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Integration of Artificial Intelligence and Machine Learning Content in Technology and Science Curriculum*

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Artificial Intelligence (AI) and Machine Learning (ML) are required subjects of Information Technology Literacy in a new curriculum required by the Ministry of Education in Taiwan requires. A few people have discussed the integration of teaching methods and curriculum design, the difficulties of teaching practice, and the assessment of the approach. This study aims to explore. The impact of the integration on students' leaning satisfaction, problem-solving ability, and interest in taking further AI courses. Participating students were divided into an experimental group with 101 students and a control group with 99 students. MANCOVA statistics were used to analysis the data collected related to academic achievement. The results showed that the scores of students in all aspects examined with the curriculum integration of AI, Machine Learning, and Big Data were significantly higher than those of the control group.

Keywords: Artificial Intelligence (AI); Teaching Effectiveness; Curriculum Integration; Technological Literacy; Machine Learning (ML); Big Data

1. Introduction

The new Teacher Education Law emphasizes the professional quality of teachers, and the new curriculum emphasizes core competency. Literacy includes functional literacy, and common ability across various disciplines [1]. Literacy is to enhance literacy by connecting knowledge with real situations. The core competency refers to the knowledge, skills and attitudes that a person should possess to adapt to the current life and tackle future challenges [2, 3].

The Information Education Master Blueprint Planning Group of the Ministry of Education launched the 2016-2020 Information Education Master Blueprint. They emphasize the use of information technology to cultivate students' key capabilities and should enhance the ability of principals and teachers to apply information technology to teaching [4]. Facing the teaching challenges of the new curriculum and the application of information technology, both teaching methods and curriculum design need to conform to the connotation of technological competency emphasized in the new curriculum [5]. Among them, the subjects of Artificial Intelligence (AI) and Machine Learning are compulsory courses for information technology competency in the new curriculum. Emerging technologies such as, Artificial Intelligence [6], robotics [7], metaverse [8], Big Data [9], cloud computing [10], Internet of Things [11], autonomous driving [12], mobile communications [13], biotechnology [14], nanotechnology [15], 3D printing technology [16], material science and material

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technology [17], quantum computing [18], new energy technologies [19] and energy storage [20] will have a significant impact on all walks of life including educational activities [21]. In teaching practice, in terms of teaching methods and course quality, how to integrate each other, and what the teaching effect after integration is, only some people know.

The spirit of Artificial Intelligence is that not all scientific results belong to determinism but should be integrated into "probability theory". Artificial Intelligence based on bionics, cognitive psychology, Bayesian regression, probability theory, statistics, and economics is gradually fermenting [22, 23]. Artificial Intelligence in education (AIED) refers to incorporating Artificial Intelligence courses and teaching materials into school education to cultivate students with the knowledge, ability and attitude to design and use Artificial Intelligence [24–26]. In the past few years, Artificial Intelligence has been integrated into various fields of education, and its effects have gradually been recognized [27–31]. Therefore, how to use the advantages of Artificial Intelligence to improve the quality of education is a topic that must be carefully examined today [32].

Based on the concept of technological core competency in the new curriculum, this study starts with an Artificial Intelligence technology competency-oriented interdisciplinary curriculum, hoping to attract ideas and spark academic dialogue.

2. Literature Review

The new curriculum advocates that when teacher training units provide information technology-related courses required by student teachers. They enrich student teachers' knowledge and practical skills on commonly used teaching technologies and media and help them integrate and apply information technology into the curriculum and teaching of related subjects. Gradually assist students to use information technology to build the literacy of applied technology [33, 34]. Among them, Artificial Intelligence (AI) is a compulsory subject for teacher training.

The phrase artificial intelligence in education (AIED) refers to the combination of artificial, intelligence and education. Artificial is man-made, not innate. Therefore, artificial intelligence is the intelligence displayed by machines made by humans. It must operate through complex and intelligent computer algorithms to realize the technology of human intelligence. Let the machine have various abilities such as calculation (optimization), perception (brain, eyes, hands, ears, and mouth), thinking (playing Go), reasoning (theoretical proof) and learning (Baysian regression of probability theory). The field of AI also includes: Machine Learning (ML), Deep Learning (e.g., Neural Network Algorithms), Big Data, and so on [6, 35–37]. With the rapid development of modern smart technology and the diversified development of AI-centric teaching technology in the field of education, technology education needs to integrate teaching methods and curriculum design in order to achieve teaching effects [38]. To this end, all schools are vigorously promoting teaching intelligence, technology and cross-field integration [39, 40]. Therefore, understanding AI's intelligent thinking principles and problem-solving methods, what it has, what it can do, how to integrate knowledge, teaching methods and course materials across disciplines are all important considerations.

