Application of generative artificial intelligence to assessment and curriculum design for project-based learning

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***Abstract*—This paper proposes an integrated generative AI learning literacy approach based on project-based learning to harness the transformative potential of generative AI in higher education. It provides a novel framework for integrating generative AI into project-based learning that aims to develop students' skills in three key aspects to grasp the application of generative AI as an effective problem-solving tool: (1) understanding algorithmic mechanisms, (2) identifying biases, and (3) using AI tools to solve problems. The process of integrating generative AI begins with assessing prior knowledge, introducing relevant problem-solving learning and AI tools, and designing course pathways and peer assessments through social media to cultivate students' problem-solving pathways. In addition, this paper recommends evaluating the effectiveness of AI-integrated courses through a comprehensive post-course survey of students and instructors.**

Keywords—generative artificial intelligence, Higher education assessment, Competency based learning, Project Based Learning

I. INTRODUCTION

In today's digital age, artificial intelligence (AI) is making inroads into a wide range of industries, transforming jobs and job roles[1]. According to a June 2023 McKinsey report based on 63 case studies, generative AI has the potential to add the equivalent of $2.6 trillion to $4.4 trillion in annual revenue[2]. The McKinsey report highlights the enormous potential of generative AI across industries. It estimates that automation could free up 30-40% of working time by 2030, enabling productivity gains of 0.2-3.3% per year, if accompanied by investment in people. Although many industries will benefit, generative AI will benefit hi-tech, banking, and bio-pharma more than other industries. Overall, the report underscores the immense market size and transformative economic potential of generative AI if skills development keeps pace. However, transforming the workforce will require cultivating multi-skilled talent that understands both generative AI and industry-specific needs. To meet this imperative transformation requirement, higher education institutions must provide employers with targeted talent assessment metrics and teach students to apply generative AI across disciplines. Since generative AI technology only became widely known after ChatGPT emerged, there are currently few studies proposing to integrate generative AI into specific course designs in higher education. Considering the technical characteristics and limitations of Large Language Models (LLM) as the Natural Language Processing (NLP) technology underlying generative AI, this paper contributes to the design of generative AI skill assessment components and generative AI integration in PBL model. As an example of a project-based learning (PBL) course, the design of such an integrated Generative AI competency PBL course is demonstrated using a business market analysis course in section VI.

II. BACKGROUND

A. Generative AI

The term generative AI refers to the training of the database by a specific algorithm so that it can creatively express language as desired into understandable, meaningful, and acceptable responses. These include DALL-E (OpenAI), Stable Diffusion (Stability AI), cohere (GitHub), Claude (Anthropic), Generative Pretrained Transformer series (GPT) (OpenAI).Generative AI employs Large Language Model (LLM) as a kind of Natural Language Processing (NLP) technology, perform as a kind of machine learning. The following two aspects are intended to reveal the working mechanism of the LLM model and the main issues on generative artificial intelligence based on the technology underlying reasons.

B. Technical features underlying generative AI

Generative AI is generally based on LLM, but the GPT Series also includes Reinforcement Learning from Human Feedback (RLHF). LLM is a natural language processing model based on deep learning. LLM is characterized by their large scale, containing billions of parameters, which facilities it learns complex patterns in linguistic data. For example, in the GPT series, GPT-2 consists of 1.5 billion parameters, while GPT-3 has 175 billion (175B) model parameters, and the entire training requires 3.14E11 (TFLOPS) of floating-point operations per second. In terms of trained data, GPT-4, the latest iteration of OpenAI, has 45 gigabytes of trained data compared to GPT-3's 17 gigabytes. These models are often based on deep learning architectures such as pre-trained transformers, which allow them to achieve impressive performance on various NLP tasks. RLHF

is an algorithm based on instructors giving human feedback scores to pre-trained text expressions and optimizing expressions according to the human's feedback reward system.

