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Original Article

A Competency-Based Curriculum for Fostering Artificial Intelligence Skills in Thai Children and Youth

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Abstract *- This study introduces a carefully constructed curriculum based on competencies, with the objective of fostering artificial intelligence skills in children and young individuals. It addresses the pressing requirement for a complete AI education throughout different educational stages. The curriculum has been carefully structured into three unique tiers, namely Basic, Intermediate, and Advanced, in order to accommodate the varied educational backgrounds and developmental stages of learners. A comprehensive training package was created, encompassing a diverse range of educational materials such as video lectures, motion graphics, quizzes, and other resources, which were disseminated through an online assessment platform. The training approach aligns with the UNESCO competence curriculum development model, which encompasses the essential components of knowledge, abilities, and attitudes pertaining to artificial intelligence. Following this, the curriculum was put into effect, and further evaluation endeavors showed noteworthy accomplishments. The initiative provided benefits to a total of 2,700 pupils and 184 newly appointed instructors, constantly surpassing the established pass requirements. Moreover, the engagement of children and young people from 23 schools in an innovation contest, resulting in the receipt of 76 ideas, highlights the broad popularity of the curriculum. The results highlight the significant influence of the curriculum in fostering knowledge and skills related to Artificial Intelligence (AI) among children and young individuals. This curriculum plays a crucial role in reducing the educational disparity in this rapidly evolving domain and equipping the upcoming generation with the necessary ability to succeed in a society heavily influenced by AI.*

Keywords *- Artificial intelligence, Literacy, Competency, Youth, Curriculum.*

1. Introduction

The technology trends in the 21st century encompass digital advancements such as applied AI, Web3, cloud and edge computing, and digital security [1]–[3]. Among these, one crucial technology is artificial intelligence. Therefore, there are several reasons why children should learn about AI, including understanding the world, problem-solving, collaboration, ethical considerations, and the future job market. Firstly, understanding the world: Artificial Intelligence (AI) has already become indispensable to individuals' everyday routines, from voice assistants on phones to the algorithms powering social media platforms. By learning about AI, children can better understand the technology that shapes their world. Secondly, problem-solving: AI is a powerful tool for solving complex problems. Learning about AI can help children develop problem-solving skills and encourage creative thinking. Thirdly, collaboration: AI is a highly interdisciplinary field that necessitates collaboration among individuals with diverse backgrounds and skills. Learning about AI can assist children in developing their collaboration and communication skills. Furthermore, ethical considerations: AI has the potential to impact society profoundly. Children need to learn about the ethical considerations surrounding AI and its potential for both positive and negative outcomes. Lastly, with the world becoming more digitalized and automated, there will be an increasing demand for individuals with AI skills in the job market [4]. Learning about AI early can prepare children for a future where AI skills will be highly valued. In summary, learning about AI can be a valuable component of a child's education, equipping them for a future in which AI will play an increasingly significant role in society. Numerous research studies have focused on AI education and employ various teaching techniques within school settings. For instance, the

iRobot [5] training course is designed for secondary schools in Australia. Encompassing a broad spectrum of subjects, the curriculum includes Search Algorithms, Problem Solving, Agent Systems, Data Structures, Automata, Graphs, Planning, and Machine Learning. Problem-solving is the primary objective of this training, where theoretical concepts are taught and then applied through the use of robots. For instance, the automata module teaches systems and behaviors that illustrate the decision-making process, while intelligent agents represent the programmed decision-making processes executed by the robot. Additionally, problems encountered by artificial intelligence are tackled by guiding the robot through a small maze, recording routes, and determining the optimal path with the aid of graph theory and data structures such as stack, queue, and trees. In the People's Republic of China, Han Xiao introduced an AI training course in 2018 for high school students[6]. The course aims to foster students' enthusiasm while imparting knowledge about artificial intelligence from the basics, computational thinking, and adaptability to future advancements. This training course is integrated with the Chinese Academy of Sciences iSTREAM system, endorsed by the government. In 2018, a different AI curriculum was created specifically for students in grades 5-8, employing the Jibo robot and PopBots as educational aids to ignite curiosity. The Jibo robot is a compact and reasonably priced conversational robot that closely resembles a human. On the other hand, PopBots is a robotic toolkit developed to educate children about artificial intelligence. This curriculum cleverly utilizes these resources to actively involve children in practical learning activities, cultivating their enthusiasm for AI. In 2020, the American Community Schools (ACS) developed an AI curriculum [7] with the aim of providing AI training to students. The curriculum commences with an analysis of the societal and economic ramifications of artificial intelligence.

The intermediate level focuses on perception, capability, and the practical applications of intelligent systems. At the advanced level, students delve into specific mathematical examples of machine learning to better understand algorithms. The training framework, depicted in Figure 1, illustrates the structure of the curriculum and its progression through these levels. The exploration of artificial intelligence competency represents a vital and contemporary facet of education and computer science. It is imperative to address practical questions, such as defining the essential competencies for effectively engaging with and evaluating artificial intelligence. Furthermore, designing learner-centric learning experiences using artificial intelligence technology is paramount to nurturing an understanding of artificial intelligence, especially among children and young individuals. The educational framework for crafting learning experiences and assessing the necessary competencies in artificial intelligence education should revolve around key inquiries, including understanding what artificial intelligence is, comprehending the various capabilities it offers, grasping the operational mechanisms of artificial intelligence, recognizing its diverse applications, and evaluating individuals' perceptions of artificial intelligence. While numerous AI curricula have been developed internationally, a notable gap exists in creating competency-based frameworks tailored to the varied educational stages of Thai children and youth. Existing initiatives often lack adaptability to diverse learning environments, emphasizing either theoretical knowledge or highly technical applications. This study addresses the gap by constructing a tiered curriculum that progressively introduces AI skills aligned with developmental stages. The novelty of this work lies in its structured approach, guided by the UNESCO competence curriculum development model, and its application across a large-scale educational program in Thailand. In contrast to previous studies, such as Australia's iRobot course or China's iSTREAM initiative, which focuses on specific AI topics or advanced learners, this curriculum offers a unique, competency-based framework that integrates practical, ethical, and theoretical AI education across multiple age groups. This structure fosters a deeper understanding of AI while catering to a broad spectrum of learners, from primary school students to early university levels.

1.1. Artificial Intelligence

AI is often misconstrued as solely pertaining to robots and technologies that fall short of human-like intelligence are often disregarded as non-artificial intelligence [8]–[10]. However, artificial intelligence encompasses much more than this common perception. In fact, artificial intelligence refers to the human creation of intelligent machines. Understanding what constitutes artificial intelligence is crucial for effectively engaging with it. Various definitions of intelligence exist, including its capacity to enable proper functioning and predictability in each environment [11], the ability to think or express thoughts in a manner akin to humans (based on empirical understanding), or even rationality based on mathematical reasoning [12].

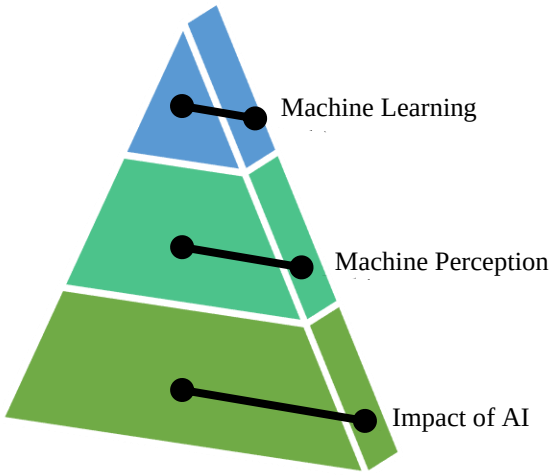


Fig. 1 Training framework of Artificial Intelligence course for american community schools

When it comes to defining artificial intelligence specifically, numerous interpretations are available. The concept of artificial intelligence encompasses a wide range of interpretations, reflecting its complex nature and the different perspectives of academics and specialists in the field. According to the source [13], the concept can be defined as the automation of cognitive processes associated with human intelligence, encompassing tasks such as making decisions, solving problems, and acquiring knowledge. The aforementioned study emphasizes [14] the pursuit of developing computers that possess cognitive capabilities, hence enabling authentic cognitive processes.

