UPSKILLING THE COMPETENCEIES OF TEACHERS IN THE PRIVATE SECTOR THROUGH STEAM AND DDMT MODEL

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Abstract

Apart from public education, private education plays an important role in the education arena in Taiwan. In 2017, it has been estimated that the amount of money that parents in Taiwan spent on after school enrichment classes is way above public education [1] [2]. This amount is also exceedingly high considering the average median salary [3]. With such high emphasis in the after-school education scene, especially with public education costing just a fraction amount, there is an essential need to upskill the teaching abilities of educators in these organizations. For this research, after school educators from AI4Kids embarked on a 2-day professional development workshop to enhance the curriculum design capabilities of educators using the DDMT Model [4]. In this 2-day workshop, participants will learn how to incorporate critical thinking [5] into their designed courses as well as the use of a digital portfolio [6] to capture the learning pathway of individual students [7]. At the end of the workshop, each participant will submit a DDMT designed course to be implemented in the upcoming summer holidays.

Keywords: Tsing Hua STEAM School, STEAM, Critical Thinking

1 INTRODUCTION

Automation, in tandem with the COVID-19 recession, is creating a “double-disruption” scenario for workers. Companies’ adoption of technology will transform tasks, jobs and skills by 2025 with 43 per cent of business indicating they are planning to reduce their workforce due to technology integration [8]. In Taiwan, Ministry of Education added the "Science and Technology Course Outline" in 2018, listing programming and artificial intelligence as compulsory courses for national and high school students. However, domains of Artificial Intelligence (knowledge and technology) are broad and deep, meaning developing educators with the right skills to teach AI cannot be attained in a short period of time. In preparation for children to become self-directed learners, there is a need to introduce a comprehensive methodology scaffolding students in developing their critical thinking ability. Although Taiwanese students spend an average of 5 hours in school, majority of parents will send them for afterschool classes for 2 reasons; namely to avoid becoming latchkey children [9] and to further develop their abilities. The afterschool private education scene in Asia is very vibrant, where parents’ biggest financial commitment is likely to be their child’s education [1]. The resources (money and time) invested by parents on afterschool programs is astonishing [10], although there remains a gap regarding the abilities of educators providing these services due partly in fact of them not attending full-fledged teacher training programs. At the same time, another significant change in education policies and practices focused on industries’ need to employ workers with highly refined skills in STEAM disciplines [11] where critical thinking often heavily emphasized. The aim of this paper is to suggest how curriculum following Tsing Hua STEAM School and DDMT Model helps strengthens the teaching capabilities of the afterschool educators to develop critical thinking skills in the students in a systematic approach. In our work, we will also showcase how a digital portfolio is pivotal in documenting the learning pathway as an alternative form of assessment for critical thinking.

2 RELATED WORK

2.1 Tsing Hua STEAM School

Tsing Hua STEAM school is a “Quality STEAM Education for All Learners initiative advocated by Prof Chi-Hui Lin and Prof Tzu-Hua Wang in 2018. Educators from different disciplines are encouraged to develop a learning process of measuring academic content and competencies [12]. While traditional instruction focuses on convergent thinking (in which students are seeking the right response), a hallmark of creativity is divergent thinking (in which multiple solutions and ways of thinking are encouraged) [11], this can also be interpreted as critical thinking as students are looking at the problem through different perspectives [13]. Lessons that involved more divergent types of learning allows students to define problems, and then encourages them to find as many different ways to solve the problem as possible [14].

To address this problem, we created an intensive 30-hr PD workshop after reviewing the existing research on STEM and STEAM Education and created a DDMT Model to facilitate the development of competency-based teaching practices [4]. Primarily, the DDMT model is defined through the four stages of ‘Define’, ‘Discover’, ‘Model & Modelling’ and ‘Transfer’.