2.1 Curriculum Integration Theory

Curriculum integration is not just a technique for organizing subject content or a method for rearranging programs of study. It is a curriculum design theory, including implications for schools, the nature of learning, the organization and use of knowledge, the educational experience, and other views [41, 42].

Curriculum integration covers knowledge, experience and society [43, 44]. Therefore, cross-disciplinary and inter-disciplinary integration have become the main methods to promote curriculum integration [45–48]. Interdisciplinary is a process and also a goal. In the course, it is necessary to promote the dynamics of student's learning process and demonstrate the integration of learning and knowledge [49, 50].

In college, cross-disciplinary courses should consider the diversity and complexity of work in today's workplace, and many jobs have moved towards cross-disciplinary teamwork. Therefore, colleges can offer interdisciplinary courses to enable students with different majors to interact and exchange knowledge to solve the problem of poor communication between knowledge systems, thereby promoting college students' awareness of real social problems and enriching their learning experience [51].

2.1.1 Course Organization

Mao et al. believes that curriculum integration is a part of curriculum organization. Curriculum organization aims to promote the vertical and horizontal connections of courses so that students' learning can produce the most significant cumulative effect [52]. Curriculum integration emphasizes the horizontal connection of courses, hoping to establish a consistent relationship between specific course content and other courses so that students can connect the various courses they have learned and understand the relationship between different courses [53].

Curriculum integration and review includes a selection of topics, various activities of the integrated curriculum, time, place, students' responses, teacher's guidance, and teaching evaluation [54, 55].

2.1.2 Curriculum Philosophy

Li and Ou focus on the fundamental idea of integration, and believes that curriculum integration is not just a form or technique for organizing subject content but a comprehensive and progressive educational philosophy practice. It is a pluralistic, democratic, and critical curriculum. Integration of knowledge, social adaptation, and curriculum content, a curriculum that takes students' experience as the starting point [54]. Beane believes that curriculum integration is a theory of knowledge, involving Progressivism and constructivism, and advocates that students use knowledge and skills to seek answers to questions. Students have to learn autonomy and construct the meaning of learning [56]. The idea of curriculum integration reflects the view of school education and the nature of learning and should be regarded as an educational philosophy [57]. Since it is a curriculum philosophy of Progressivism, the focus of curriculum designers is on removing the knowledge barriers, attaching importance to the value of students' experience, and promoting students' participation in learning [55].

2.1.2.1 Orientation/elements of Curriculum Integration

Beane pointed out that curriculum integration should include the integration of experience, society, and knowledge [57]. The integration of experience refers to the integration of new and old experiences into a meaningful system to be applied to new problem situations. The integration of society refers to the relationship between social life and school and the democratic social relationship shown in the joint participation of teachers and students. The integration of knowledge is integrating the knowledge of various disciplines and applying the methods and languages of different disciplines to solve real problems [55].

2.1.2.2. The Method/Mode of Curriculum Integration

There are many integration modes, and there are roughly four types; integration within a subject, interdisciplinary integration with clear subject boundaries (multidisciplinary style), interdisciplinary integration of disciplinary blending (interdisciplinary integration), and transdisciplinary integration [58, 59]. Jacobs believed that integration is not an all-or-nothing distinction but a degree of differentiation [48]. From integration within a subject to crossing subject boundaries, it is a process of gradual evolution. Even though scholars agree that the transdisciplinary model has the highest degree of integration and best embodies the ideal of curriculum integration, in practice, many schools still adopt the design method of maintaining the boundaries of disciplines, and most cases of integrated curriculum are subject-centered style [55].

3. Methodology

3.1 Research Design and Participants

The quasi-experimental objects of this study are students from the university of Science and Technology in Taiwan as the research participants, and the students are divided into the experimental group and the control group by class as a unit. 101 people in the experimental group underwent a 16-week AI course integration training with four modules (6 weeks of teacher-led introduction to AI + 1 week of AI-assisted teaching system + 6 weeks of machine learning + 3 weeks of big data analysis) [42]. The 99 people in the control group only received the traditional "Teacher-led introduction to AI" for 16 weeks [42], and did not mix related courses in other AI fields.

This study adopts unequal control group design to collect quantitative data. The quasi-experimental "pretest-posttest" uses MANCOVA statistics to "control" the interference effect of the pretest, and then compare the adjusted mean of the experimental group vs. the control group difference in effect.

The two groups of students took pre-test and post-test respectively before and after the teaching intervention to evaluate the immediate effect of the course. One month after the course ended, interviews were conducted with all 101 students in the experimental group to further understand the impact of this course on students (Table 1).

3.2 Integrative Curriculum Connotation of the Experimental Group

This study developed a 16-week college AI course with four modules (see below). The first half of the course is based on the traditional introduction to AI "AI topic concepts and application function modules", while the second half of the course emphasizes the integration of AI-related course applications [60, 61].