As presented in reference [15], one perspective interprets AI as studying cognitive abilities using computational models. Conversely, reference [16] characterizes AI as the art of creating computers that can perform activities that generally need human-like intellect. [17] This study focuses on Artificial Intelligence (AI) as the examination of enabling computers to surpass human abilities in specific areas, whereas [18] elucidates computational intelligence as the investigation of creating intelligent agents. In conclusion, [19] emphasized that artificial intelligence is centered on demonstrating intelligent behavior in artificially created entities. The compilation of these definitions highlights the extensive range and complex nature of the field of artificial intelligence.

In conclusion, based on the definitions provided, artificial intelligence can be categorized into four groups. The first group encompasses artificial intelligence miming human thinking processes to replicate human-like cognition. The second group focuses on artificial intelligence that operates based on logical reasoning and problem-solving methods. The third group involves artificial intelligence that imitates human behavior, seeking to emulate human actions and responses. Lastly, the fourth group involves artificial intelligence based on logical principles, employing rationality and mathematical reasoning. These distinct categories demonstrate the diverse approaches and objectives within the field of artificial intelligence.

1.2. Various Capabilities AI Offers

Artificial intelligence can accomplish diverse tasks, offering valuable support for decision-making processes. However, a crucial consideration arises: when should individuals trust artificial intelligence? While humans excel in tasks that demand creativity, emotional intelligence, knowledge transfer, and social interaction, artificial intelligence demonstrates remarkable proficiency in pattern detection within vast datasets, performing repetitive work, and making decisions within controlled environments. It is essential to recognize that artificial intelligence possesses distinct capabilities, and users can harness its potential more effectively by comprehending both its strengths and limitations. By understanding the strengths and weaknesses of artificial intelligence and human intelligence, individuals can enhance problem-solving abilities and maximise each unique capability. Artificial intelligence is experiencing rapid advancements, necessitating a proactive approach to future planning, long-term policymaking, and assessing potential implications. Individuals must consider the current capabilities of artificial intelligence and anticipate its future advancements.

One effective strategy to foster this mindset is creating speculative designs, envisioning possible artifacts and their impact on society. By engaging in fiction design, stakeholders can collectively explore the potential influence of artificial intelligence on future cities. Moreover, a comprehensive grasp of children's viewpoints towards artificial intelligence gadgets can yield significant insights [20] while tackling ethical concerns in K-12 artificial intelligence teaching [21]. The capacity to envision "artificial intelligence in the future" empowers individuals to engage in creative ideation, undertake critical assessments of technology's intrinsic worth, and evaluate its enduring societal and global ramifications.

1.3. Grasping the Operational Mechanisms of AI

Gaining a comprehensive understanding of the inner workings of artificial intelligence allows for a more precise analysis of its learning capabilities. In this study, the components exploration of artificial intelligence was done across different fields to ensure the course design is well-suited and aligns with the desired competencies. The key focus areas include cognitive systems, machine learning, and robotics.

Cognitive System - Present-day cognitive systems can be categorized into key groups encompassing knowledge representation, planning, and problem-solving. These systems are crucial in determining how artificial intelligence learns and operates [22]. Machine Learning (ML) - Machine learning is a versatile and essential tool within the field of artificial intelligence. It encompasses various techniques and approaches that enable systems to learn and improve their performance based on data [23] and [24].

Robotics - Robotics represents a specific branch of artificial intelligence education that studies AI within robots. Robots offer a tangible platform for demonstrating real-world interactions. Many research studies propose models that utilize robots to teach fundamental principles of artificial intelligence. For instance, sensor systems and responsive actions can be combined to illustrate the functioning of artificial intelligence [25]. Algorithms necessary for robot response, including determination, finding, and planning, have been explored extensively [26]. Machine learning, particularly in the context of vision, has been used to create awareness and recognition capabilities [27]. By delving into these components, this research aims to develop a curriculum that effectively addresses the intricacies of artificial

intelligence, providing learners with the necessary knowledge and skills in these crucial domains. These three components - cognitive systems, machine learning, and robotics- contribute to a comprehensive understanding of artificial intelligence and its practical applications.

1.4. Recognizing AI Diverse Applications

Numerous ethical concerns arise in the adoption of artificial intelligence, encompassing various aspects such as its impact on the job market, issues of prejudice and discrimination within AI systems [10], scandal [28], and data privacy breaches [29], [30]. It is evident that artificial intelligence applications can have both positive and negative ramifications for society [31]. Recognizing the significance of addressing these ethical dilemmas, efforts have been made to develop artificial intelligence ethics in education curriculum, particularly for individuals with non-technical backgrounds [21].

These initiatives draw insights from relevant technology and ethics textbooks, aiming to shed light on the ethical dimensions of artificial intelligence. Furthermore, a comprehensive review of the papers presented at the 2016 Machine Learning Symposium on fairness, accountability, and transparency revealed a wide variety of important topics, including privacy and surveillance, employment, concerns about harm from singularity, ethical decision-making, diversity, prejudice and fairness, accountability, and responsibility [32], [33].

The categorization of artificial intelligence learning for individuals under the age of 18 or those in K-12 education can be delineated into five primary domains [34]. Computers acquire information about their surroundings by the use of sensors. Furthermore, agents can uphold models or representations of the world and employ them for the purpose of logical deduction. Moreover, computers possess the capacity to acquire knowledge through the analysis and interpretation of data. One major challenge AI developers face is the establishment of seamless interaction between humans and AI agents. Ultimately, utilising Artificial Intelligence (AI) in many applications might yield both advantageous and detrimental consequences for society.

Applying these five main concepts to different stages of education, this research can summarize the following recommendations. For children in grades below 3, fostering interaction and hands-on experience with artificial intelligence technology is important, allowing them to coexist with and utilize AI in their daily lives. In grades 3-5, children should be encouraged to adapt to AI systems using simple tools or programs, potentially exploring applications such as object recognition, voice controls, chatbots, and critical thinking about the impact of new AI technologies. At the junior high school level, students can delve into more complex applications, such as creating graphical displays and gaining an understanding of machine teaching, while also exploring the transformations brought about by Industry 4.0. Students should be equipped to develop novel AI technologies in high school and beyond. This involves activities like designing, selecting algorithm analysis tools and employing machine learning tools. Educators can provide students with a comprehensive artificial intelligence learning experience by incorporating these concepts and skill progressions.

1.5. Competency-based Curriculum and Conceptual Framework for Developing an AI Curriculum for Youth Education

Artificial Intelligence (AI) is crucial in facilitating and augmenting children and young people's learning, facilitating their transition into self-directed learners rather than exclusively dependent on conventional teacher-led pedagogy. Children and young people now have the opportunity to harness the power of artificial intelligence as a dynamic learning resource that offers intelligent features. This technology enables the seamless integration of diverse content and activities, catering to individual learning needs. Artificial intelligence is a valuable teaching assistant, fostering collaboration among classmates and friends. It entertains and facilitates innovative learning experiences, even without direct teacher guidance.

