***	**Suitability level**
1. Hyflex learning process using ai to enhance technological innovation performance	4.67	0.58	Highest
2. AI steps for instructional management using the Hyflex learning model to enhance innovation technology performance	4.67	0.58	Highest
3. Approaches to using the Hyflex learning model using AI to enhance innovation technology	4.67	0.58	Highest
4. The Hyflex learning model using AI to enhance innovation technology and enhance technological innovation performance.	4.33	0.58	Highest
5. The learning model can be adapted to suit each individual learner in terms of time, location, and learning methods	5.00	0.00	Highest
Sum	**4.67**	**0.49**	**Highest**

From Table 1, the results of the evaluation process found that Hyflex Learning Model using AI to Enhance Innovation Technology performance is highly appropriate.

2. The results of the development of the Hyflex learning model using AI to enhance innovation technology were as follows:

1. Start by adding Line: TechGenius_ODS as a friend by scanning the QR Code below.

Figure 2. QR code for adding TechGenius_ODS as a friend

2. Press the Add Friend button, then press the Chat button to start a conversation.

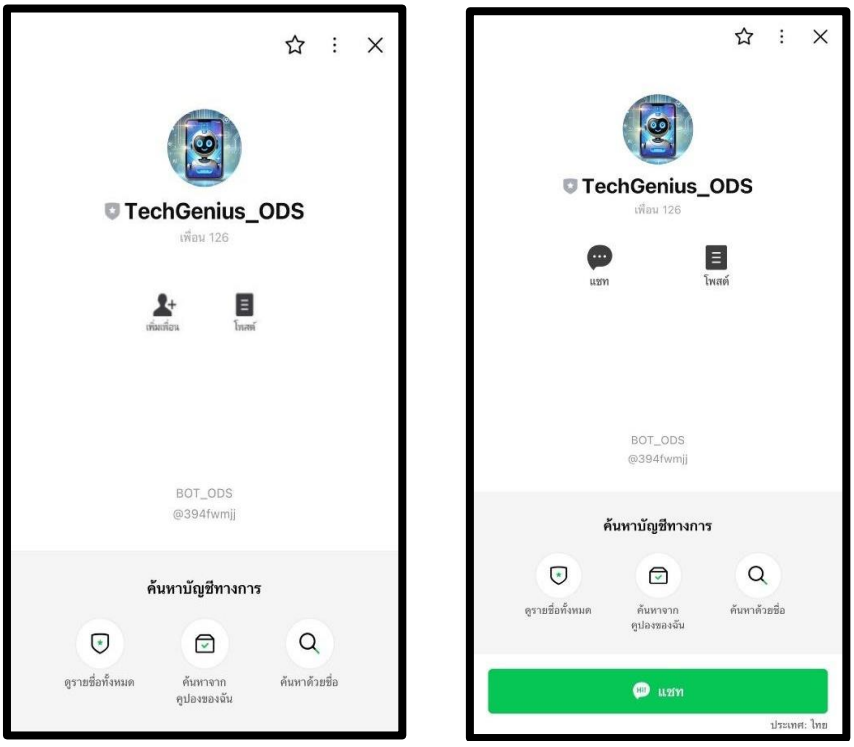

Figure 3. Shows adding friends

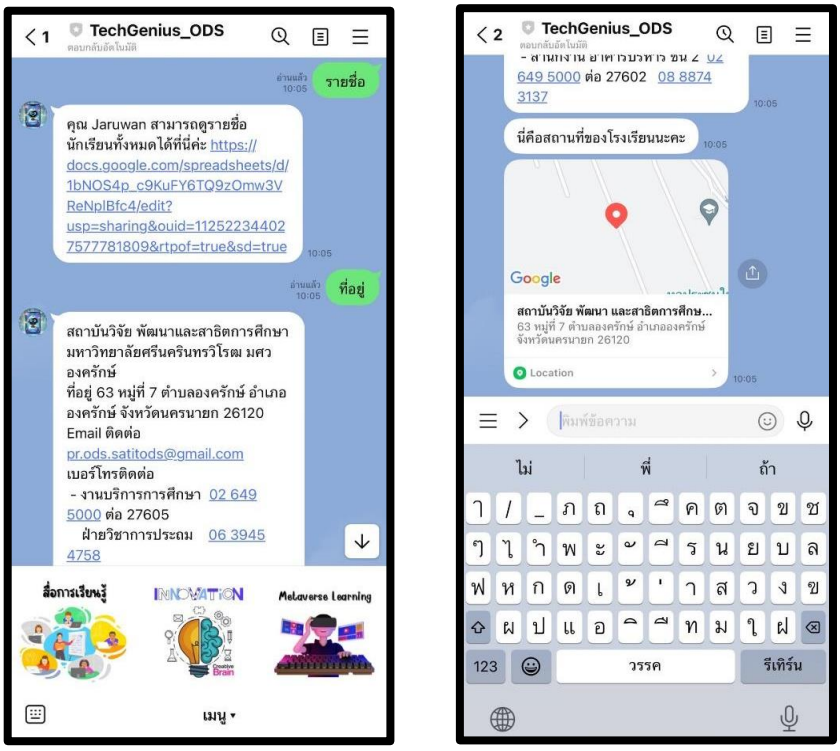

Figure 4. An example picture of TechGenius_ODS answering questions

Table 2. The Results of the Evaluation of the Efficiency of the Hyflex Learning Model using AI to Enhance Innovation Technology

Key Aspects for Measuring System Efficiency	Expert opinion		
	M	***SD***	**Suitability level**
1. Appropriateness of System Functionality			
1.1 The naturalness of human-like conversation	5.00	0.00	Highest
1.2 The appropriateness of the language level used for the users	5.00	0.00	Highest