This course consists of a total of 16 weeks, 3 hours of indoor classes per week, and programming design is added to the class. The content of the

Table 1. Instruction Experimental Design

Instruction period	Grouping method	Pretest	Experimental treatment	Posttest	Interview
Experimental group	Heterogeneous grouping	O_1 Pre-test	X_1 Experimental processing (With AI integrated education)	O_3 Post-test	O_5 Interview (1 month after the end of the course)
Control group	Heterogeneous grouping	O_2 Pre-test	X_2 Control processing (No AI integrated education)	O_4 Post-test	

course can be divided into four teaching modules, as follows

3.2.1 Module 1, Teacher-led Introduction to AI (3 hours × 6 weeks)

This module mainly refers to the "issue analysis and skill training module" of many scholars [42, 62]. The teacher selects the AI topic as an example, and guides the students to analyze and try to propose a solution. The teaching methods used in module 1 include lectures, discussions, video appreciation and sharing of growth experience. This module is to promote students' learning in the cognitive and emotional stages.

3.2.2 Module 2, AI-assisted Student-led Introduction to AI (3 hours × 1 week)

This module is also based on the "AI Issue Analysis and Skills Training Module". The whole class is divided into several groups according to the number of people, and students are free to choose AI issues they are interested in, such as robots, face recognition, Internet of Things, Metaverse, unmanned vehicles, unmanned stores, smart homes, etc. Conduct independent investigation and analysis, and then present them to the class in lively ways such as collaborative lesson study, cross-debate, role-playing, value clarification, and video appreciation. Guide the whole class to discuss, then decide on your own problem orientation and position, and finally propose solutions and action strategies. The main purpose of this module is to promote students' learning in cognitive, emotional and technical stages.

This module also utilizes the Intelligent Assisted Teaching System (ITS) to provide great flexibility in the presentation of materials and to better respond to students' unique needs [25]. ITS achieves its "smart" teaching function through: teaching decisions about how to teach and information about learners. Through ITS, it can better interact with students independently and realize the function of self-learning.

AI and Internet technology are constantly improving, and the functions of Intelligent Computer-Assisted Instruction (ICAI) are also continuously improving [53]. This type of ICAI already has three components: (1) problem-solving expertise, student models, and tutoring modules. Show students using this type of program some information from the problem-solving expertise section. This is the knowledge base for such AI programs. (2) The student responds in some ways to the presented material by answering questions or otherwise demonstrating his or her understanding. (3) The student model analyzes the student's responses and decides on an action to take, which usually, in this case, involves providing some review material or an introduction to the knowledge preview for the student to advance to the next stage. Tutorial modules may or may not be used at this point, depending on the student's level of mastery of the material [63].

3.2.3 Module 3, Machine Learning Algorithm Integration in AI: Supervised Learning (3 hours × 6 weeks and two days of programming practice)

The teaching content of "Module 3" mainly refers to the educational literature on machine learning experience [37, 64]. Indoor teaching is supplemented with YouTube videos to strengthen students' knowledge and feelings of machine learning, and through programming and growth experience sharing to stimulate students' cognition, emotion and skills of machine learning.

Machine learning is to let the computer learn how to judge the classification to which various features belong through a large amount of historical data. AI broadly uses algorithms and programming techniques to enable computers and even machines to behave and think like humans (simulating human eyes, brains, hands, and ears) [37].

3.2.4 Module 4, Big Data Analysis Integrate AI: Statistical Implementation of Neural Networks for Education and Management (3 hours × 3 weeks)

The teaching content of "Module 4" mainly refers to the educational literature on big data analysis [65–67]. Indoor classes will be supplemented with YouTube videos to strengthen students' knowledge and experience of big data and through programming and growth experience sharing to stimulate students' cognition, emotion, and skills on big data.

Big Data is a large amount of unstructured or structured data from various sources. Big Data has no statistical sampling problem; it just observes and tracks what happens (events). As a result, the volume of big data often exceeds the capacity of traditional software to process in an acceptable amount of time. The homework is: to use deep learning neural networks to predict the stock market.

3.3 The Connotation of the Unintegrated AI Course in the Control Group

The control group only received the traditional "teacher-led introduction to AI" for 16 weeks, without mixing other relevant courses in AI fields (Appendix A: Table A1).

3.4 Research Hypothesis

H_1: If there is an integration of courses in the field of Artificial Intelligence, there will be differences in the learning satisfaction of learners.

H_2: If there is an integration of courses in the field of Artificial Intelligence, there will be differences in the perceptual curriculum integration for learners.

H_3: If there is an integration of courses in the field of Artificial Intelligence, there will be differences in the technical literacy of learners.

H_4: If there is an integration of courses in the field of Artificial Intelligence, there will be differences in the problem-solving ability of learners.

