Infusing Computational Thinking into the Accounting Curriculum – Framework and Perspectives

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***Abstract*—In the last two decades, computational thinking has been integrated into teaching of Engineering majors, Computer Science, and other science and engineering disciplines in universities. Computational Thinking plays a potential role in cultivating Accounting major students' ability to use technology to solve problems. To extend the application of computational thinking in the discipline other than science and engineering, this study proposes a theoretical framework and curriculum design for the computational thinking infusion in the curriculum of Accounting.**

Keywords-Computational Thinking (CT); Constructivism; Accounting; curriculum design; framework;

I. Introduction

Since Wing (2006) brings the term Computational Thinking (CT) to the forefront of the educational research field [1], more and more studies in K-12 education attain attention in teaching experience and strategic framework. Most of CT in higher education research appear in Computer Science and engineering discipline. Wing argued that CT is not only a skill useful to computer scientists, but to anybody who uses mental processes to solve problems and discover computational solutions. This view can prove to be the basis for interdisciplinary education integration and innovation. Computational thinking can be adopted as part of problem-solving skill in various disciplines and deserves more attention.

Accounting is a discipline that focuses on the data analysis while considering financial framework and political system. Accounting is a profession in which data and information processing, analysis, and reporting are critical components and accountants have a significant role to play in the data analytics [2][3]. Although accountants use of technology in data analytics is increasing, some of them still have their knowledge and understanding lagged the broader business community [4][5]. In higher education, the goal of professional Accounting training is to cultivate more proficient skills in data analysis under financial framework and be able to meet the financial needs of various potential stakeholders.

Due to the lack of revolutionary innovation brought up in Accounting subject domain, the curriculum design of Accounting in the past is severely lagging. Computational Thinking appears and helps accounting educators and students understand how to communicate with computers, what computers can do, and how computers can simplify complex tasks, which manual works cannot be replaced.

To elaborate the related terms, we can make it clearer that the tasks followed by computers are based on an algorithm, the thinking methods used by people are logical thinking, and the predictive results such effect are models. The bridge between computers and people is to transform abstract concepts of human society through decomposition and classification.

To facilitate development of CT in Finance and Economics discipline, this paper discusses a CT-based curriculum design framework and specific evaluation principles for constructing Financial and Accounting professional training courses.

II. BACKGROUND

Companies usually collect and use data to make decisions about consumer products, advertising, and effectiveness. The growing demand for graduates is for people with data analysis skills, and therefore students are required more data analysis guidance in the business degree programs. The Association to Advanced Collegiate Schools of Business (AACSB) has prompted scholars to urgently integrate data analysis teaching into existing curriculum due to such demands from the business community [6].

Meanwhile, some researchers have realized the relevance of Computer Science and Accounting. Cohn suggests that universities design accounting courses with a focus on data skills and foster interactions between accounting and computer fields [4]. Information technology skills and knowledge for accounting majors require universities to have separate AACSB accreditation to include content and learning objectives related to data analysis and information technology skills in the curriculum.

Accounting can be divided in financial accounting and management accounting. For management accounting, graduates need to determine the order quantity of the next batch based on the past orders and to determine the price of the order accordingly. This is the inventory management model in management accounting. On the other hand, the graduates of financial accounting are not only to prepare the balance sheet and income statement for the board of directors. They need to make a financing plan based on the current operating conditions and make a budget plan for the whole year based on past data and current economic indicators.

When Wing first defined Computational Thinking, she believed that "computational thinking is a way of considering the effective use of large amounts of data" [1]. After 4 years later, Cuny, Snyder and Wing further defined computational thinking as "the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent" [7]. To use its methods more accurately at different teaching levels, this definition should be more specific for professional work. Selby and Wollard proposed consensus terms based on literature review, including thought process, abstract and decomposition concepts [8]. Guzdial referred computational thinking as a way of thinking about computing [9].

Cultivating students to use computers as a tool and use computational thinking to solve practical problems from methods to skills and thinking processes will be the orientation of accounting school. The primary goal of paper is to provide guidance and framework regarding implementation of computational thinking into accounting curriculum.