By leveraging AI, children and young people can engage in accurate, personalized learning that significantly improves the quality of their education. Additionally, AI tools empower children and young people to reflect on their past studies, enabling them to create suitable study plans within the curriculum. In summary, integrating artificial intelligence into education has brought a transformative impact, enabling children and young people to assume greater agency in directing their learning trajectories. It provides adaptive and enriching experiences while facilitating efficient tracking and planning of academic progress. To develop an AI competency-based curriculum, it is essential to establish a conceptual framework that outlines key concepts, learning objectives, and teaching methods. Presented below is a conceptual framework for the development of an AI curriculum:

- Core Concepts: Define the core concepts of AI that will form the basis of the curriculum.
- Learning Objectives: Establish clear and measurable learning outcomes that align with the curriculum. The desired results should align with the knowledge and abilities children and young people will attain upon completing the course.
- Learning Activities: Identify appropriate learning activities that support the attainment of learning outcomes. These activities may encompass lectures, interactive projects, case studies, and guest presentations. Hands-on projects can involve constructing and programming robots or creating AI models using programming languages like Python.

- Assessment Methods: Design assessment methods to evaluate children and young people's learning. These methods may include tests, quizzes, projects, presentations, and research papers. Assessments should align with the learning outcomes and assess children and young people's ability to apply the acquired AI concepts.
- Instructional Resources: Determine relevant instructional resources, such as textbooks, online courses, and open-source AI tools, to facilitate effective teaching and learning.
- Ethics and Social Implications: Integrate discussions on ethics and the societal implications of AI into the curriculum. Encourage children and young people to explore and critically analyze the ethical dimensions of AI technology.

The conceptual framework for developing an AI curriculum should be adaptable, interactive, and aimed at immersing children and young people in impactful learning encounters. It should remain attuned to the latest advancements in AI and equip children and young people with the necessary knowledge and abilities to excel in a society that AI progressively influences.

By incorporating this framework, educators can create a comprehensive AI curriculum that encompasses fundamental concepts, fosters enriching learning experiences, and promotes ethical reasoning and thoughtful contemplation. This research aims to identify the appropriate level of AI literacy that can adequately prepare Thai children for the evolving landscape of technology, particularly in the realm of AI. Subsequently, a learning package has been developed to cater to the competency levels of youth, categorized into three tiers: basic, intermediate, and advanced.

To ensure the efficacy of the designed courseware, it has been tested by a significant sample of Thai children and young people. The subsequent sections of this paper are organized in the following manner: Section II introduces the methodology employed in this research, followed by the results and discussion in Section III. Lastly, Section IV presents the conclusion of the study.

2. Research Methodology

Implementing a competency-based curriculum is of utmost importance in effectively utilizing the workforce's capabilities to fulfil the labour market's requirements and contribute to the nation's progress. The qualification system plays a vital role in evaluating an individual's capacity for learning and matching it with relevant qualifications and experiential transfer.

The concept of fostering lifelong learning among individuals in Thailand is achieved by establishing connections and collaborations across different educational levels, encompassing formal education, informal education, and self-directed learning. These connections and collaborations occur in both online and offline settings. This method provides individuals with the essential knowledge and skills needed to fulfill domestic and global job market demands. The construction of a competency-based curriculum involves two primary procedures: firstly, the identification of a framework for constructing a competency-based learning management curriculum, and secondly, the formulation of a course management strategy grounded in competencies.

The model developed for competency-based curriculum development is founded on applying the UNESCO Model's curriculum development concept, which encompasses two primary steps. The first step involves the competency-based curriculum development cycle, which comprises four sub-steps: (1) Requirement assessment stage, (2) Competency-based curriculum design stage, (3) Experimental stages and refinement of the competency-based curriculum, and (4) Competency-based curriculum evaluation stage.

The second step entails the learning management plan preparation cycle for competency-based courses, which encompasses four sub-steps as well: (1) Designing and preparing a course management plan for competency-based courses, (2) Conducting in-service stages and trials of course management plans for competency-based courses (also referred to as try-out), (3) Implementing the competency-based course management plan, and (4) Evaluating the learning management plan to gauge the effectiveness of the competency-based course. These cycles are visually depicted in Figure 2.

2.1. Data and Sample

This study's target population and sample size comprise approximately 2,700 children and youth residing in Bangkok and the surrounding areas. This includes children and young people from basic high schools, high schools, vocational schools, diploma programs, and first-year higher education institutions. The competency of the sample groups is assessed after they receive training from pre-trained instructors.

These instructors, totaling 156 individuals from 18 schools, have undergone prior training. Experts in the field of artificial intelligence evaluate the quality of the designed courses. They assess various aspects, including course structures, requirements, and descriptions. The matching between the course content and the examination questions is determined using the Item-Objective Congruence (IOC) score.

The demographic distribution of the children and young people's sample based on gender and course level can be seen in Table 1. In Figure 3, the distribution of training participant data is presented based on educational institutions and levels. In Figure 4, the distribution of teacher samples by school is presented. This data was collected from the period of 24th to 29th January 2022.

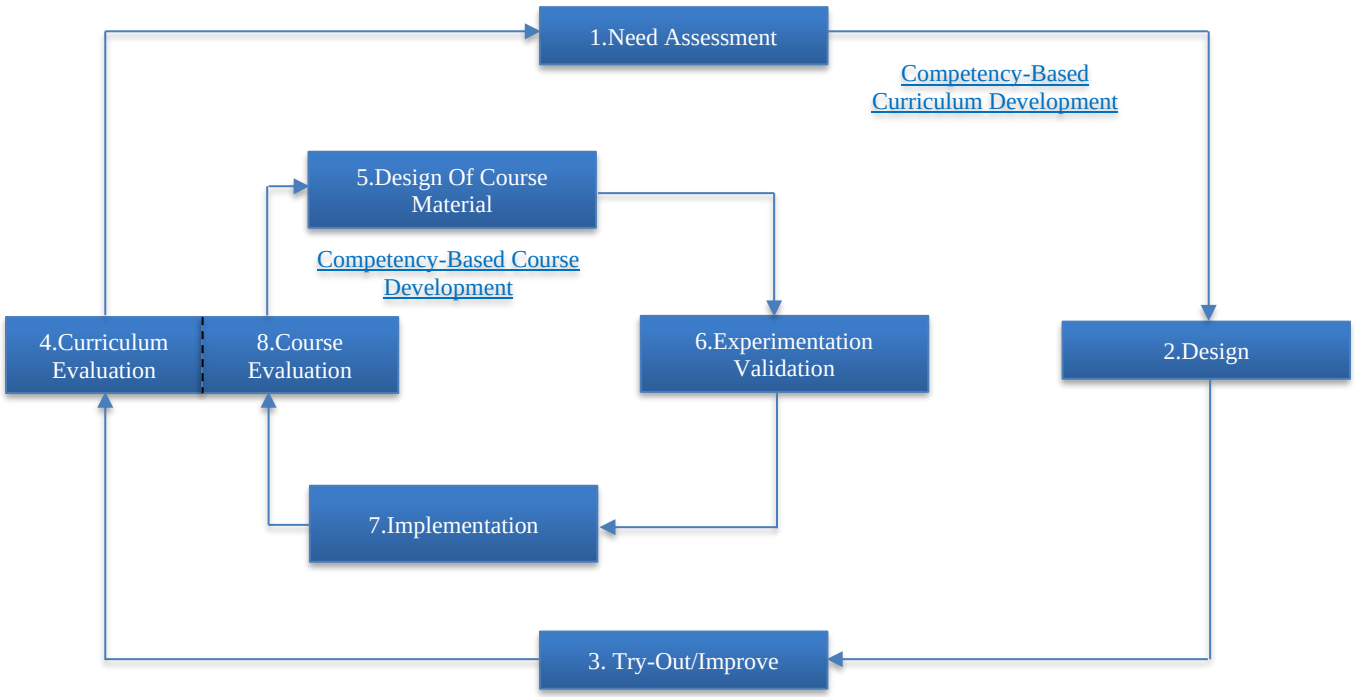


Fig. 2 UNESCO Model's curriculum development concept finding reference

Table 1. Demographic data based on gender

Course Level	Number of Samples	Male	Percentage	Female	Percentage
Basic	518	202	39,00%	316	61,00%
Intermediate	943	457	48,93%	486	52,03%
Advanced	994	569	57,24%	425	42,76%
Total	2455	1228	50,02%	1227	49,98%