H_5: If there is an integration of courses in the field of Artificial Intelligence, there will be differences in the learners' intention to continue taking courses.

3.5 Measurement Tools, Concept Definitions

3.5.1 Quantitative Questionnaire

The scales developed in previous studies were fine-tuned in this study, and the wording was adjusted and revised to fit the study context (Table 2). For example, technological literacy items were adapted from scholars' versions [68, 69].

A seven-point Likert method was used. It ranges from strongly disagree (1 point) to strongly agree (7 points), and vice versa for reverse questions. In order to reduce the potential anchoring effect that may cause monotonic responses, the questionnaire items were randomly ordered and mixed with reverse questions.

3.5.2 Noun Explanation (definition)

3.5.2.1 Definition of Learning Satisfaction

Attitude (such as satisfaction and liking) is an individual's evaluation feeling and action tendency towards a specific object, which includes three components: cognition, emotion and behavior. Learning satisfaction is a feeling or attitude towards the learning process. This feeling or attitude is formed because students feel happy in learning activities, or their physical and psychological needs are met during the learning process [70, 71]. Learning satisfaction is also a feeling of achievement and affirmation when individuals achieve their goals [72]. It is also a measure of whether psychological cognition, needs, and expectations

Table 2. Research variables and their operational definitions

Research facet	Operational definition
Perceptual Curriculum Integration [81–83]	1. I think AI class can help me learn to criticize and reflect by exploring problems. 2. I think the AI class can help me to clarify different/similar tasks by comparing different methods and approaches, in order to fully understand the problem. 3. I think the teaching content of AI courses provided by the school has covered skills in different fields. 4. I think the AI class is in line with cross-curricular teaching, which makes it easier for me to learn cross-field knowledge and skills.
Technology Literacy [68, 69]	1. I can understand the impact of information technology on individuals, society, AI and culture. 2. I can make good use of IT knowledge, creative thinking, and problem solving. 3. I cannot clearly understand the scope and classification of the field of information technology. (reverse question)
Learning satisfaction [84, 85]	1. I am satisfied with the content and progress of this AI course. 2. If there is a chance, I will recommend this AI course to other classmates. 3. The content of AI courses can meet the knowledge you need to find a job.
Problem solving ability [78]	1. When I get stuck, I will use general (or ad-hoc) solutions to solve the problem. 2. When studying AI class, I can use programming algorithm to analyze the nature of the problem and solve it. 3. When I encounter a difficult problem, I think about the root cause of the problem and how to solve it.
Continuing behavioral intention [79]	1. In the future, if I can choose whether to take it or not, I will still choose to continue taking related courses in the field of AI. 2. If there are different computer courses to choose from, I will actively take related courses in the field of AI. 3. Overall, I will continue to participate in courses in the field of AI.

are satisfied with value, and it is also an evaluation of the learning process and results [73].

3.5.2.2 Definition of Scientific Literacy

Curriculum Guidelines of 12 Year Basic Education [74, 75] emphasizes core literacy, and the "Teacher Cultivation Law" [76] stipulates guidelines for teachers' professional literacy, both of which emphasize "quality". Among them, scientific literacy is the science-related knowledge that a person needs to know and use to communicate with others. Similarly, scientific literacy refers to the most basic understanding of science and technology that the public should have. It includes three concepts. (1) The ability to recognize and understand a specific scientific term and concept. (2) Keep up with the basic ability of scientific reasoning. (3) The ability to understand public policy issues including scientific and technological content. At present, scientific literacy is summarized as three components, which are scientific knowledge, scientific research process and methods, and basic understanding of the impact of technology on society and individuals [77].

3.5.2.3 Definition of Problem-solving Ability

Problem solving is methodical, using general or ad-hoc methods to find solutions to difficult problems. Problem-solving capability refers to the ability of individuals to see through the core of knowledge and apply it to reality through continuous assumptions and verifications. Individuals with problem-solving skills will also use previous learning experience, knowledge, skills and understanding degree to think and explore in order to meet the needs of unsolved unfamiliar situations. Therefore, their learning process also includes autonomous learning and characteristics of self-direction and self-control [78].

3.5.2.4 Definition of Persistent Behavioral Intention

Psychologists believe that individual behavior is predictable and influenced by individual intentions. Behavioral intention refers to the individual's subjective probability of doing a certain behavior [79]. Behavioral intention is also the intensity with which an individual desires to perform a particular behavior. The strength of the behavioral intention determines the occurrence of the actual behavior, that is, the more positive the individual is towards a certain behavior, the higher the behavioral intention [80].

3.5.3 Quantitative Questionnaire Items (operational definition)

Operationalization is to define constructs as several measurable items, which can be divided into physical characteristics and highly abstract constructs. The operational definitions of the five constructs in this study are as follows.