In the Discovery phase, the key intention is to allow learners to practice empathy through identification of problems revolving their daily life experiences. Teachers will serve as facilitators to guide learners through the discovery process; the three areas include developing social and environmental awareness, creating motivation, and determination of the core problem. In the Define phase, the teacher needs to regain control and navigate masterfully through the numerous problems provided by the learners and choose a problem that aligns with the national curriculum. The concepts and contents learnt should correspond to the respective grade level of the learners. After identification of a core problem, the teacher will then define the variables associated with the core problem and start a second round of brainstorming for learners to discuss data collection processes and procedures. The data collection process needs to be based on both scientific and mathematical principles. The Model and Modeling phase is the phase associated with hands-on education. One of the strategies to foster an authentic STEM education is the utilization of models and modeling [15]. Transfer is the final phase that leads to the learners’ abilities to display their abilities to apply their knowledge in another setting.

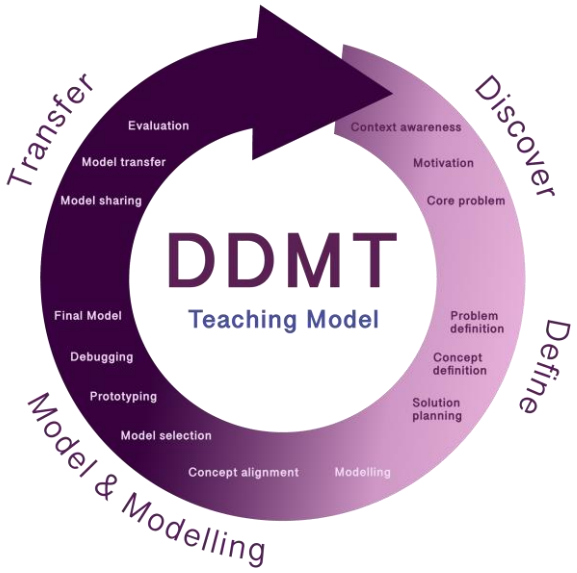


Figure 1. DDMT Teaching Model

2.2 AI4Kids

AI4kids comprises a group of alumni from AIA Taiwan Artificial Intelligence School. With the original intention of AI education to facilitate implementation at Grades K-12, AI4kids has invested heavily in curriculum development adhering to the framework of the New Taiwan Education Guidelines as well as AI4k12.org in the United States to build a complete set of learning maps covering 6 major pillars; "computer science", "computer perception", "representation and reasoning", "machine learning", "human-computer interaction" and "social impact" . To make learning relevant, real-life case studies

(such as manufacturing, service, medical treatment, architecture, art) have been incorporated, enabling students aspiring in various fields to become interested in AI. Working closely with academics and industry experts, AI4kids have developed a series of high school AI textbooks currently used by many schools. Professional development workshops have also been organized for 100 teachers from Taiwan.

2.3 Digital Portfolio

The use of an assessment portfolio has shown to aid learners in developing thinking and learning through thinking skills approaches and metacognition [16],[17]. Research into metacognition has also suggested that teaching needs to make the process of learning as well as curriculum content explicit [18]. One way of doing this is to review learning and help learners to see their success [19]. There are three types of portfolios: documentation, assessment portfolio and showcase portfolio [20]. A documentation portfolio includes all the works of a learner through one course. An assessment portfolio allows learners to select works for assessment based on criteria given by the instructor [21]. A showcase portfolio allows learners to select only their best work for inclusion. In order to observe the learning behavior of each student, it would be more suitable to use the documentation portfolio to collect the completed work by the students over the course of the curriculum. In this research, participants will also be taught how and what to collect in the digital portfolio. It is also noteworthy to mention that Taiwan is undergoing a mindset shift in the use of digital portfolio as a new initiative by Ministry of Education proposes using digital portfolio as part of university application [22].

3 METHODOLOGY

To accommodate the financial and time constrains of the private sector, the original 30-hr PD face-to-face workshop has been refined to 12-hr face-to-face and 18 hours self-directed. For the face-to-face sessions, participants will be equipped with knowledge such as mission & vision of Tsing Hua STEAM School, theory and hands-on approach to applying DDMT Model as well as how to create learning pathways on the digital platform (See Table 1).