Sum	**5.00**	**0.00**	**Highest**
2. Accuracy of System Performance			
2.1 The appropriateness of the text used to effectively communicate with users	4.33	0.58	Highest
2.2 The suitability of layout, font size, and images	5.00	0.00	Highest
2.3 The ease of understanding and the clarity of the system's responses or conversations	5.00	0.00	Highest
2.4 The accuracy and relevance of the responses provided by the system in terms of the questions asked	5.00	0.00	Highest
Sum	**4.83**	**0.39**	**Highest**
3. System Usability and Ease of Use			
3.1 Convenience and accessibility of system usage	4.67	0.58	Highest
3.2 Appropriateness of overall screen design	5.00	0.00	Highest
Sum	**4.83**	**0.41**	**Highest**
4. System Speed and Responsiveness			
4.1 System response time	5.00	0.00	Highest
4.2 The provision of up-to-date and regularly updated information by the system	5.00	0.00	Highest
4.3 Overall appropriateness of the system's speed and performance	5.00	0.00	Highest

Key Aspects for Measuring System Efficiency	Expert opinion		
	M	***SD***	**Suitability level**
Sum	**5.00**	**0.00**	Highest
5. System Security			
5.1 The adding a friend login function of the system	5.00	0.00	Highest
Sum	**5.00**	**0.00**	**Highest**
Total average	**4.92**	**0.28**	**Highest**

From Table 2, it can be seen that the evaluation results with regard to the Hyflex Learning Model using AI to Enhance Innovation Technology, overall, indicate a high degree of appropriateness (M = 4.92, SD = 0.28).

3. Comparison of Innovation Technology Development of Students of Mathayom 1 Computational Science
The comparison of innovation technology development of the Mathayom 1 Computational Science students, based on the innovation assessment results of the control group and the experimental group, is as shown in Table 3.