3.5.4 Reliability and Validity of Each Construct

Quality assessment of the model, including overall model fit or predictive power, measurement model goodness, and structural model goodness. Both the structural model and the measurement model are used to ensure the reliability, discriminant validity and convergent validity of the scale [86–89].

Table 3 shows that the Cronbach' α of each facet in this study is greater than 0.7, the composite reliability (CR) is greater than 0.7, and the average variance extracted (AVE) is greater than 0.5, all of which are higher than Hair [90]. In terms of discriminant validity, the values of the diagonal lines in the table are all greater than the corresponding correlation coefficient values, indicating that this study has good discriminant validity. In addition, none of the correlation coefficients between constructs exceeded 0.80, indicating that the problem of collinearity is not serious [91].

3.5.5 Data Collection and Analysis

In terms of quantitative data, this study conducted

Table 3. Correlation coefficient matrix and AVE CR values

Item	Problem solving ability	Intention to continue taking AI courses	Learning satisfaction	Technology Literacy	Perceptual Curriculum Integration
Problem solving ability	0.852				
Intention to continue taking AI courses	0.740	0.891			
Learning satisfaction	0.787	0.799	0.894		
Technology Literacy	0.694	0.704	0.7.5	0.886	
Perceptual Curriculum Integration	0.701	0.840	0.850	0.847	0.883
Alpha reliability of Cronbach's	0.806	0.846	0.877	0.790	0.847
Composite reliability	0.891	0.893	0.938	0.947	0.928

[1] AVE = $(\text{loadings}^2)/\Sigma(\text{loadings}^2) + \Sigma$ The error of each measurement variable.
[2] CR = $(\text{loadings})^2/(\Sigma\text{loadings})^2 + \Sigma$ The error of each measurement variable.
[3] Diagonal is the value of AVE.
[4] *p < 0.01; *p < 0.05.

a pre-test and a post-test at the beginning and end of the course respectively. Among them, the "pre-test" is the covariate (when the control variable is used), and the "post-test" is based on the variable and then the multivariate items are combined. Analysis of variables (MANCOVA), and then empirically demonstrate whether the intervention of AI curriculum integration can improve: the immediate effect of perceptual curriculum integration, learning satisfaction, technological literacy, problem-solving ability, and intention to continue taking AI courses.

In terms of qualitative data collection, students submitted a total of 3 course reflection notes in the middle of the semester. Interviews will be conducted one month after the course ends. The interview location is determined by the interviewees. The interview lasts from 1 to 3 hours and the whole process is recorded. Using introductory words, the participants take the initiative to explain their thoughts and feelings, and then I convert the recording process into a verbatim draft. Then the two experts segmented, cut, and coded the qualitative data, and then compared and summarized the two codes to find out the categories and patterns, and form preliminary assertions. Then compare it with the existing materials that show differences and supports, and constantly confirm and revise the claims to form the final stable claims. The qualitative data of this study also uses the triangular verification method to establish the credibility of the conclusions and the real situation by using a variety of data collected over a long period of time, in conjunction with the theory and the comparison of the opinions of "researchers and research objects".

4. Statistical Analysis

4.1 Immediate Effect after the Course

In this study, unequal control group design was adopted. In order to reduce the influence of sample selection bias, the pre-test score was used as a covariate for covariate analysis. Table 4 shows that after controlling the interference effect of the "pre-test" score, the adjusted mean scores of the "post-test" of the experimental group and the control group are in: perceptual curriculum integration, learning satisfaction, technological literacy, problem-solving ability, continuous revision There are significant differences in AI course intentions. This means that learners who have integrated the "AI + Machine Learning + Big Data" course can improve their learning effectiveness more than those who have not.

4.2 Immediate Effect after the Course

Multivariate analysis of covariates (MANCOVA) is an extension of univariate covariate analysis, which considers the situation of multiple dependent variables, and considers whether ANOVA needs the accompanying continuous "independent variable-covariate" control. The MANCOVA design is superior to the simple MANOVA because it uses co-variables to control noise and 'factoring out' of errors. The commonly used ANOVA F statistic, the corresponding multivariate is Wilks' Lambda (symbol Λ), Λ represents the ratio between the error variance (or covariance) and the effect variance (or covariance).

Step 1 Test: Are the effects of each group equal after covariates adjustment? (A test of equality of group effects adjusted for the covariates)

Table 4. MANCOVA Analysis Summary Table

Wilks Λ	Source of variation	Dependent variable	F value	Effect size
	Covariate (pre-test)	Perceptual Curriculum Integration	5.572*	0.056
		Learning satisfaction	0.183	0.002
		Technology Literacy	4.572*	0.044
		Problem solving ability	5.547*	0.053
		Intention to continue taking AI courses	0.011	0.001
0.909*	Between groups (Effect of experimental group vs control group)	Perceptual Curriculum Integration	13.309*	0.083
		Learning satisfaction	14.822*	0.093
		Technology Literacy	10.879*	0.052
		Problem solving ability	13.448*	0.084
		Intention to continue taking AI courses	13.480*	0.084
	Within group	Perceptual Curriculum Integration		
		Learning satisfaction		
		Technology Literacy		
		Problem solving ability		
		Intention to continue taking AI courses		

* $p < 0.05$.