III. COMPUTATIONAL THINKING FRAMEWORK OF FINANCIAL ACCOUNTING CURRICULUM

Dan Damelin, Lynn Stephens, and Namsoo Shin (2019) have developed a contextualized framework to integrate systems thinking (ST) and computational thinking (CT) [10]. They propose a framework from identifying problems to modeling analysis and adjustment to finally using models to explain phenomena and predict results. They claimed that the integrated framework has great support for the detailed curriculum design. Our team believes that this integrated systemic thinking is indeed helpful in the integration of curriculum design. However, we have also proposed a framework based on conceptual elements and are proposing our own course activity process idea.

According the characteristics of accounting and the above framework of computational thinking, the research team proposes a new theoretical framework for the integration of computational thinking into accounting courses. There are five components in the proposed framework: Identification, Abstraction, Decomposition, Algorithm, and Evaluation. First, it is important to have a clear understanding of learner situations and course designer's purpose on initial step:

(1) Identify the task: The course designer should set the learning goal and the difficulty level for learners who have different mastery levels. The learners should know what problems they can solve, and which data should be collected and processed.

(2) Identify circumstance set: The designer must give relevant regulations and original data sources to guide learners in collecting data and using tools to process data. The learners must be aware of the resources and tools as well as subsequent supplements. They should know how to use tool and what they can do.

In the Abstraction component, the designer must provide the formulation that transforms the event in real world into a specific vector. The learners must try to identify the elements and to find the connections between them so the problem can be solved correctly according to existing knowledge and experience.

The Decomposition component provides two ways for the decompositions: parallel decomposition and progressive decomposition. Parallel decomposition is adopted for the simple combination of knowledge components as such combination does not need to be decomposed layer by layer. It is suitable for simple tasks and introductory lectures at the beginner level. Progressive decomposition requires some logical thinking and the ability to reason and work backwards for objects are complex component blocks and cannot be obtained from simple splits for processing. It suits for the advanced level learning content and learners.

There are two elements in the Algorithm component: algorithm design and optimal path selection. Algorithm design is the use of mathematics, programming, or application software to calculate the outcome based on the decomposition of the components according to the mind flow – the outcome can be a combination or a direct result. Algorithms can be recursive and iterative, and it can process the data for different purposes like making a summary of the data and predicting results based on the given data. For the optimal path selection, it involves mostly of iterations. But it also needs to take dynamics of factors and conditions into consideration due to the instantaneous changes in economic activity – big data enables instantaneous nature of optimal path changes.

The first evaluation in the Evaluation component is the evaluation of the completion rate. The ratio between the results submitted by the learners and the expectations can be used as one of the bases for quantitative analysis. The ratio can also come the summative assessment, where the feedback from the learners can be used as a basis for future improvements. Another evaluation is the evaluation of efficiency, considering the time, efforts, and resources spent by learners as well as the results.

Accounting courses that apply computational thinking are primarily advanced practical courses or case-study course after learners mastering basic accounting and financial knowledge. The purpose is to present real-world problems in the classroom so that learners can experience the efficiency gains coming from incorporating problem-solving ideas, problem-solving paths with computational thinking skill.

The introduction of computational thinking is all about making efficiency gains, improvements in thinking stereotypes and the integration of innovative technology. The following principles need to be considered by the course designers when they begin to implement their blueprints.

- Basic ability: does the learner have sufficient computer knowledge and mastery of financial software and data analysis software?
- Tool support: can the original knowledge framework provide sufficient problem-solving elements?
- Clear Guidelines: how does the instructor ensure that the group or individual learners understand the required actions and the learning guidelines clearly?

IV.CT IN CURRICULUM DESIGN

This section explains applicable objects and specific strategies in applying CT in the design of Accounting courses. The constructivism concept of "experience-sharing-acquisition" can be used as a foundation for the design. Due to the time limit in class and the required mastery level of basic skills, it is difficult for freshmen to use case analysis and work on practical training courses. Therefore, accounting courses that can adopt computational thinking to solve problems in practice mainly are financial statement analysis, accounting costs of management accounting, inventory management, financial management practice and tax planning courses.