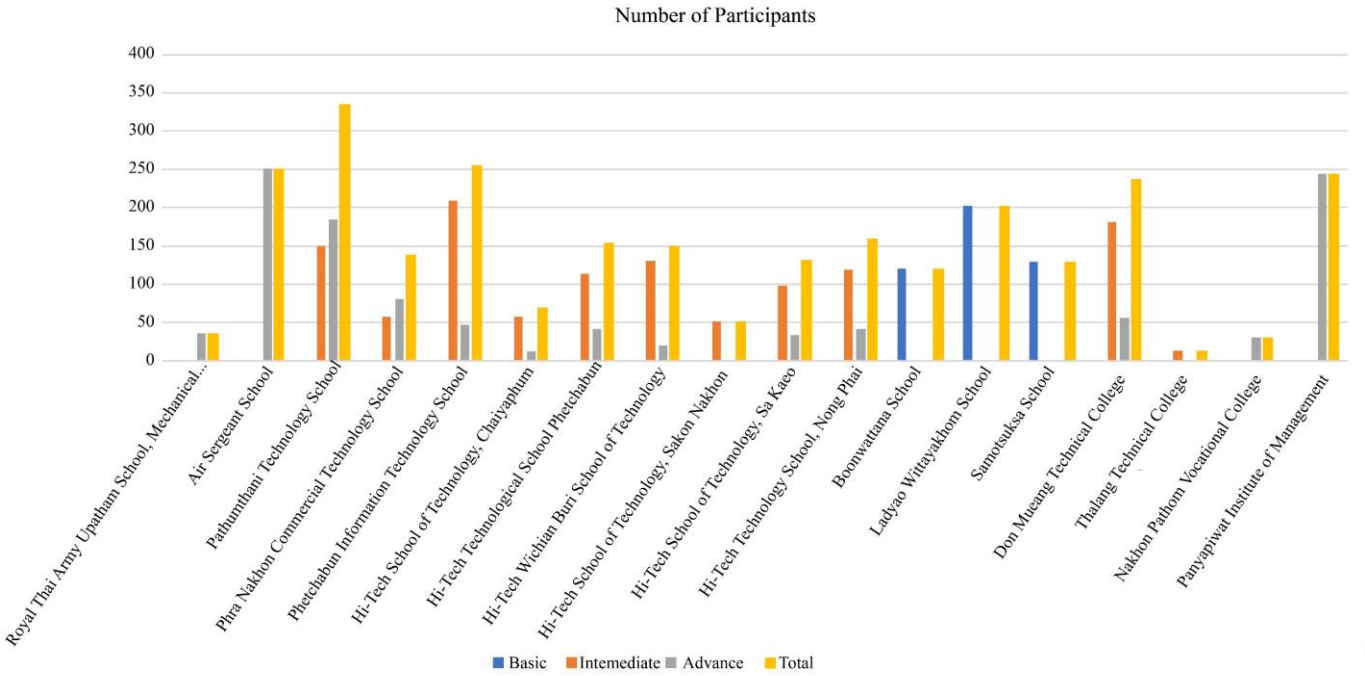


Fig. 3 Participants in the artificial intelligence training course for children and youth, classified by educational institutes and levels

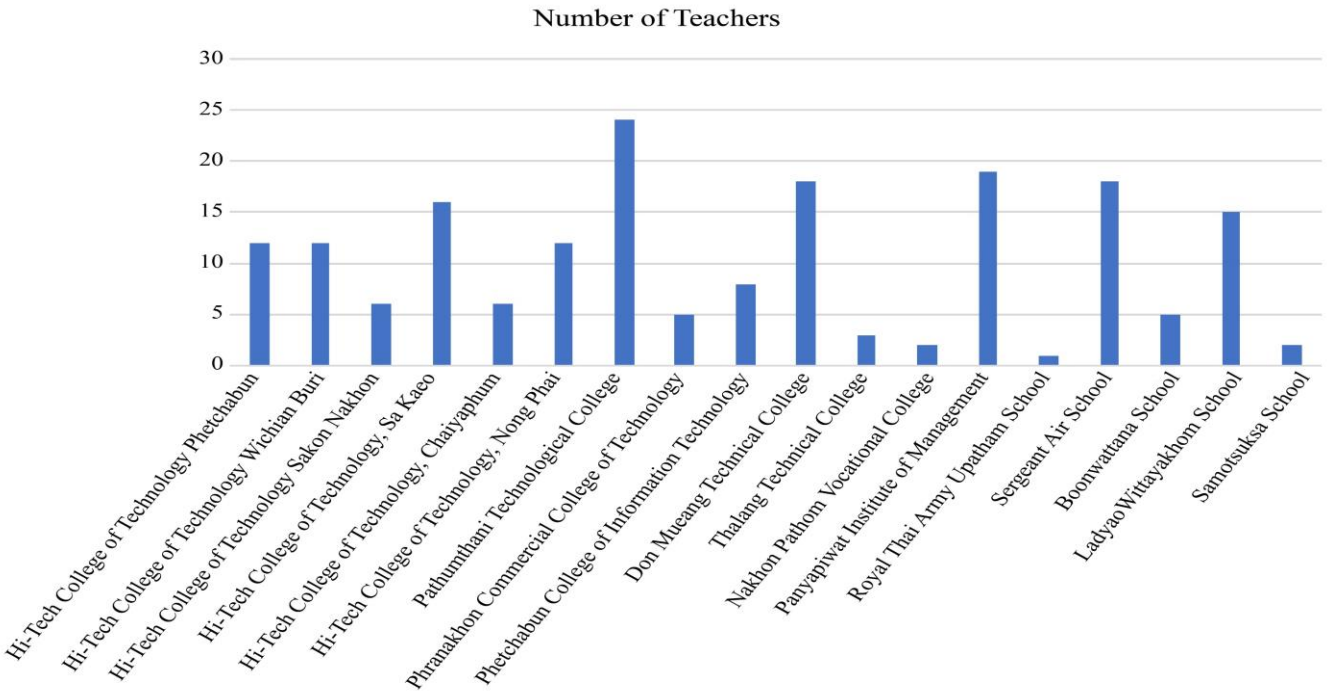


Fig. 4 Total number of role model teachers by school name

2.2. Research Instrument

This research encompasses two main areas: the exploration of fundamental digital competencies and their relation to artificial intelligence, as well as the design of an AI curriculum for children and youth. The research follows the Prototyping Functional Analysis (PFA) approach, which involves conducting activities related to developing an AI curriculum specifically tailored for children and youth. Figure 5 illustrates the flow diagram of the designed AI curriculum for children and youth. The research process involves the following steps: (1) Requirements analysis: analyzing the essential artificial intelligence competency requirements for children and young people involves a comprehensive approach. This includes techniques such as Focus Group Discussions (FGD) with professionals to gather insights on the specific Knowledge, Skills, and Attributes (KSA) needed. (2) Designing and developing a basic artificial intelligence competency curriculum tailored to the needs of Thai children and young people. (3) Assessing the quality of the prototype of the artificial intelligence skills development competency training course necessitates conducting an expert evaluation, which involves engaging professionals from educational organizations, professional associations, and industrial organizations. (4) Developing a courseware/training package for the prototype of the basic artificial intelligence curriculum involves developing various resources to support instructors and learners. These include an instructor's manual, learner's guide, training materials, and worksheets/exercises/quizzes with clear instructions. (5) Evaluating the quality of the competency-based training kits developed by experts involves a comprehensive assessment conducted by professionals from educational organizations, professional associations, and industrial organizations. (6) Implementing the prototype of the developed competency-based training kit involves conducting a trial or "tryout" with a sample group of 30 individuals. (7) Assessing the achievement of the training for the sample group. (8) Make revisions as necessary based on the evaluation results. The analysis of AI competencies for children and youth begins with a literature review involving desirable competencies in terms of Knowledge, Skills, and Attributes (KSA). Focus group discussions are then conducted to refine the training courses and assessment guidelines.