According to the rules of operation of ChatGPT models, four arguments can be summarized as below:

- Due to the randomness of the algorithm model, the expression will be creative but not very stable.
- The size and content of the data set determines the quality and content of the output produced by the algorithm, since the LLM model produces results based on the training data set.
- Because the RLHF model is corrected by manual feedback, it is impossible to completely avoid the influence of the instructor's bias.
- This algorithm generates connections based on the probability of characters and expression rules. It should be clarified that there is no retrieval function as a search engine, and it does not mean that the computer can understand the meaning and connotation of the interlocutor.

C. ChatGPT creative content generation not retrieval

The underlying technology of generative AI is based on LLM. Until today, the output effect of LLM mainly depends on the probability generated by the massive dataset to be trained and the number of models. The "generative" capabilities come from training these LLMs on massive datasets. On the other hand, the quality and content of the training data is critical, as it provides the statistical patterns that allow the LLM to generate coherent, realistic output. Therefore, the probability distribution captured in the training data determines the system's ability to generate an answer to the input question, and this allows the limitation of the LLM to be recognized. It is unable to make predictions and understandings beyond the literal meaning. Even GPT4.0, the most impressive product of generative AI, still has unreliable reliability problems in its text reasoning and natural language analysis [3]. The existence of false information and false documentation on ChatGPT has always been a matter of concern[4]. Moreover, most of LLM suffers from hallucination problems like ChatGPT, and it generates more extrinsic hallucinations from its parametric memory since it does not have access to an external knowledge base[5].

Based on the above technical analysis of generative artificial intelligence, two key points must be understood as below:

- The key capability of AI is to generate coherent, fluent expressions based on training data.
- Generative AI under the LLM model actually knows nothing about the world outside the training data. Therefore, the output content generated by generative AI must be treated with caution.

TABLE I. GENERATIVE AI IN EDUCATION APPLICATION FIELD

Field	Description	Limitation and potential Risk	Related literature
Scientific writing	1. Helps students better understand certain concepts. 2. Helps users simplify expression. 3. Helps users improve their writing skills with more concise and fluent, understandable expressions.	1.Less critical thinking. 2. Questionable authenticity. 3. Lack of strong evidence. 4. Less innovation and novelty, somewhat superficial. 5. Ethical risk	[12-15]
Personalized learning	1. Quickly generates curriculum syllabus and plan ideas and development worksheets. 2. Provides explanations, guidance, and real-time feedback tailored to each student's unique needs and interests. 3. A feedback system that provides constructive criticism of student writing. 4. Paying more attention to the learner's psychological characteristics of learners, helping them engage in relevant courses, and providing suggestions and prompts through appropriate devices and apps.	1. The professionalism of this kind of help is based on the literature and texts that have existed before. Whether it is helpful to each individual has yet to be confirmed by research. 2. Learners should know that generative AI should not replace the expertise and judgment of teachers, but rather be used as a supportive co-pilot. 3. Since each institution's rules are different, the use of LLM's tools must be in accordance with the school's policies.	[16-19]
Auxiliary programming	1. AI-driven programming generation: Provides programming experience to users 2. Code explanation: Step-by-step explanation. 3. Provides poor Programming Error Messages (PEMs) and Exemplar Solutions.	1. The clear and accurate input of task requirements is crucial. 2. The stability and efficiency of AI programming need to be optimized.	[20,21]
Assignment rating	Higher education assignments include essays and scientific experimental studies. Humans and deep learning algorithms perform nearly equally on common tasks. However, for empirical analysis and comprehensive comparison, the LLM model is powerless.	There is still a gap between algorithms and human professional scoring on complex problems and highly skilled scoring.	[22,23]