In order to understand whether there is an integrated course in the field of AI, the difference between the five teaching effects (knowledge integration effect, learning satisfaction, technological literacy, problem-solving ability, and intention to continue taking courses), this study uses MANCOVA analysis. And the type I error (=0.05) was used as the significance level of the hypothesis test, and the MANCOVA analysis results were organized into Table 4. It was found that the Wilks' lambda of the groups (experimental group vs. control group) was 0.909 ($p < 0.05$), so the null hypothesis "the effects of each group are equal after covariate adjustment" was rejected. Represents the experimental group vs. the control group (group factor). After adjusting the 5 covariates of the "pretest", the 5 dependent variables (knowledge integration effect, learning satisfaction, technological literacy, problem-solving ability, continuous course Intention) there was an overall significant difference in the effect.

Looking at the average of the 5 dependent variables in the two groups in detail In Table 5, those who have integrated the "AI + Machine Learning + Big Data" course are more likely to be integrated in the perception course ($t = 3.735$, $p < 0.05$), learning satisfaction ($t = 3.736$, $p < 0.05$), technological literacy ($t = 3.207$, $p < 0.05$), problem-solving ability ($t = 6.610$, $p < 0.05$), intention to continue taking courses ($t = 3.707$, $p < 0.05$), all of which were significantly higher than those who did not integrate courses in the field of AI. Said that those who have integrated courses in the field of AI have significantly improved the five learning outcomes compared with those who have not.

Step 2 Test: the coefficients for the covariates are equal across groups

Whether this test sample conforms to the assumption that the regression lines of each group are parallel. The results of the analysis found that "group × knowledge integration effect", "group × learning satisfaction", "group × technological literacy", "group × problem-solving ability" and "group × intention to continue taking courses" Wilks' The lambda significance test p-values were all >0.05, thus accepting the null hypothesis ": the coefficients of covariates across groups are equal". Indicates that this study conforms to the assumption that the regression lines of each group are parallel.

Step 3 Test: the joint covariate coefficient is equal to zero (coefficients for the covariates are jointly equal to zero)

The analysis of the results shows that "pre-test of knowledge integration effect", "pre-test of learning satisfaction", "pre-test of technological literacy", "pre-test of problem-solving ability" and "pre-test of continuing course intention" "The p-values of the five Wilks' lambda significance tests are all < 0.05, so the null hypothesis is rejected": the joint covariate coefficient is equal to 0", which means rejecting the assumption that the "common slope is 0". Indicates that the regression coefficient of at least one covariate in this example is not 0, so this example should include at least one or more time-invariant covariates.

5. Discussions

In the past, the design and teaching methods of AI-related courses often emphasized the learning of cognition, emotion, and skills in a single discipline and subject. Few people discussed the cross-field learning process and the effectiveness of curriculum integration. Curriculum integration is not just a technique for organizing subject content, or a method for rearranging programs of study, it is a theory of curriculum design, including implications for the purpose of schools, the nature of learning, the organization and use of knowledge, the educational experience, and so on.

Table 5. ANCOVA Analysis Summary Table

Item	Group	Number of people	Adjusted mean	Adjusted standard deviation(Adj-SD)	Levene test	t value	Wilks' Lambda
Perceptual Curriculum Integration	Experimental group	101	20.97	2.133	Homogeneity of variance	3.735*	0.909*
	Control group	99	19.88	1.996			
Learning satisfaction	Experimental group	101	11.985	5.2201	Homogeneity of variance	3.387*	
	Control group	99	9.076	5.3175			
Technology Literacy	Experimental group	101	7.861	4.7792	Homogeneity of variance	3.207*	
	Control group	99	5.939	3.6276			
Problem solving ability	Experimental group	101	9.822	5.7557	Homogeneity of variance	6.610*	
	Control group	99	7.212	4.3875			
Intention to continue taking AI courses	Experimental group	101	16.27	6.253	Homogeneity of variance	3.707*	
	Control group	99	12.85	6.783			

* $p < 0.05$.

Industry-oriented AI course design and integration make it easier to lay out a complete knowledge teaching system and construct a set of systematic course maps. (AI) curriculum is also an organism. It still needs to meet the physical and mental development of students, the needs of society, and the progress of subject knowledge. It attaches great importance to the coherence and cohesion of courses between disciplines in the vertical direction, avoids excessive overlap. At the same time strengthens the integration and connection of courses horizontally, and integrate the content of each subject.