The next step involves evaluating the quality of the prototype AI competency-based training course. Experts assess aspects such as course structure, training duration, training tools, age appropriateness for the target group, and the content structure used in the training. Finally, the designed courses are evaluated by qualified individuals responsible for ensuring their quality. The evaluation is based on the difference between pre-test and post-test scores and the frequency of test administration using questions from the test library. Another measure of course quality is monitoring the usage by trainees and assessing their satisfaction with the basic artificial intelligence training principles through questionnaires. The online assessment platform utilized a combination of quizzes, hands-on projects, and real-time AI modeling tasks to evaluate students' understanding of AI concepts. This platform allowed for immediate feedback, and performance metrics were collected to assess both theoretical knowledge and practical application, providing a comprehensive measure of AI competency.

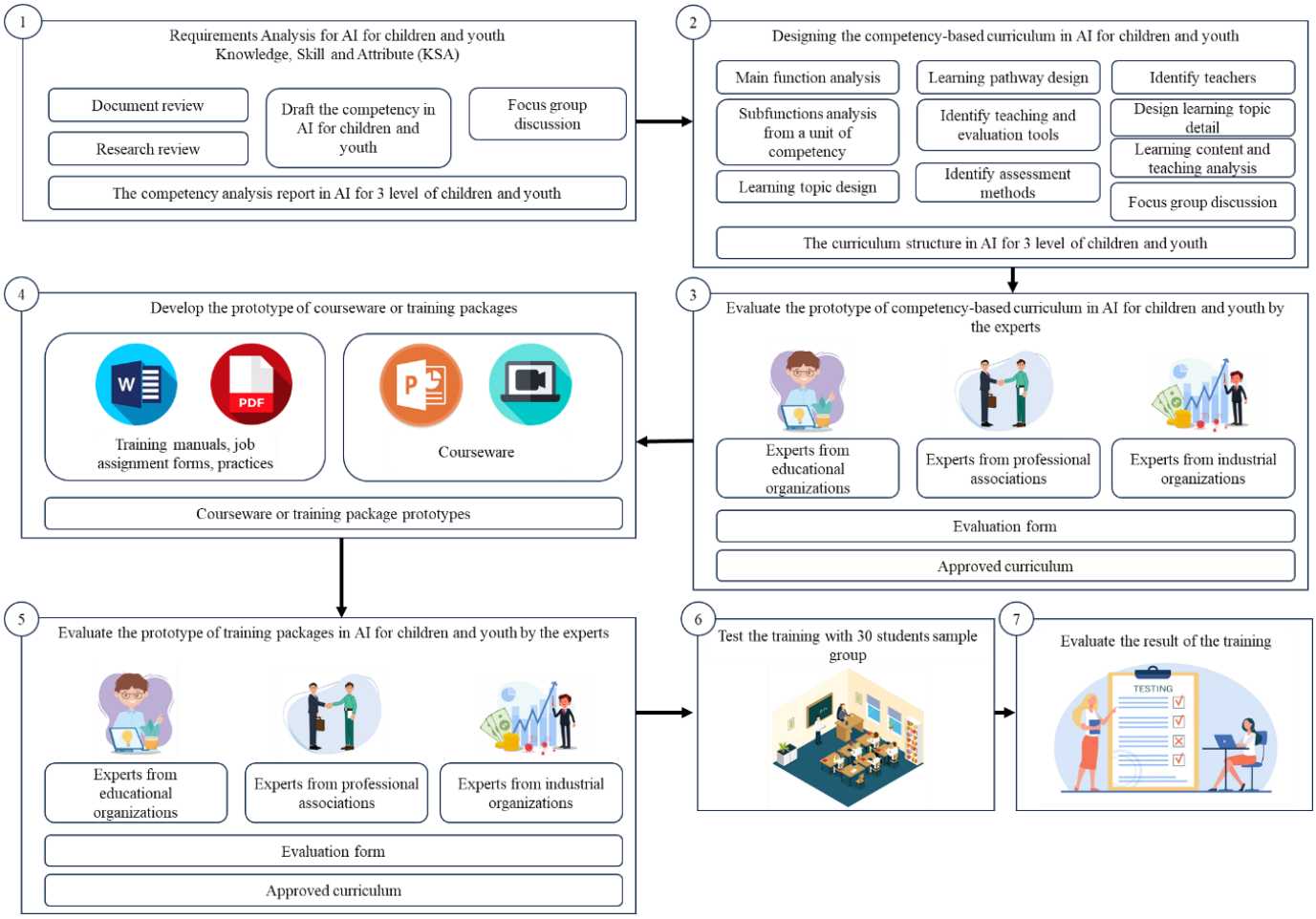


Fig. 5 Curriculum design diagram

2.3. Statistical Analysis

Quality inspection of innovations by experts is conducted to evaluate the prototype of the AI training package. The first toolset is the Curriculum and Training Package (Courseware). A basic artificial intelligence skills course for children and youth is designed at three levels: elementary, intermediate, and advanced. The second set of tools comprises an online test database system platform, which has undergone quality testing and was used in the experiment. The third set of tools is a test that assesses learning achievement. Lastly, the fourth set of tools includes a satisfaction assessment form, evaluated by three experts who have confirmed its quality and potential for further research. At least three specialists then examine the created tool. If at least two specialists agree on the quality of the content or innovation's form, the Item-Objective Congruence (IOC) index is calculated using an assessment form. It can be seen in Equation (1) that ΣR represents the total points given by each specialist, where R is the points given by each specialist, and N is the number of specialists [35]. An IOC value of 0.5 and above is considered valid for instrument quality inspection.

$$IOC = \frac{\Sigma R}{N} \quad (1)$$

After examination by experts, the innovation must be tried out (Try-out) or given to children and young people who are different from the study group. This examination, called the performance criterion (E1 /E2), involves two components: E1, which refers to process efficiency (running), and E2, which refers to the efficiency of the results. The efficiency criterion is expressed as a percentage ratio, such as 75/75, 80/80, or 90/90, depending on the nature and content of the subject. For example, the performance criterion is set at 80/80 or 90/90 if the content type involves knowledge or memory. Conversely, the performance criterion is set at 75/75 for skill or attitude-related content. Regarding the performance criterion, E1 represents the percentage of children and young people who met the specified satisfaction criterion during all teaching and learning activities (study/work process), while E2 signifies the percentage of children and young people who met the satisfaction criteria specified at the end of the teaching and learning activities (achievements/outcomes).

Both E1 and E2 have two implications: 1) E1 is the average percentage of all children and young people during learning activities (teaching includes all activities), and 2) E2 is the average percentage of all children and young people at

the end of the learning activities (teaching achievements/outcomes). This study also assessed the implemented AI training for children and young people. Mean, Standard Deviation (SD), and paired T-test analyses were performed to examine performance, satisfaction, and accomplishment. Training evaluation is an essential process that helps assess the effectiveness of a training program and the level of improvement achieved by the participants. The difference between the pre-test and post-test results is estimated using the paired t-test analysis. In this context, the given explanation outlines the specific steps and criteria used to evaluate the achievements of individuals after completing a training program. Here is a detailed explanation: (1) Evaluating Achievements after Training. After completing the training program, an evaluation is conducted to gauge the participants' progress and performance in the subject matter covered during the course. (2) Considering Participants with Pre-Test Results. To ensure a comprehensive assessment, only those participants who have both pre-entry test results and post-training results are included in the evaluation.

The pre-entry test is conducted before the training begins and serves as a baseline to measure the participants' initial knowledge or skill level. (3) Estimating the Difference in Test Results. The difference between the pre-entry test results and the post-training results is calculated to quantify the impact of the training program. This difference represents the progress made by each participant during the training period. (4) Using Paired T-Test Analysis. The paired t-test analysis is a statistical method used to compare the means of two related groups (in this case, pre-entry and post-training test results). It determines whether the difference between the two sets of scores is significant or occurred by chance.