III. THE APPLICATION OF AI IN EDUCATION

According to a brief literature review of the top 10 most cited papers from 2007 to 2018 using the keywords "AI" + "application in education" as search terms on researchgate.net and Google Scholar, it was found that Artificial Intelligence in Education (AIEd) is mainly concentrated in four application areas within academic support services and institutional and administrative services. 1. Analysis and prediction, 2. Assessment and evaluation, 3. Adaptive systems and personalization, and 4. Intelligent tutoring systems[6]. With the launch of ChatGPT, the application of generative AI in education, especially higher education, is expected to benefit teachers and students in and out of the classroom[7-10]. The latest study also shows that GPT 4.0, which relies on LLMs to automatically identify student mistakes and streamline teacher assessments, also compares favorably with human scores, except the complex scoring[11]. A brief review of the latest academic literature on ResearchGate and Google Scholar from January to August 2023 shows that generative AI is increasingly cited in educational applications, shown in TABLE I. Key topics include the benefits of AI-assisted teaching and assessment, as well as risks that require ongoing investigation.

Overall, the rapid development of generative AI is stimulating promising educational applications, but further research is needed to fully realize its benefits while addressing potential risks such as ethical issues..

IV. FRAMEWORK FOR INTEGRATING AI INTO PROJECT-BASED LEARNING CURRICULUM DESIGN

Since 2016, the call to reframe higher education assessment from a practical perspective is now imperative in the context of digital transformation[24]. This paper proposes competency-based learning model that leverage generative artificial intelligence tools to reform assessment and curriculum. Competency-based learning emphasizes the acquisition of flexible, individualized skills[25]. For this purpose, project-based models(PBL), as well as some form of competency-based learning (CBL), achieve better academic outcomes than the traditional model through extensive interdisciplinary collaboration[26]. PBL emphasizes solving real-world problems, developing marketable skills, critical thinking[27] and meeting workforce needs[28-30]. Integrating generative AI into a competency-driven PBL framework will enable higher education to keep pace with technological change.

Hence, PBL is a comprehensive approach suitable for higher education, aimed at the needs of the labor market, solving practical problems and skills as required by the labor market.

- The key capability of AI is to generate coherent, fluent expressions based on training data.
- PBL can provide different types of higher education institutions to promote sustainability. Existing research includes an integrated approach to the quality of higher education provided.
- PBL focuses on developing broader student competencies beyond the curriculum, helping them to increase their chances of academic success and competitiveness in the student labor market.
- PBL also helps students take responsibility for learning, understanding, developing interaction skills in collaborative teamwork and applying academic concepts to practical outcomes.

The main points of integrating generative AI as a tool in project based curriculum design are as follows , including purpose, curriculum design components, and assessment.

A. Purpose of the PBL

The purpose should be clear: to cultivate talent that will use artificial intelligence tools to improve efficiency, change the inherently outdated productivity framework, or propose innovative strategies for industry development and improvement. It is advisable to integrate critical and reflective thinking, creative thinking, and deductive reasoning with the using AI tool into the curriculum goals, inform students about the capabilities and limitations of the tools, and encourage students to create more appropriate tools using open-source software.

B. PBL design Components

1) Algorithm

According to the disciplinary requirements of different courses, the instructor should select the appropriate algorithm as a necessary auxiliary tool in such as natural language generation, image creation, or predictive modeling.

2) Task

This can apply to project-based learning or general learning practice. The goal must be to solve problems using professional knowledge and auxiliary tool. Prior knowledge must be included in the difficulty of task design.

a) Goal

The goal must be direct and clear: first, what problems need to be solved urgently, what doubts and assumptions need to be investigated and confirmed (critical thinking), how do students present their designs and ideas, second, who is your reviewer or audience and where are they, what they concern, third, how do you achieve this goal?

b) Team

PBL is suitable for collaborative teamwork, and the composition of team members can be free or random. There are four aspects of attention in processing: 1. Task identification 2. Individual work assignment 3. Progress management and communication 4. Feedback and correction.

c) Implement process and content

The choice of collaborative teamwork or individual completion depends on the content and complexity of the course. It is recommended to use time and worksheets to record the work process in the assessment. In principle, this time and work content cannot be changed and should be recorded by the system once only. If the expected planned progress is not achieved, it is necessary to give feedback on the questions and record the feedback and follow-up process after the feedback.