Recognizing the long-term and stage-specific nature of learning computational thinking skills, Kong (2016) proposes a specific strategy framework in his study of K-12 courses [11]. He argues the curriculum design strategies should focus on both the task difficulty and tools. The proposed framework can be useful in in-depth discussions of case studies and case studies based on the characteristics of accounting and finance courses in higher education. According to the learner's Computational Thinking skill level, the learning process could be set as three stages with three different level of goals – Basic, Mastery, and Creative. At Basic stage, learners have little or no computer knowledge and skill. At Mastery stage, learners have required knowledge to engage in case study and case-based heuristic education mode. They need to analyze and deconstruct problems independently and complete tasks under the premise of proficient use of software. At Creative stage, learners should use creative ideas as well as improve tools to help them enhance their performance as well as complete some complex problems – for instance, they may be capable of coding programs that automate some tasks.

In view of the different skill requirements and learner with different knowledge and skills at each stage, the research team categorizes the stages learning objectives and complexity of tasks and tools in the curriculum design, illustrate in Table 1.

TABLE I. COMPUTATIONAL THINKING SKILL GOAL

	Basic (Initial)	Mastery (Professional)	Creative (Advanced)
Tool	Competency of using software to complete tasks based on instructions	Set up the appropriate tool software under circumstance set	Coding programs to complete the work
Logical thinking	Inferences based on evidence	Heuristic Reasoning	The ability to develop and test hypotheses
Thought Process	Process the information and clarify the workflow	Formulating problems and their solutions	Ability to design algorithms and building model to solve problem

Taking the Practical Financial Analysis course as an example. Figures 4 to 5 illustrate the teaching strategies for learners with different computational thinking abilities at different stages. Adapting different learners by formulating teaching goals at different stages so learners' problem-solving skills can be improved. Computational thinking is incorporated in the process to enable learners to master the idea of problem-solving and the idea of using tools.

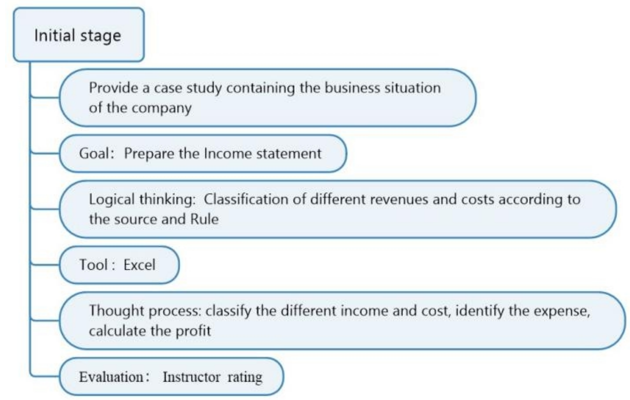

Fig.1. CT based curriculum design and strategies for Practical Financial Analysis at Basic (Initial) stage

At the Basic (Initial) stage, learners are considered to have no adequate problem-solving skills and do not master the use of problem-solving tools. The integration of computational thinking at this stage is designing of problem-solving paths, parallel decomposition of tasks, (e.g., division of income into operating and non-operating income) using tools (software) to perform the simple functions of problem solving with preliminary computational thinking skills.

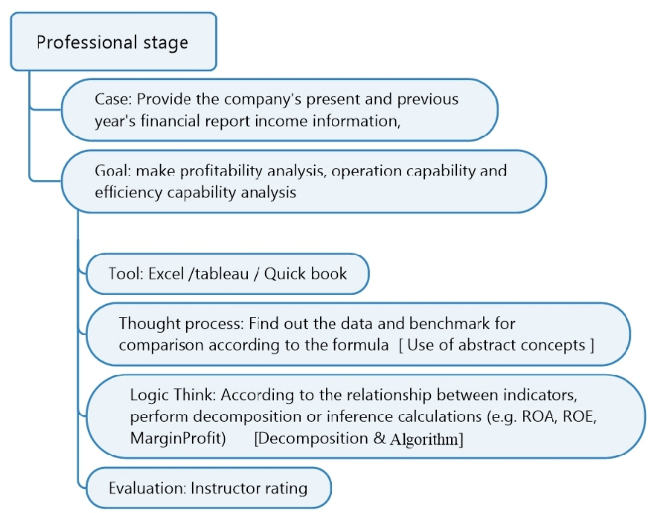

Fig.2. CT based curriculum design and strategies for Practical Financial Analysis at Mastery (Professional) stage

At the Mastery (Professional) stage, the learners are considered to have acquired a certain cognitive ability of knowledge. They can identify connections between knowledge points and grasp the skill in using tools to solve problems. The integration of computational thinking at this stage is understanding of formulas so they can use algorithms to solve problems. The use of tools at this stage is based on the acquisition of prior knowledge, so accounting software and data analysis software can be introduced into the thought process as an extension of algorithms.