Using the paired t-test analysis, the training evaluators could ascertain if the improvements observed in the post-training results are statistically significant and not merely due to random variation. Overall, this evaluation process provides valuable insights into the effectiveness of the training program, allowing educators and organizations to identify areas of success and areas that may need further improvement. It also helps validate the training's impact by offering quantitative evidence of the progress made by the participants over the course of the training.

3. Results and Discussion

Based on [36], in this work, a meticulously designed competency-based curriculum aims to cultivate artificial intelligence skills among children and young people. Recognizing the diverse educational backgrounds and developmental stages, the curriculum is divided into three levels: (1) Basic level designed to align with children studying in junior high school. (2) The intermediate level is designed to align with children studying at high school and vocational certificate levels. (3) Advanced level designed to align with children studying in advanced vocational certificate and 1st-year children and young people in a university.

However, this training course does not limit the age or level of education in any way, and the above level is only a recommendation and a starting point for developing the curriculum in accordance with the learning level according to the age. Each level is designed to provide learners with accurate knowledge about artificial intelligence technology, fostering an understanding of its impact and potential in various aspects of everyday life. As shown in Table 2, the course objectives for each level are presented.

Table 2. Course objectives

Course Level	Objectives
Basic	To provide children and young people with accurate knowledge about artificial intelligence technology.
	To raise awareness about using innovative AI by children and young people.
	To educate children and young people about the level of artificial intelligence.
	To enable children and young people to understand the emergence of innovations from combining various sciences.
	To provide children and young people with knowledge about ethics for using artificial intelligence.
	To raise awareness of Digital intelligence Quotient (DQ) for children and young people
Intermediate	To provide children and young people with an accurate understanding of artificial intelligence technology.
	To provide children and young people with an understanding of how to choose AI innovations.
	To educate children and young people about digital literacy.
	To educate children and young people about machine learning principles for decision-making.
	To provide children and young people with knowledge about ethics for using artificial intelligence.
	To raise awareness of Digital intelligence Quotient (DQ) for children and young people
Advanced	To understand the meaning of business intelligence analysis procedures.
	To be used in business decisions and problem-solving.

Table 3. Course structure

Course Level	Key Function	UOC: Unit of Competence	EOC: Element of Competence
Basic	K1 Knowledge of the Artificial Intelligent	U01 Artificial intelligence around us	E011 The meaning of artificial intelligence
			E012 Artificial intelligence in everyday life
			E013 The impact of artificial intelligence
		U02 The evolution of artificial intelligence	E021 The history and evolution of artificial intelligence
			E022 Level of artificial intelligence
			E023 The future of artificial intelligence
	K2 Intelligent and AI level	U03 intelligence	E031 The meaning of intelligence
			E032 Factors that contribute to intelligence
			E033 Making AI intelligence
		U04 The role of humans in artificial intelligence	E041 Strengths and weaknesses of artificial intelligence
			E042 The role of humans in artificial intelligence
			E043 Digital Intelligence Quotient: DQ
Intermediate	K1 Knowledge on Interdisciplinary	U01 Inductive	E011 Definition and types of agents for artificial intelligence
			E012 Structure of the agent characteristics and rules
			E013 PEAS: Performance Agent Sensor
		U02 interdisciplinary	E021 Interdisciplinary definition
			E022 Robots and its components
			E023 Artificial Intelligence vs. Robotics
	K2 Data and machine learning	U03 Data capabilities	E031 Data Literacy
			E032 Basic steps of data analysis
			E033 Definition, process, and decision-making based on the structure of the problem
			E034 Digital Intelligence Quotient: DQ
		U04 Machine Learning	E041 The definition of machine learning
			E042 The evolution of machine learning
			E043 Types of machine learning
			E044 Stages of machine learning
Advanced	K1 Data Literacy	U01 Artificial Intelligence, Machine Learning, and Business Intelligence	E011 Business environment and business decisions
			E012 Artificial Intelligence Process
			E013 Machine Learning
			E014 Business Intelligence Process
		U02 Data mining management	E021 Data Mining Process
			E022 Analysis data mining with CRISP-DM
		U03 Manage data engineering in an ETL context	E031 Data preparation (Data Cleansing)
			E032 Extract data from many data sources
			E033 Data transform
			E034 Load the data
	K2 Data Learning	U04 Analysis business intelligence with Classification techniques	E041 Analysis Business Intelligence with Classification
			E042 Business intelligence evaluation with classification
		U05 Analysis business intelligence with Association techniques	E051 Data mining analysis with the association
			E052 Analyze and evaluate data mining with the association

As this research explores the course structure, it comprises some key functions. Each function is further broken down into specific Units of Competence (UOC) and Elements of Competence (EOC) to ensure a comprehensive and structured approach to learning. The three levels of curriculum structure that the accreditation faculty have assessed are shown in Table 3.

This research includes the development of a training package used as a guide for both trainers and trainees. The training set (Courseware) comprises various components such as training slides, lecture videos, motion graphics, etc., designed for ease of use. Additionally, it includes 4,000 questions on an online test database platform, ensuring consistency.

The result is a training package (Courseware) applicable to training management, enabling normal study with a teacher. It allows for onsite (Onsite) or mixed (Hybrid Learning System) teaching, combining online learning (Online) to adapt to different learning conditions, including situations like the COVID-19 virus epidemic.

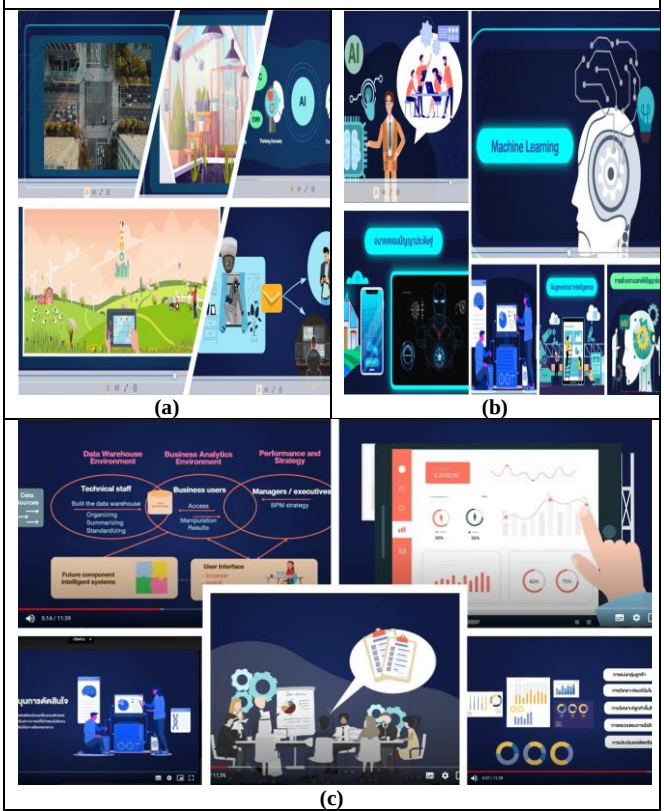
Figure 6 presents AI practicum modules for basic, intermediate, and advanced levels. Figure 7 shows presentation slides containing theoretical material, while Figure 8 showcases examples of motion graphics media that have been created. At each level of the curriculum, ethical considerations were integrated into learning activities, from the Basic level's discussions on AI's role in daily life to the advanced level's focus on the societal impact of AI in business and technology. By addressing AI ethics early on, students were better equipped to understand AI's long-term implications on privacy, employment, and governance. Evaluation is then carried out after the AI training course is implemented. This study investigated the effectiveness of AI training courses by conducting a paired T-test analysis, which provides strong evidence to ascertain their effect on student scores. The paired T-Test analysis in Table 4 provides compelling evidence of the impact of the three different course levels (Basic, Intermediate, and Advanced) on the learners' scores. In the context of statistical analysis, the Degree of Freedom (DF) holds significant meaning as it represents the number of independent pieces of information considered in the calculation of the T-test.