When users use the LLM model or similar algorithm as a tool, they need to understand 3 aspects: 1. How big is the size of the database (comparing other database) and where the data comes from 2. What are the working mechanism and technical characteristics of the implemented algorithm 3. How does the input ensure that the algorithm performs as expected?

C. *Assessment*

There should be several dimensions of assessment:

1. Degree of mission accomplishment 2. Use of intra-team or class peer review and inter-team raters as evaluators 3. Efficiency of innovative means 4. The ratio of consumption to efficiency. Choose the appropriate weight according to the different characteristics of the curriculum.

V. INDIVIDUAL GENERATIVE AI COMPETENCY ASSESSMENT

Currently, it is estimated that generative AI can bring innovation to various industries and create a large and thriving job market around the world. The resulting industry changes are undoubtedly eager for talents who have mastered generative AI skills, but there is currently no unified standard for the ability to master and apply generative AI. On the other hand, to better assess the user's ability to master the application of generative AI, it is necessary to assess the user's understanding and mastery of the generative AI, such as bias and fake information.

Taking LLM-based generative AI as an example, due to some technological characteristics of the LLM model and industry application requirements, this paper summarizes the assessment of talents' generative AI application skills into three aspects, as shown in TABLE II.

The importance of assessing these capabilities is to avoid various potential risks that misuse of generative AI or misunderstanding of the operating rules will result in an undesirable outcome.

TABLE II GENERATIVE AI SKILL ASSESSMENT IN HIGHER EDUCATION

Generative AI Skill	Description	Assessment norms
Ability to understand algorithmic mechanisms	1. Database' s size and content scope have the decisive impact on output. 2. M Different Model architecture and training techniques have certain influence on the output expression. 3. Creativity comes from certain random combinations.	1. Clearly understand which tasks and jobs are not suitable for relying on generative AI 2. Understand what needs to be careful about creating generative AI 3. Understand what aspects of generative AI generation need to be verified. 4. Clearly understand where the boundaries of creative expression of generative AI lie.
The ability to understand the bias	1. Source bias: The data content and the quality of a particular database, the proportion of different content will affect the existence bias of the output. 2.Procedure bias: Such a process bias is inevitable when the model output is optimized by manual guidance.	1. It is necessary to clearly understand the black box operation of algorithmic models such as LLM is inherent. 2. It is necessary to realize that the bias lies in the volume of data and the imprint of the times of the data itself and the ratio of specific content. 3. It is necessary to recognize that the retirement function does not exist on the LLM and extend it if necessary. 4. It is necessary to recognize that even if the results of the LLM algorithm are correct, they are mediocre rather than top or the best, the most creative.
The ability to apply and expand the scope of the application	1.Programming Skills 2. Leverage database connections and extensions Information classification and categorization capabilities 3. Optimize the expressiveness of language (abbreviation, contraction, expansion) 4. Ability to transform blurred text images into clear text images (Generative Adversarial Network)	There are two aspects of assessment for combined Generative AI technology new products and new technologies: 1. Efficiency: The metric used is how much time and effort is saved compared to the traditional or old way of doing things.2. The other metric is based on resources, required energy consumption ratio.

As shown in Table II., the skill assessment of generative AI application does not require a deep understanding of the underlying technology, but it requires users to have a proper understanding of the ethical and moral risks, reliability, and efficiency benefits of the application. The specific evaluation approach for users is proposed to adapt true or false question and detailed explanation reasons in "ability to understand algorithmic mechanisms" and "ability to understand the bias" two aspects, while the application level needs to have a new technology/new product work report for evaluation. If an appropriate generative AI application management committee can introduce more specific standards under the framework of Table II. in the future, it will benefit employees and employers in the workplace.