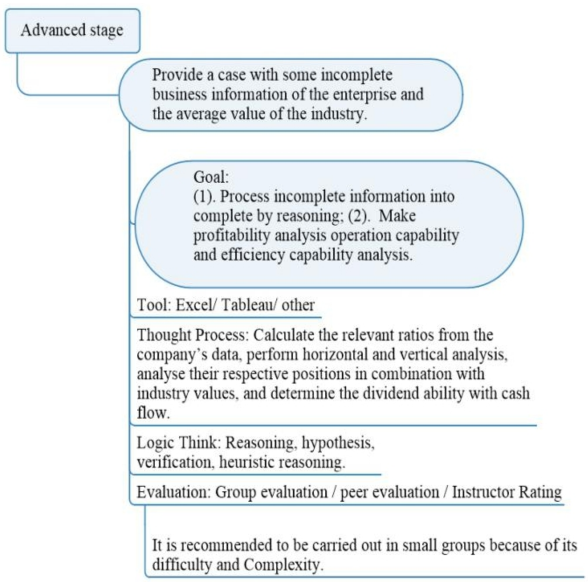

Fig. 3. CT based curriculum design and strategies for Practical Financial Analysis at Advanced stage

At the Creative (Advanced) stage, the learners are already capable of using known problem-solving tools proficiently and can complete tasks independently. The real-world problems are always different, have insufficient resources and powerful tools. Therefore, certain scenarios should be designed, and the tasks are slightly vague.

As the above example of 3-stage CT-based curriculum design in higher education shows, there is no extra or special class to explain the definition and connotation of Computational Thinking. On the other hand, only the course designer needs to have several important elements of computational thinking in mind and integrated them into the instructional model. Learners will be able to have some understandings of all the elements included in computational thinking in the problem-solving process.

V. Example

"Financial Statement Analysis" is a required professional course for students in Accounting program. Before taking this course, students must have basic knowledge of bookkeeping and accounting. Financial statement analysis systematically measures the effect of factors taken from the earning statements and determines their ability to predict future returns; subsequently, it ranks, sorts, and filters companies to create a portfolio with improved financial strength. The course aims to foster students' software analysis skills and chart visualization ability. This course is most suitable for using computational thinking teaching ideas and methods to make the course design more effective. Computational thinking used in different stages of ability development is not the same in terms of composition.

First at the initial stage, students need to cultivate the ability of basics like software use and formula judgment. For example, the course should have a **CASE** designed for analyzing a company's balance sheet and profit statement and ask students to calculate ROE (Return on Equity) and gross margin based on profitability indicators. The **GOAL** is to ask students to use the knowledge of the profit rate calculation formula with their **LOGICAL THINKING** via the related indicators correlation analysis. The case can be solved by software **TOOL** like Tableau and Excel. While they only need to substitute the data according to the formula to get the result, they need to make a clear chart for their **THOUGHT PROCESS** through the software to express the source and composition of the data.

This initial stage case still requires students to use of abstraction and simple algorithms in computational thinking to solve problems. Abstraction lies in the abstraction of formula expression and algorithms are simple formula derivations. The teacher needs to let students know the source and the meaning of the formula. The calculation of the formula is a simple algorithm. It makes students learn the relationships among the data and the other, and use the same process to deal with similar problems.

At the professional stage, the course will have real-world scene **CASE** designed. The students will receive the sales information of a company in different countries or different sectors. They will also see the data of the competitors. The **GOAL** is to have students deciding a reasonable price for sales to ensure the company's profit. Simple calculation formulas are no longer very useful here due to the profit is subject to unit sales price, quantity and cost.