(a) (b) (c)

Fig. 6 An example of an artificial intelligence training course for the (a) Basic level, (b) Intermediate level, (c) Advanced level

(a) (b) (c)

Fig. 7 An example slides for an AI course lecture at the (a) Basic level, (b) Intermediate level, (c) Advanced level



(a) (b) (c)

Fig. 8 Examples of motion graphics media for the (a) Basic level (b) Intermediate level (c) Advanced level

For each subject level, the degree of freedom is determined by subtracting 1 from the total number of paired observations. Specifically, the Basic Level, with a sample size of 518, has a degree of freedom (df) of 517; the Intermediate Level, with 943 paired observations, has a df of 942; and the Advanced Level, with 994 paired observations, has a df of 993. Prior to the basic course, the average score stood at 24.98, but after completing the course, the average score significantly increased to 44.50 (p-value < .001).

Similarly, the intermediate course showcased a significant improvement, with the learners' scores increasing from an average of 13.29 before the course to an average of 43.08 after the course (p-value < .001).

Furthermore, the study revealed a noteworthy score enhancement even when transitioning from the intermediate course, where the average score increased significantly from 16.05 to 43.68 (p-value < .001). This table highlights the effectiveness of the AI training program by demonstrating statistically significant enhancement in participants' comprehension across all levels of the course." The negative T-test values indicate a consistent improvement in knowledge, and the low p-values offer strong evidence to support the positive influence of the training.

Figures 9 to 12 collectively illustrate the effectiveness of the educational intervention across different course levels: Basic, Intermediate, and Advanced. Figure 9 compares the pre-test and post-test average scores, revealing a significant improvement in participant performance after the intervention. Figure 10 enhances this analysis by displaying the mean scores alongside standard deviations, highlighting the consistency of these scores across participants.

Figure 11 presents the results of paired T-tests for each course level, with the T-test statistics indicating statistically significant score increases, reinforcing the intervention's effectiveness. Finally, Figure 12 showcases the degrees of freedom for the paired T-tests, emphasizing the robustness of the analysis, as higher degrees of freedom contribute to more reliable results. Together, these figures provide a comprehensive overview of the positive impact of the educational program on participant learning outcomes.

Compared to existing AI curricula, our program demonstrates good engagement and competency acquisition results, as evidenced by our large-scale deployment across 2,700 students and statistical analysis showing significant improvements in learning outcomes across all levels.

This curriculum integrates AI ethics and societal impact discussions more comprehensively than previous models, preparing students for technical challenges and future ethical dilemmas in AI. All of these curriculum designs have been implemented and evaluated, as shown in Figure 13.