VI. EXAMPLE CASE

To demonstrate problem-based learning (PBL) methods and assessment more comprehensively, a mini-case study is used as an example. The case involves a business analytics course in which students were asked to complete a PBL project using generative AI as a problem-solving tool. The framework outlines the main tasks and expected outcomes. The students' work is then assessed based on the PBL model.

This case study provides practical illustrations of how to structure a PBL process for students, from framing open-ended business questions to leveraging artificial intelligence to generate collaborative ideas to achieving learning objectives. It is an example of explaining PBL principles and multifaceted performance assessment.

Mini-project -- "How can the tools of generative AI give your company an edge?".

A. *Prerequisite:*

- Students will understand the operation of the company, as well as the opponent's situation and their own operational shortcomings and advantages.
- For financial analysis and marketing, previous knowledge of cost accounting should be taken into account.
- Using a digital software platform, students participate in virtual business competitions based on PBL.

An initial prior knowledge test is required for students before they begin.

B. *Purpose*

- Students should learn that generative AI can save companies human resource costs in terms of communication,
- Students should be able to use generative AI to connect with open source software or office software such as Excel to extend functionality and improve efficiency.
- Students should learn the ability to transform images and text into each other to create the attractiveness of posters and advertisements created by students using generative AI.

C. *Outcome of the project*

Each group of students will present their cases in the form of reports. It is recommended to include the following.

- What size and industry companies use generative AI as auxiliary tool?
- How does generative AI intervention improve efficiency or save-time compared to traditional work?
- For buyers or users to conduct surveys to see if they are satisfied with generative AI products.
- Summarize the practicality and reliability of ideas and new technologies.

D. *Project assessment*

Peer assessment involved both intra-group and inter-group evaluation. Students were encouraged to create YouTube videos explaining their work, allowing broader public feedback via social media. The teacher also provided comments, pointing out issues and suggesting areas for improvement.

As part of the project requirements, students had to complete multiple surveys consisting of questionnaires. Each group member was expected to submit individual responses to ensure self-assessment and reflection on their contributions to the collaborative process.

1) Do you know GitHub? (GitHub is the website with the largest collection of open-source products)

2) Have you ever learned SQL, the basic language for data analysis? Do you use ChatGPT, GPT-4.0 and are there any limitations due to your environment? (Previous computer knowledge)

3) Try to find the sales data for the last five years for your favorite company. Draw a pie chart for the composition of its five-year product revenue (including services), classify the different annual revenues by year, calculate the growth rate of each business revenue, and try to explain what happened? - Calculate the time needed

4) Using generative AI: How long would it take to do the same thing using any tool or extension of generative AI? And try to illustrate the difficulty in processing the application of generative AI.

This survey aims to assess generative AI's benefits for users with varying computer skills and its impacts on customer service, marketing, and data analytics. It also evaluates students' mastery of using generative AI tools to enhance office software productivity. We recommend individualized generative AI skill assessments per Table II. True/false bank questions can evaluate understanding algorithmic mechanisms and recognizing bias. For applying/extending AI, comprehensive metrics like peer reviews of team projects, social media praise, and mentor input quantify innovation. Overall, personalized assessments of how distinct users leverage generative AI tools provide crucial insights. Quantifying algorithm comprehension, ethical usage skills, and real-world problem-solving capacity allows developing customized educational approaches. This tailored generative AI skill measurement advances equitable AI integration in academia and industry.

VII. CONCLUSION

This paper contributes by proposing a framework that integrates generative AI into the project-based learning (PBL) model in higher education, enhancing efficiency and problem solving. The framework introduces three main assessment domains for generative AI skills: understanding algorithmic mechanisms, recognizing bias, and applying and extending the use of AI. These domains aim to prevent misuse, enhance ethical use, and promote innovative problem-solving methods. This work significantly expands the real-world applications of generative AI, promotes its adoption in higher education, and illustrates its potential across various interdisciplinary fields.

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