Qualitative analysis found that, on the one hand, curriculum integration should enable students to learn the important concepts of each subject in the program and the interrelationship between subject concepts; In other words, it is necessary to take into account both integrity and depth of learning.

5.1 Learning Synergy after AI Course Integration

The five hypotheses of this study were all supported by statistical test results (Table 6). Indicating that this research has developed a curriculum integration method and retested the arguments of many scholars. The curriculum integration system is conducive to students' learning effectiveness, including five dimensions: learning satisfaction [84, 85, 92], Perceptual Curriculum Integration [56, 81–83], Technology Literacy [68, 69], problem-solving ability [78, 93, 94], behavioral intention to continue taking courses [70]. In other words, the learning effect of the "AI + machine learning + big data" course integration is better than that of the unintegrated ones.

This study also echoes the "social-cognitive" framework advocated by many scholars (socio-cognitive framework) knowledge integration [95–97], emphasizing that teaching should start with students' prior concepts, and apply the knowledge integration design model to carry out a series of teaching activities, induce students' knowledge integration, and then promote students' scientific literacy and professional knowledge and skills. deep understanding. In other words, science courses developed from the perspective of knowledge integration can cultivate students' interdisciplinary scientific literacy. Therefore, the importance of cross-disciplinary integrated courses for the cultivation of scientific and technological literacy/key abilities that is valued by the academic circle cannot be ignored.

5.2 Opportunities and Challenges of New Curriculum and Curriculum Integration

Curriculum integration still needs to match the teaching objectives to teach important educational issues that occur today, and flexibly adjust the teaching content and arrange classroom activities according to the characteristics of different departments, the characteristics and needs of students in different classes, and the current teaching atmosphere.

Teacher training of curriculum Guidelines of 12-Year Basic Education, life technology and information technology "core literacy" curriculum integration, can follow the method of this research to integrate the curriculum. Implement it in terms of course material design and teaching methods "interdisciplinary" teaching, and successfully integrated technological literacy into the pedagogy and curriculum design process of various subjects (AI, machine learning . . .).

5.3 Practical Issues of Curriculum Integration

Curriculum integration should include knowledge, experience and society [56]. One of the common problems in curriculum integration is mixing many seemingly related contents together but in an unstructured combination [48].

The lack of "depth" of the integrated curriculum is mainly due to teachers' insufficient knowledge of curriculum integration [98]. If teachers lack the ability to design curriculum integration and want to implement integration in a short period of time, their curriculum will either be unrealistic or reduced to patchwork. This phenomenon reflects a serious problem that school teachers only seek to conform to the curriculum reform policy, but do not under-

Table 6. Results of research hypotheses

Research Hypotheses	Reject/Support
H_1: If there is an integration of courses in the field of AI, there will be differences in the learning satisfaction of learners.	Support
H_2: If there is an integration of courses in the field of AI, there will be differences in the integration of perceptual courses for learners.	Support
H_3: If there is an integration of courses in the field of AI, there will be differences in the technical literacy of learners.	Support
H_4: If there is an integration of courses in the field of AI, there will be differences in the problem-solving ability of learners.	Support
H_5: If there is an integration of courses in the field of AI, there is a difference in the students' continued course behavior intention.	Support

stand the meaning and method of integration, resulting in a formalized curriculum and a lack of depth in learning. The original pursuit of curriculum integration is to make students' learning meaningful, generalized, and internalized. However, when it is implemented, it becomes a curriculum with empty thematic integration and activities that are more than lively but not deep enough. It is really counterproductive.

In short, the implementation of the integrated curriculum relies on the collaborative teaching of teachers with different expertise, rather than forcing one teacher to teach multiple subjects. To implement curriculum integration in schools, teachers must have the belief in curriculum integration and the knowledge of curriculum design, but it also requires collaboration with other teachers

5.4 School Face-to-face Suggestions for Cross-Disciplinary Integrated Courses

To sum up, four factors promote the maintenance of the integrated curriculum plan: common goals, cooperative relationships, commitment to refinement, and support structures. Among them, the cultural factor is mainly the cooperative relationship between teachers. The structural factor includes flexible schedule, time of curriculum planning, appropriate teaching space and teaching resources [99]. On the contrary, the reasons for the failure of curriculum integration include teachers' lack of knowledge and belief in curriculum integration and difficulty in adjusting curriculum [100–103]. Today's "cross-disciplinary curriculum" appeals to the cultivation of core technological literacy, which seems to have fostered curriculum innovation. However, like the previous curriculum integration, it needs the support of cultural and structural factors before it can be implemented.

It is recommended that designing and implementing an efficient integrated curriculum is superior to teaching a single subject. Teachers must have broader and deeper professional knowledge, and teachers of various subjects must also have good collaboration and communication. In addition, there must be more flexibility in the teaching space and time arrangement.