Table 3. Results of the assessment of the average innovation of the control group and the experimental group

Assessment	Control group (traditional learning)		Experimental group (learning using Hyflex Learning)	
	M	***SD***	***M***	***SD***
Students can creatively devise solutions to complex problems	2.76	0.44	3.84	0.37
Students can integrate knowledge from various fields to create innovations	2.84	0.37	3.80	0.41
Students can use technology and tools to develop their work	2.72	0.46	3.64	0.49
Students are confident in expressing opinions and presenting new ideas creatively	2.76	0.44	3.72	0.46
Students can work as a team and exchange ideas to develop innovations.	3.00	0.50	3.84	0.37
Students can evaluate and improve their ideas to enhance their effectiveness	2.84	0.37	3.8	0.41
Students are determined and persistent in experimenting and developing innovations until successful	2.76	0.44	3.84	0.37
Students can analyze trends in societal problems or needs to create innovations	2.80	0.41	3.84	0.37
Students have good communication skills to present innovations in a way that others can understand	2.80	0.41	3.76	0.44
Students can apply the results of innovations to real-life situations	2.84	0.37	3.76	0.44
Sum	**2.81**	**0.04**	**3.78**	**0.04**

From Table 3, it can be seen that the average innovation assessment results of students who learned through the Hyflex Learning Model using AI to enhance innovation technology were compared to students who learned through the traditional method. Overall, the innovation assessment of the experimental group is at the highest level (M = 3.78, SD = 0.44) when compared to the innovation assessment of the control group.

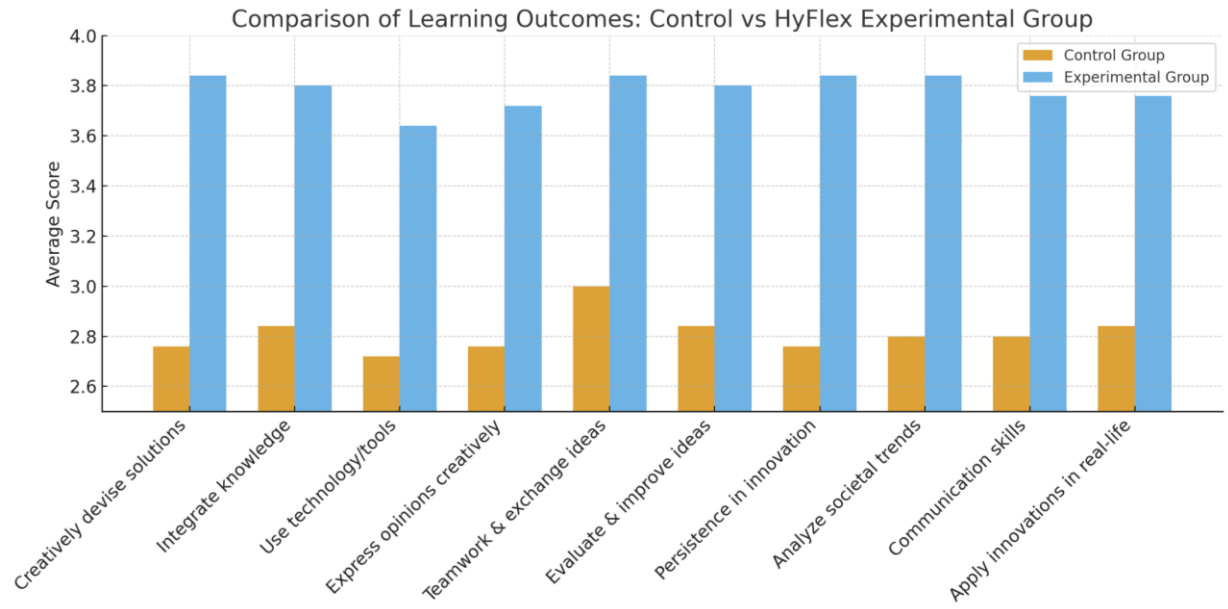

Figure 5. Bar Chart Comparing Average Student Scores Between the Control Group and the Experimental Group

4. Results of the assessment of the degree of satisfaction on the part of the students with regard to the use of the Hyflex Learning Model using AI to enhance innovation technology.