They need to walk through the **THOUGHT PROCESS** and follow the **LOGICAL THINKING** with their computational thinking skills. First, how to ensure profits? They need to look at the reports of competitors. From the competitors' profit margins, they can calculate the approximate product unit profits for the competitors. They can then estimate the sales scale changes brought by the price changes from the product sales elasticity. At this stage, the four computational thinking skills are involved, namely abstraction, decomposition, thinking process, and algorithm.

Students need to decompose the sales quantity and unit price from a predetermined profit [decomposition] and link profits with relevant influencing factors and express them with formulas [abstraction]. Students also have to infer the sales and profit margins from competitors' financial statements and to investigate the break-even point prices [thinking process]. At the end, the students can calculate the price of guaranteed sales by iterative method for preparation when the competitors decide to go for a price war [algorithm]. The final outcome of this case for teacher to evaluate will the product price positioning table for different conditions. Students can use **TOOL**s like Excel, R, and other open-source tools to creating such table.

At the advanced stage, the course can give students the real-world scene **CASE** with the company's price positioning and sales management in a virtual world. Since there are competitors in the virtual world, the **GOAL**s for students to do is to determine is the profitability of the company and the price positioning under competition, as well as the management of goods turnover and cash flow.

Similarly, students need to walk through the **THOUGHT PROCESS** and follow the **LOGICAL THINKING** with their computational thinking skills as Figure 4 shows. First, students need to draw the mind map of different financial indicators and find suitable calculation tools to deal with the problems [thinking process]. Second, they need to split the problem into small pieces one by one [decomposition]. Then the students must investigate and search for proper and correspondent knowledge points for solving a decomposed problem. With the found processing methods, students need to use right calculation tools to help them solve the decomposed problem.

The thinking process of such advanced stage case includes analysis of profitability, turnover rate, cash flow management and price setting under different competitive environments. The outcome of this case will be a complete report that combines all various data obtained in the virtual world. Due to the nature of the difficulty, complexity and heavy workload the advanced stage cases have, in general speaking, small group formed for solving the cases is recommended.

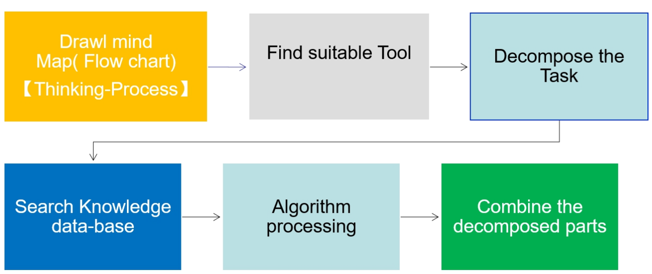

Fig. 4. The advanced stage

VI. Conclusion & Discussion

The interdisciplinary use of computational thinking in higher education is an issue that is worth exploring. In the past decade, a considerable amount of research has been conducted on the pedagogical methods of K-12. However, it is still necessary for a college freshman to understand the substance of computational thinking, whether they have ever heard of Computational Thinking before.

This research's objective is to integrate computational thinking in the accounting courses. The research team proposes a framework for the use of computational thinking in accounting curriculum and identify important elements to be used. Meanwhile, the teaching design strategies for different stages in Non-Scientific Majors are explained. The use of computational thinking does not require students to memorize concepts and knowledge. Rather, let them take the problem-solving process, methods, and steps as schema in mind to help them when they encounter similar real-world problems in the future.

In practice, the research team acknowledges the inadequacy of the theoretical framework and design, such as (1) the duration of each stage of the cycle, (2) how to make the software proficient for students who do not have basic knowledge, and (3) how to design the assignments in a more attractive to students. All of these require more pedagogical practice in the future.

The research team also recognizes that the difficulty in facilitating the integration of computational thinking in universities lies in the perceptions of teachers and their own computational thinking skills. As instruction and course designers, they need to be clear about the role that the various elements of computational thinking play in solving problems in their discipline and understand how they can be used in the classroom or in cases study activity.

What is to be expected in the future is for more disciplines that can bring the computational thinking into their courses, so their students can benefit from the CT integration.

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