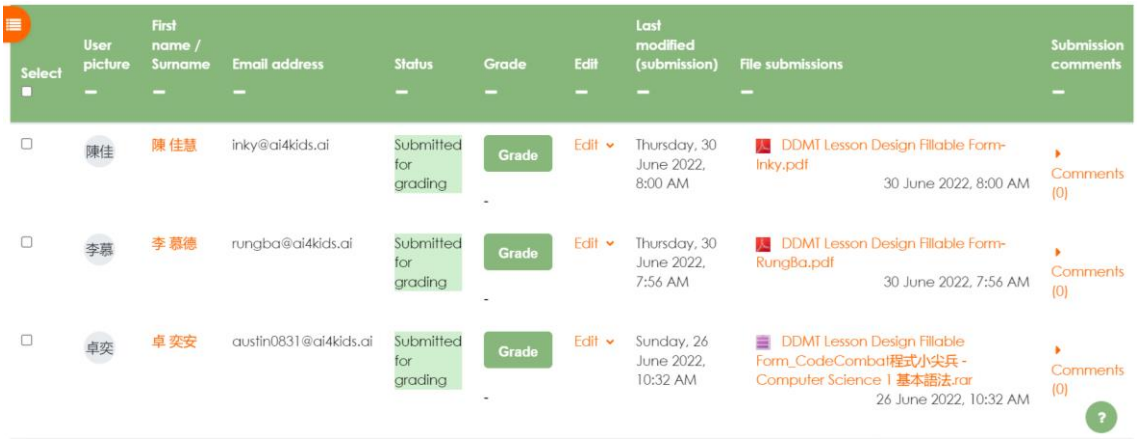
Table 1. Schedule of the 2D face-to-face workshop

	AM	PM
Day 1	• Mission & Vision of Tsing Hua STEAM School • Job Polarization • Changing Outcomes of Education	• Curriculum Planning
Day 2	• DDMT Model • Case Study • Hands-on session	• Digital Portfolio • Assessment Planning

Participants will be given 7 questions on STEAM Education and its relevance to Teaching & Learning. These questions will form the bedrock for the morning portion of Day 1. In the afternoon. participants will be introduced to DDMT Model, and a case study will be shared. After the case study, participants will be made to undergo a maker activity, where they will attempt to solve a problem 3 times using different perspectives. On Day 2, participants will begin their curriculum planning activity using the DDMT Model. At this time, participants will be revisiting their own curriculum and how DDMT can be embedded into the teaching process. At the end of the second day, participants will be required to submit a lesson plan (one month to submit complete version) developed with the DDMT Model [4]. Using the critical thinking rubric provided in the digital portfolio, a peer review will be conducted on the lesson plan to determine the impact of critical thinking rubric on the cultivation of critical thinking

4 RESULTS

After the workshop, participants developed a better understanding of mapping STEAM to their existing curriculum. As mentioned earlier, due to the new shift in policy, using digital portfolio is still foreign to many educators and convincing educators to upload their lesson plans is a huge step forward. (See Figure 2).



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☐	李慕	李 慕德	rungba@ai4kids.ai	Submitted for grading	Grade	Edit	Thursday, 30 June 2022, 7:56 AM	DDMT Lesson Design Fillable Form-RungBa.pdf 30 June 2022, 7:56 AM	Comments (0)
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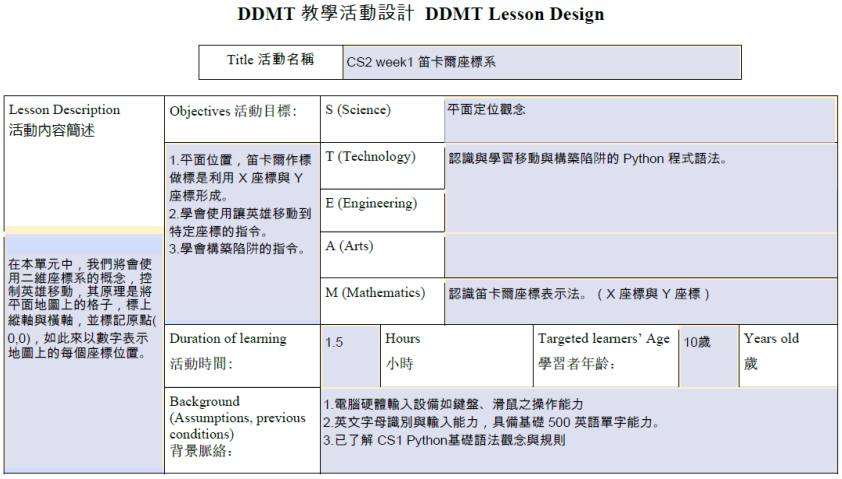
Figure 2. Submission of lesson plans via Digital Portfolio