Table 4. Results of the assessment of the degree of satisfaction on the part of the students with regard to the use of the Hyflex Learning Model using AI to enhance innovation technology

Assessment	User satisfaction		Satisfaction Level
	M	***SD***	
1. Ease of access to information	4.67	0.47	Highest
2. System response time	4.64	0.48	Highest
3. Clarity of messages in communicating with users	4.57	0.60	Highest
4. System provides up-to-date and regularly updated information	4.64	0.48	Highest
5. System delivers accurate results that meet user needs	4.56	0.60	Highest
6. System resembles human-like conversation	4.61	0.69	Highest
7. Appropriate size, color, and readability	4.63	0.59	Highest
8. Clarity of text displayed on screen	4.66	0.48	Highest
9. Overall appropriateness of screen design	4.64	0.48	Highest
10. Overall user satisfaction with the system	4.64	0.48	Highest
Total average	**4.63**	**0.54**	**Highest**

As can be seen from Table 4, the evaluation of the degree of satisfaction with regard to using the Hyflex Learning Model using AI to enhance innovation technology among students, the overall satisfaction level is at the highest level possible (M =4.63, SD= 0.54).

7. Discussion

The comparison of the results with regard to the creation of technology innovations within the Mathayom 1 classroom in the subject of Computational Science revealed that the average assessment score of the students who learned through the Hyflex Learning Model using AI to enhance innovation technology was higher compared to students who learned through traditional methods. Overall, the innovation measurement of the experimental group was at the highest level when compared to the control group. This aligns with the research (Intarapanit, et al., 2024) who found that the comparison of innovation skill development between an experimental group and a control group showed that the

experimental group scored higher in cognitive skills. The experimental group also achieved an average total score in the "very good" range, which was higher than that of the control group. Regarding satisfaction, the experimental group showed a high level of satisfaction.

1. The evaluation of student satisfaction with regard to using the Hyflex Learning showed that the overall appropriateness of this model was at the highest level. This is in line with the research (Karapakdee & Piriyasurawong, 2022) who found that the evaluation of satisfaction with using cognitive technology for academic counseling in New Normal was also at the highest level. Furthermore, the research (Munchat, 2024) indicated that the evaluation of the effectiveness of the developed learning management model showed that students' satisfaction with the model was high across all areas, with an overall satisfaction rating of "very satisfied". Similarly, (Jongmuanwai & Teemauangsai, 2022) found a high degree of satisfaction with the hybrid flexible learning model in three key areas: the speed of system operation, the reliability of the data, and the ease of using the system, with an overall satisfaction rating being at a high level.

A comparison of innovation performance between the control group (traditional learning) and the experimental group (Hyflex with AI) revealed a statistically significant difference. The experimental group ($\overline{X}$ = 3.78, SD = 0.44) scored substantially higher than the control group ($\overline{X}$ = 2.81, SD = 0.40), t (88) = 10.94, p < .001. The mean difference of 0.97 points was statistically significant at the 95% level, suggesting that the Hyflex with AI model exerted a strong and meaningful impact on students' innovation performance.

This study was approved by the Human Research Ethics Committee of Srinakharinwirot University. Participants provided informed consent prior to the study. Personal data were kept strictly confidential and anonymous, and all information was used solely for academic research purposes.

Research Limitations

This study was conducted with 90 Mathayom 1 students from a single demonstration school. This restricts the generalizability of the findings to other educational contexts and age groups. In addition, the measurement of the extent of innovation and the degree of satisfaction was limited to short-term observation, making it difficult to assess long-term outcomes such as knowledge retention or skill sustainability. While the Hyflex model offers flexibility, it presupposes universal access to devices and reliable internet, which may not hold true in under-resourced settings. Moreover, the AI tool employed (TechGenius_ODS) may face challenges in terms of natural language processing and personalization, which could influence its learning effectiveness.

Future Research Directions

Future studies could extend this work by implementing the model across diverse school types to examine adaptability and scalability. Researchers could also investigate the long-term effects of Hyflex learning with AI on innovation, digital literacy, and academic performance in addition to exploring teacher readiness and adaptation to AI-assisted instruction, including relevant support mechanisms. Finally, there is a need to examine ethical personalization of AI for learners, with attention to data security, equity, and inclusivity.

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