5.5 Suggestions on Literacy-oriented Teacher Training

The new curriculum emphasizes core literacy. The new "Teacher Training Law" emphasizes the "professional quality" of teachers. In practice, students and student teachers in our country think that the content of learning is too far from the real world. They need to figure out what to do and the use of learning, resulting in a lack of learning motivation and effectiveness, which is far from the education of technological literacy [1]. The phenomena in these real situations are all interdisciplinary, so they cannot be interdisciplinary just for the sake of interdisciplinarity. In addition, students are encouraged to find topics of interest to explore in real situations, enjoy the learning experience, and then start the learning process [104].

Although the connotation of literacy varies from person to person, literacy can be divided into "functional literacy" and "subject-independent, generic, transversal competencies". "Functional literacy" emphasizes that subject knowledge is essential, but what is more important is the connection between knowledge and context. Learners learn all kinds of knowledge from the context of real situations and can also apply the knowledge they have learned to various situations. Therefore, functional assessment is not how much specific knowledge a student possesses, but how much problem-solving ability a student has when faced with the real world, and this ability depends on a broad "understanding" of core concepts. That is to say, only when learners can apply what they have learned to solve problems, use what they have learned as the basis for mastering other knowledge, and when what they have learned can stimulate learners to think about how to apply it to other situations, is the real " comprehension" rather than merely listening to what was taught [105].

In addition, in the process of teacher training universities running preservice education courses for teachers, the core competencies of the new curriculum "Life" and "Technology", the integration of teachers' professionalism and preservice education courses must also be closely integrated with each other. Then, planning can get twice the result with half the effort.

6. Conclusions

Big data, Artificial Intelligence and Machine Learning, have important educational implications, but challenges are also to overcome. This study aims to provide schools with a teaching approach that emphasizes interdisciplinary, integrated machine learning and artificial intelligence-related courses in curriculum planning so that schools and teachers can think of a collaborative teaching approach in curriculum planning, allowing students to learn from subject knowledge from a lower level of understanding and application. This will enable students to achieve a higher learning level and transfer their learning. This is also a high-level goal that we aim to achieve in literacy-oriented learning.

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Appendix A:

Table A1. The control group adopted an unintegrated AI curriculum

Week	Topic	Description	Assignment
1	AI Basics and Agents	Intelligent agents and rational decision making; the history of AI, including two "AI winters", and the paradigm shift from expert systems to machine learning agents; the relevance of AI to various disciplines	
2	Knowledge representation	Represent internal and environmental states of intelligent agents using propositional and first-order logic; partially observable and uncertain environments	
3	Probabilistic reasoning	Probabilistic reasoning dealing with uncertainty; Uncertainty prediction using Bayesian regression; Modeling domain knowledge through ontology and semantic networks	#1: Knowledge representation: questions about first-order logic and probabilistic reasoning
4	Problem Solving: The Search Method	The agent's problem-solving strategy is used as search; classic search algorithms include: breadth-first search (BFS), depth-first search (DFS), uniform cost search	
5	Solving Problems: Planning	Problem representation and solution planning as state-space (BFS, DFS, Graphplan) and planning space search (UCPOP)	#2: Search Algorithm: Uniform Cost Search (Python)
6	Machine Learning: Decision Tree Based Classification	Intelligent agents capable of improving their efficiency by learning from examples; supervised and unsupervised learning; decision tree algorithms (ID3)	#3: Decision Trees and Ensembles: Classifying Banking Data Using Decision Trees, Random Forests, and XGBoost Algorithms (Python or Stata Programs)
7	Machine Learning: An Ensemble Approach	Ensemble methods: random forest and XGBoost; classifier performance metrics (accuracy, sensitivity and specificity, precision, recall rate and F-score)	
8	Midterm Exam		
9	Deep Learning: Neural Networks	Basic characteristics and architecture of neural networks; feed-forward transfer, backward transfer, gradient descent	# 4: DNNs: Implementation of Multilayer Neural Networks
10	Deep Neural Networks and Regularization		
11	Convolutional Neural Network (CNN)	Advanced strategies for parameter fine-tuning, regularization and optimization from the recent deep learning literature	
12	Recurrent Neural Networks and Natural Language Processing	CNN Architecture; Convolution and Pooling; Recent Developments in CNNs and Successful Architectures: VGG and ResNet	#5: CNNs: Image Processing Using Convolutional Neural Networks (Python Program)
13	AI ethics	Recurrent Neural Network (RNN) and Natural Language Processing (NLP) Fundamentals	
14	Project report	Ethical issues of using AI and possible threats to society; risks of adopting AI technology to privacy, social equality, employment and public safety	#6: Facial Recognition Doubts
15	Project report		
16	Final Exam		

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