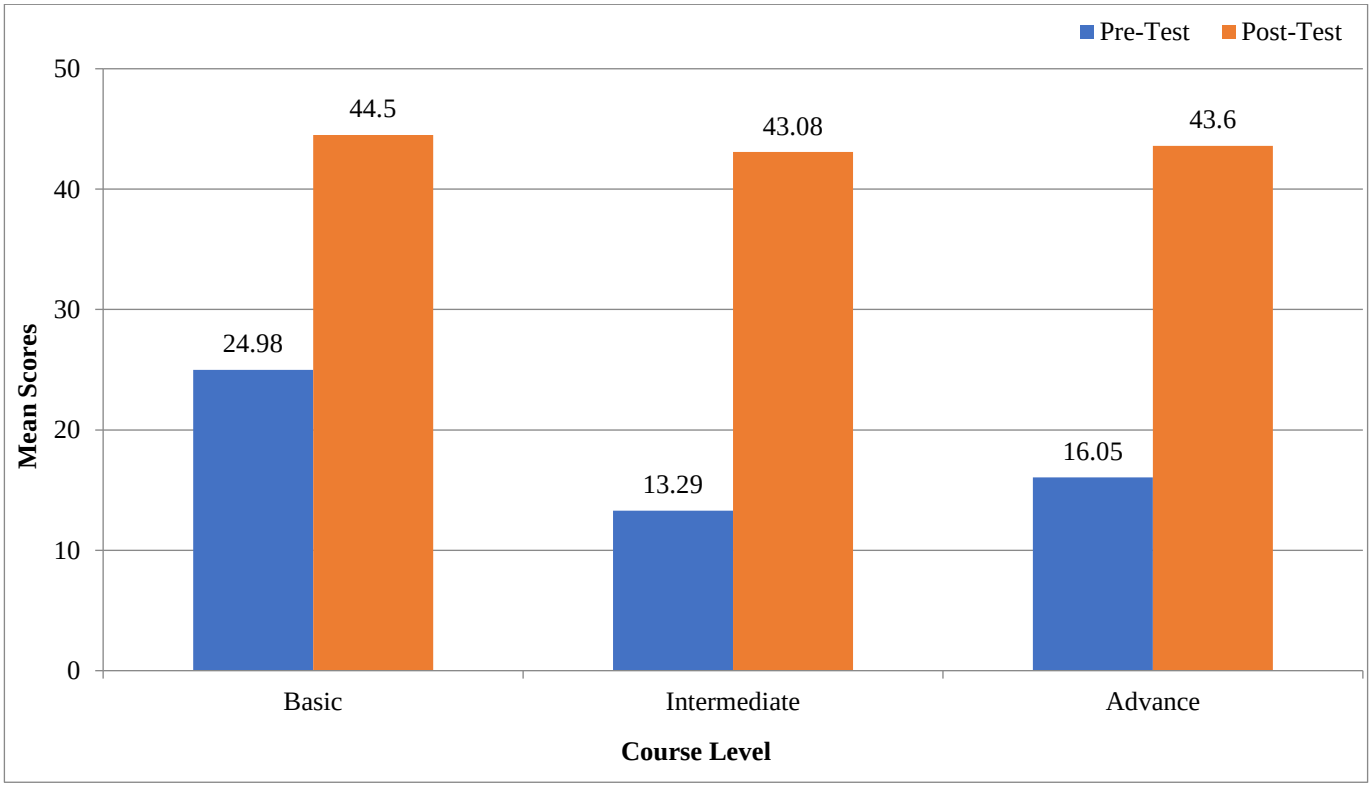


Fig. 9 Pre-test vs Post-test average scores by course level

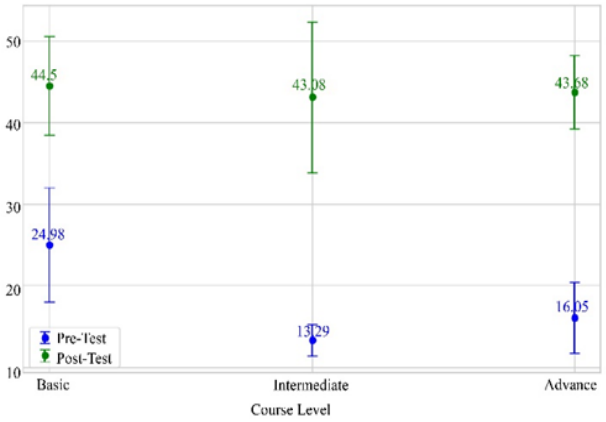


Fig. 10 Pre-test and Post-test scores with standard deviation

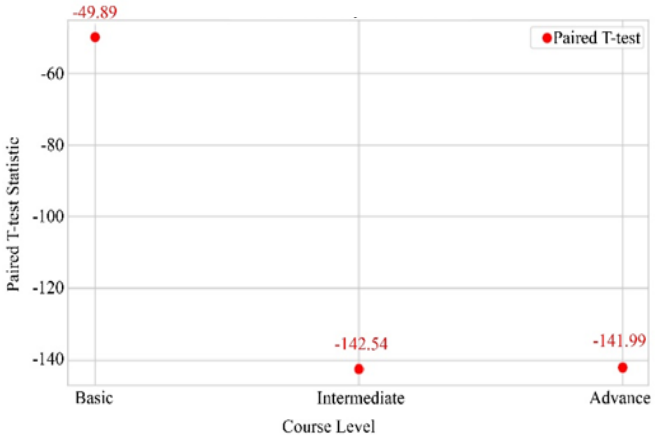


Fig. 11 Paired T-test results by course level

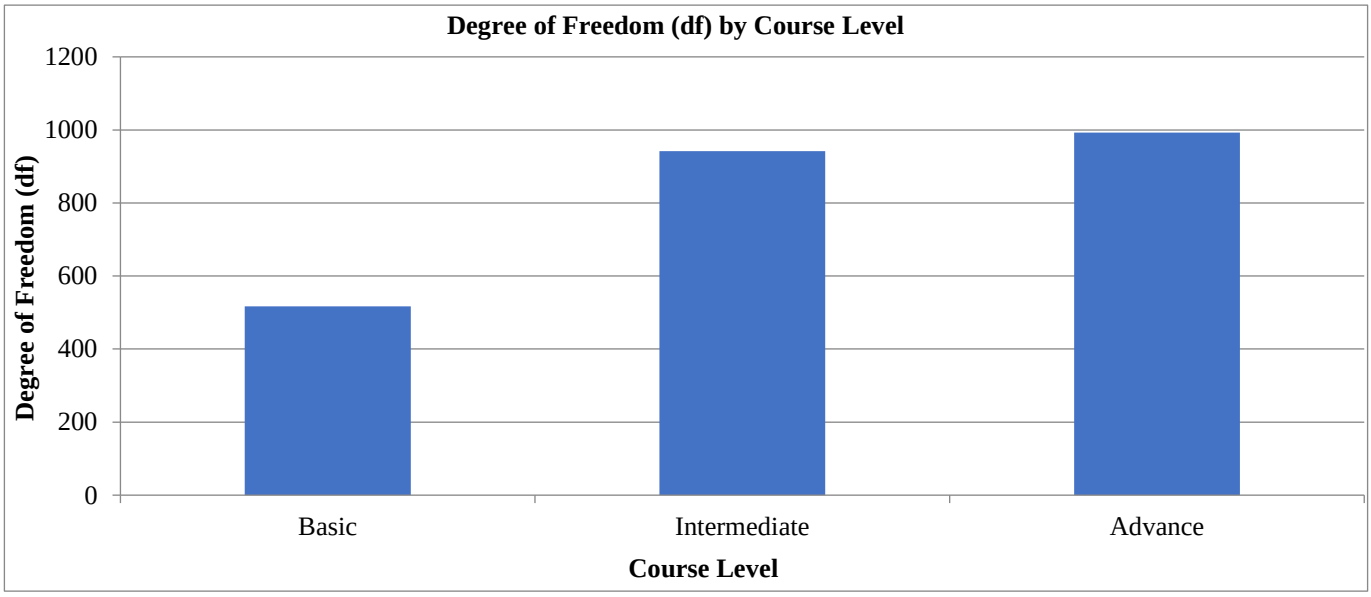


Fig. 12 Degree of freedom by course level

Table 4. Analysis of paired T-test

Course Level	Sample	Average score				Paired T-test	Degree of Freedom (df)	p-value
		Pre-Test		Post-Test				
		Mean	Standard Deviation (SD)	Mean	Standard Deviation (SD)			
Basic	518	24.98	7.04	44.50	6.05	-49.89	517	< .001
Intermediate	943	13.29	1.98	43.08	9.19	-142.54	942	< .001
Advance	994	16.05	4.31	43.68	4.50	-141.99	993	< .001

This research also organized a contest as an additional activity to motivate children and youth to create innovations. This contest encourages kids to utilize design thinking and share their work with others. 50 works were initially selected, and the list of finalists was announced on the contest's website, leaving only 15 works. These were divided into 5 works for the beginner level, 5 for the intermediate level, and 5 for the high-level category, which includes 5 creative awards. Contestants were informed to prepare media presentations of their works. A meeting was held via video conferencing on Saturday, February 19, 2022, as shown in Figure 14. The innovation contest attracted participants from 23 schools, with 76 entries showcasing diverse AI applications. The contest was judged on criteria such as creativity, technical complexity, and relevance to real-world AI challenges. This event gauged the practical application of the curriculum and fostered enthusiasm and innovation among participants.

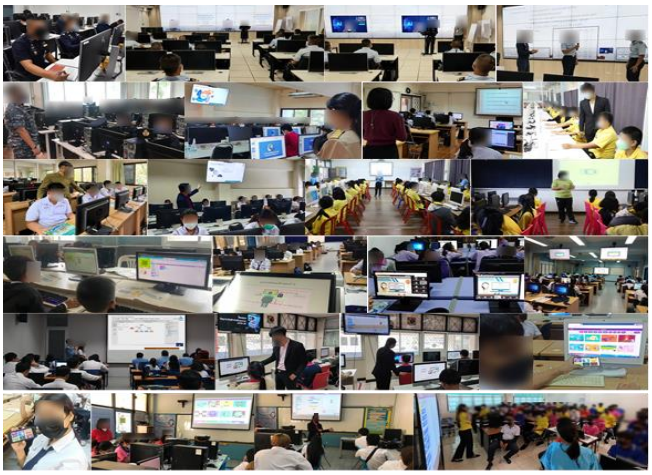


Fig. 13 Implementation of AI training course

Fig. 14 Online contest

4. Conclusion

This research focuses on designing a competency-based training curriculum and short-term courses to develop basic artificial intelligence skills for children and young people. A comprehensive training kit was also developed, including training materials such as video clips for lectures, motion graphics, exercises, quizzes, and more, which were delivered through an online test library platform. Monitoring and evaluation of competencies were conducted to assess knowledge levels after training.

The training followed the UNESCO competency curriculum development model, encompassing the analysis of fundamental knowledge, skills, and attitudes related to artificial intelligence. Key Functions (KF), Units of Competency (UoC), and Elements of Competency (EoC) were designed, and performance criteria were analyzed. Course materials were then prepared, aligning with the topics, objectives, descriptions, and exercises in both theory and practice, following the designated hours. The training kit was thoroughly evaluated by experts through discussion group meetings to assess quality in all dimensions. The training results encompassed 2,708 children and young people and 184 new instructors. Course evaluation employed the online exam database system, with a passing criterion set at an average score of over 80%.

The quality of training tools was assessed using the E1/E2 ratio, and statistical analysis was performed on the training results to showcase the achievements. The findings indicated a significant increase in the number of children and youth who passed the exam with an average score exceeding the specified threshold. Pre-tests and post-tests were conducted to assess the level of progress in each competency unit. An inclusive contest was organized regarding tracking utilisation, attracting 76 entries from 23 schools, with 380 participating children and young people.

The entries demonstrated good quality as assessed by a panel of qualified judges. Participants expressed satisfaction with the training and competition, deeming it useful for further study in the future. The participants also expressed satisfaction with the awards received, considering them appropriate recognition for their efforts. In order to monitor the long-term effects of the competency-based AI curriculum on students' career paths and their subsequent involvement in STEM disciplines, future research should concentrate on carrying out longitudinal studies. By examining a cohort of students across several years, researchers can learn a lot about how early exposure to AI education affects academic decisions, professional development, and the acquisition of pertinent skills in a work market that is changing quickly.

In order to provide empirical proof of the curriculum's efficacy, such studies could look at things like enrolment in advanced STEM courses, involvement in related extracurricular activities, and admission into STEM employment.

Additionally, exploring the curriculum's role in shaping students' perceptions of AI and its ethical implications will enrich our understanding of how educational interventions can prepare future generations for the complexities of technology-driven environments.

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