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Co-skilling for School-Industry Partnerships in STEM Education: A Design Research Study

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***Abstract*—In STEM education, school-industry partnerships are increasingly established to promote applied learning, in which students are exposed to real-world problem solving together with industry partners. Designing such learning partnerships can be prohibitively demanding for teachers. Motivated to address this issue, this study develops a theory-informed tool for STEM teachers. The research objective is to develop theory-driven design principles for such a tool using the design science research methodology. Findings from a beta test is discussed.**

Keywords—school-industry partnerships, co-creation, applied learning, design science research

I. INTRODUCTION

Science, Technology, Engineering, and Mathematics (STEM) education aims to meet the exploding demand for human capital in the digital and sustainable economy. Given its practical significance, it is not surprising that the application of conceptual knowledge to real-world situations is a hallmark of STEM education [1]. Applied learning manifests as various pedagogical practices, such as problem-based learning, project-based learning, and inquiry-based learning [1]. The teaching approach often involves identifying real-world problems, incorporating actual stakeholders, and assessing learning effectiveness. To ensure practical relevance, schools are increasingly partnering with industry to facilitate applied learning [2]. One example is the partnership between a junior college, the national food agency, and a biotechnology company in Singapore to co-establish an on-campus agri-tech facility for students to develop solutions for improving crop yield [3].

School-industry partnerships for applied learning in STEM education is promising but can be prohibitively demanding for teachers. It takes much contemplation and experience to identify real-world problems that are relevant to both the partner and students, determine useful pedagogical strategies, and select appropriate learning effectiveness measures. Helping teachers cope with these demands is the practical motivation driving this study. We aim to develop a theory-informed tool to help STEM teachers design applied learning activities in school-industry partnerships. Accordingly, our research objective is to theoretically develop the design principles for such a tool using the design science research methodology.

Specifically, this study developed a pedagogical concept known as "Co-skilling" based on a literature review and implemented the corresponding design principles to create a digital tool that helps teachers design applied learning activities. Following the design science research methodology, we initially evaluated and refined the Co-Skilling design principles for STEM education through a beta test.

II. CONCEPTUAL BACKGROUND

To develop design principles, the literatures on applied learning, school-industry partnerships, and collaborative learning were reviewed. Among the existing concepts, we found that co-creation captures the joint development of solutions to real-world problems in school-industry partnerships best. Co-creation is a management concept referring to the joint, collaborative, peer-like process of producing new value (Marco et al. 2014) and is increasingly applied in education contexts [e.g., 4]. Nevertheless, the concept tends to overemphasize the solutions and understate the need to facilitate learning and development of skills in the education context. To address this, we adapted co-creation to develop the concept of "Co-skilling" for school-industry partnerships in education.

Co-skilling incorporates the key principles of co-creation as well as collaborative learning as identified in our literature review and summarized below:

- Authenticity principle: A real-world problem of interest to learners as well as industry partners should be specified upfront.
- Co-creation principle: Learners as well as industry partners and key stakeholders work together to develop and shape solutions.
- Benefit-all principle: Expected learning outcomes for students (e.g., better skills) as well as benefits for industry partners and stakeholders (e.g., novel solutions) should be specified upfront

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III. Co-Skilling Tool and Beta Test

The principles of Co-skilling guided our design of the tool that aims to help STEM teachers design applied learning activities in school-industry partnerships (see Figure 1). The tool is not restricted to any specific industry. To illustrate, the Authenticity principle manifests as a function that recommends possible real-world problems based on inputs such as the industry partner's nature of business, student level, subject knowledge of interest, and expected duration of the partnership. Teachers can provide inputs by following through a step-by-step guided process or enter free text describing any available information about the partnership.

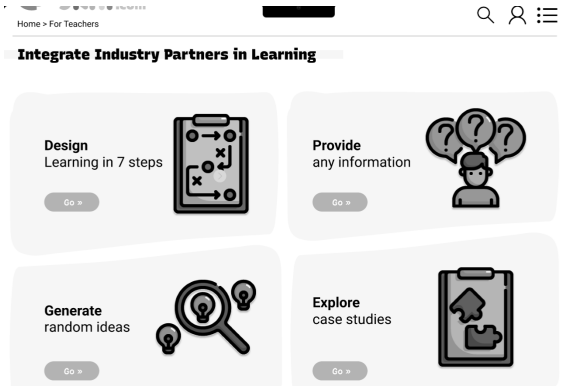

Figure 1. Tool for Designing School-Industry Partnerships in STEM Education

The recommendations are expected to help narrow the knowledge and experience gaps teachers face when designing applied learning activities in school-industry partnerships. Using the tool, teachers can adopt or adapt a recommended real-world problem rather than starting from scratch. The recommendations are provided based a natural language processing algorithm that analyzes more than 200 published case studies of school-industry partnerships. In line with the Authenticity principle, the algorithm is optimized to recommend real-world problems relevant to the learners as well as industry partners specified by teachers.

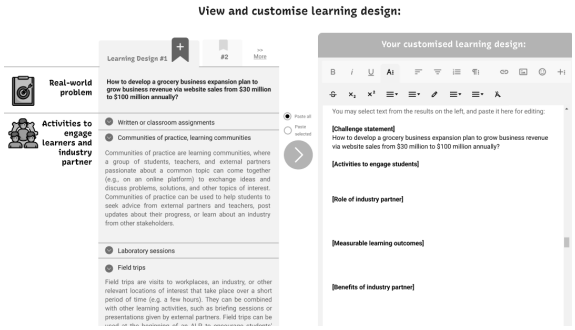

Figure 2. Recommendations for the design of applied learning

In a similar vein, the Co-creation principle mainly manifests as a function that recommends learning strategies engaging both learners and industry partners in the development of solutions to the selected real-world problem; The Benefit-All principle manifests as a function that recommends relevant outcomes for both learners and industry partners (see Figure 2).

Following the design science methodology [5], a beta test involving nine STEM teachers who had experience in applied learning and school-industry partnerships was conducted to initially evaluate the tool and identify potential refinements to the functions or Co-skilling principles. The teachers were instructed to design applied learning activities for their upcoming school-industry partnership using the Co-skilling tool. The researchers observed their use of the tool and noted any questions or comments they had. The teachers were also prompted to comment specifically on the ease of use (e.g., "did you encounter any difficulty?") and usefulness of the tool (e.g., "would you adopt the recommendations?") as well as their intention to use the tool in future. The responses were voice recorded and transcribed. The transcriptions were then analyzed by three researchers.

The beta test findings indicate that all teachers found the tool useful, especially for getting started on designing a school-industry partnership. Although the recommendations often need to be adapted for their context, the tool effectively inspired new ideas that they would not have thought of and helped to significantly reduce the cognitive load of designing a partnership. Many teachers noted the need to improve the tool's ease of use. For example, more description could be provided for each function to explain what they do; An animated walkthrough could be provided for first-time users; A searchable user guide should be provided for users' reference as needed.

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IV. Conclusion

The tool for designing a school-industry partnership is currently being refined based on the beta test results and will be tested in a full-scale experiment involving a snowball sample of more than 100 STEM teachers experienced in applied learning and school-industry partnerships.

This research-in-progress potentially contributes to research by theoretically developing design principles for STEM education and rigorously evaluating them using the design science research methodology. The design principles contribute to practice by guiding the design and development of useful tools for STEM education. The tool developed in this study can also be used by practicing STEM teachers to improve learning design of school-industry partnerships. Research data from the beta test and the full-scale experiment are stored in a 256GB encrypted hard disk and will be retained for three years after the end of the project.

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