Figure 3 showcases the introduction of a level 2 Computer Science curriculum. In this curriculum, students need to learn the different functions of each command and use them to solve puzzles for advancement. Apart from the detailed mapping to the various STEAM components, the participant was also able to list down explicitly the assumptions of what is needed in order for the child to undergo this program. Having clear assumptions makes it easier for the application of the critical thinking rubric. Figure 4 illustrates exactly the learning outcome of the activity, requiring students to perform an action to demonstrate their understanding of the game function.



DDMT 教學活動設計 DDMT Lesson Design

Title 活動名稱	CS2 week1 笛卡爾座標系					
Lesson Description 活動內容簡述	Objectives 活動目標:	S (Science)	平面定位觀念			
	1.平面位置，笛卡爾作標做標是利用 X 座標與 Y 座標形成。 2.學會使用讓英雄移動到特定座標的指令。 3.學會構築陷阱的指令。	T (Technology)	認識與學習移動與構築陷阱的 Python 程式語法。			
		E (Engineering)				
在本單元中，我們將會使用二維座標系的概念，控制英雄移動，其原理是將平面地圖上的格子，標上縱軸與橫軸，並標記原點(0,0)，如此來以數字表示地圖上的每個座標位置。		A (Arts)				
		M (Mathematics)	認識笛卡爾座標表示法。（X 座標與 Y 座標）			
	Duration of learning 活動時間:	1.5	Hours 小時	Targeted learners' Age 學習者年齡:	10歲	Years old 歲
	Background (Assumptions, previous conditions) 背景脈絡:	1.電腦硬體輸入設備如鍵盤、滑鼠之操作能力 2.英文字母識別與輸入能力，具備基礎 500 英語單字能力。 3.已了解 CS1 Python基礎語法觀念與規則				

Figure 3. Detailed Mapping of the curriculum to DDMT Model

	DDMT Learning Phases DDMT 學習階段	Context Awareness 情境覺察	Inquiry Process & Discussion 探究歷程&討論	Evidence of Learning 學習表現
Define 定義	• Problem Definition 定義問題 *Set a problem statement and hypothesis* 設定問題及假設	如何應用物件、方法及參數來做出最快速的破關方式。	編程中hero.moveDown()的意思為英雄向下移動一步，應該在何處加上數字，讓英雄一次可以移動多步？	請學生回答數字可以讓編程有什麼功能。

Figure 4. Clear Evidence of Learning

5 CONSIDERATIONS

STEAM Education is new and unchartered currently. Lecture-based teaching, multiple-choice and written tests, and providing projects in which all products “look the same” would be easier to implement in the classrooms [23]. In this research, educators identified 2 major challenges when using the DDMT Model to develop STEAM curricula: standards alignment and assessing critical thinking. While we have created the assessment for critical thinking in the digital portfolio, owing to a lack of time, it has not been implemented to students currently. We will be reviewing the effectiveness of the critical thinking rubrics and digital portfolio in another research.

6 CONCLUSIONS

Teaching Computer Science can be achieved using traditional instruction or convergent thinking but that would greatly diminish the students’ ability in developing critical thinking as all students would submit a similar answer to the problem. To allow divergent thinking, apart from repurposing the curriculum the curriculum, keeping abreast of instructional methodology is also very important as ‘we teach the same way we were taught’. To ensure the private afterschool educators continue to value-add, especially in the wake of changing outcomes of education, it is imperative that affordable and quality professional development workshop continues to be made available to these educators. Our hope is to impact educators with a sound understanding of STEAM Education to guide their instructional practices to improve Teaching & Learning and deeper learning. This way, regardless of private or public educators, education and economic ecosystems can continue to be sustainable.

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