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An Analysis of K-12 Artificial Intelligence Curricula in Eight Countries

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Abstract: Against the backdrop of increasing attention to the importance of infusing Artificial Intelligence (AI) knowledge and skills into K-12 education, there is an urging need to have a comprehensive understanding of the existing AI curricula designed and implemented in different countries. The present work aims to examine and compare the AI curricula in eight countries (including the United States, Finland, Australia, Singapore, India, China, South Korea, and the United Kingdom). An analytical framework has been developed to instrumentally analyze and identify the common and unique features among these countries. Through the thematic analysis, we have constructed a number of theme-based discussions on these curricula. The findings can provide the field with new insights into AI curriculum development and the corresponding curricular practices.

Keywords: AI curriculum, comparative analysis, thematic analysis

1. Introduction

As Artificial Intelligence (AI) technology is pervasively influencing and gradually reshaping our lives (Zhai et al., 2021), it is imperative for K-12 students to understand and use the technology with an awareness of its benefits and risks (Webb et al., 2017). Motivation and engagement are always two paramount elements in the course of learning and teaching (Jong et al., 2006, 2008, 2014, 2018); equipping students' AI knowledge and literacy can better motivate and engage them in participating in activities pertaining to computational thinking education and STEM education which are both important educational initiatives in this decade (e.g., Chai et al., 2020; Geng et al., 2019; So et al., 2020). On the other hand, the need for AI professionals in the development of technological enterprise calls for more AI talents to close the gap in the workforce in the technology sector (UNESCO, 2019). The trend of teaching young people to learn AI has been on the rise in recent years (Dai et al., 2020: Knox, 2020). Many countries are developing national guidelines for AI curricula and learning resources to integrate topics about AI into K-12 classrooms (Eguchi, Okada & Muto, 2021). Nonetheless, discussions in the academic literature are actively centered on AI education carried out at universities with a well-established curriculum. In-depth discourse on what to teach how to organize a K-12 AI curriculum receives little attention from AI education literature (Lin et al., 2021). To address this gap, this work aims to review and analyze the current AI curricula of eight countries worldwide. These eight countries include the United States, Finland, Australia, Singapore, India, China, South Korea, and the United Kingdom. These eight countries were selected because they have developed relatively comprehensive curriculum guidelines with illustrative lessons. This study compares the existing curriculum guide and reports the key features of these curricula.

2. Literature Review

2.1 Curriculum Development Theories

The landscape of curriculum development models shows that the approaches of curriculum development vary broadly from product-focused to process-focused Model (Hunkins & Ornstein, 2016;

Neary, 2002). The product-focused approach emphasizes the technical-scientific perspective for the development of logical, efficient, and effective delivery of content. Tyler Rationale (1949) is one such approach. The process-focused approach is oriented with the non-Technical perspective, which is shown as subjective, personal and aesthetic. One example of the process-focused approach is Wheeler's Model with the focus on the role of learners (Hunkins & Ornstein, 2016).

There are several important models providing basic insights into curriculum development including Tyler Rationale (Tyler, 1949), Hilda Taba induction model (1963), Wheeler circular model (1974), Galen Saylor and William Alexander (1974) and Oliva (2005), etc. Tyler Rationale states four basic principles which need to be followed in a sequence. These four basic principles encompass: defining the purpose of the school, selecting related educational experience, organizing related educational experience, and evaluating the objectives. Tyler Rationale uses a logical and sequential approach to develop curriculum and it has been criticized as being a linear model. It may limit the sustainability and fluidity of curriculum development (Bhuttah et al., 2019). In consideration of this, Wheeler (1974) developed a cyclical model showing that evaluation is not the final stage of curriculum development but a source of improvement in objective and other stages of the curriculum system by introducing the concept of continuity. Wheeler's Model (Figure 1) includes five interconnected phases: aims, goals and objectives, learning experience, selection of content, organization and integration of learning experiences and content, and evaluation. The completion of one cycle initiates the next cycle of refinement with data gathered from the first cycle as the foundation for iterative design and development. Accordingly, Wheeler provided a model that is more flexible and dynamic in the curriculum development process compared with Tyler Rationale. It is a model that promotes the continued improvement of the curriculum by incorporating new information.

Figure 1. Wheeler's Model of curriculum development

2.2 National Curriculum Frameworks

A national curriculum framework document generally includes the following ten components: a rationale or platform, scope and parameters of the curriculum area, broad goals and purposes of subjects within the curriculum area, guidelines for course design, content, teaching and learning principles, guidelines for evaluation of subjects, criteria for accreditation and certification of subjects, and future developments for the area (Hardy,1990). Hardy (1990) argues that the rationale or platform for a curriculum framework is of major importance as it provides a statement of the values, principles, and assumptions for the design of a national curriculum framework. According to the International Bureau of Education (UNESCO, 2015), there is a prototype of national curriculum framework organized around eleven components: introduction, curriculum vision, aims and objectives, values and principles, philosophy of teaching and learning, curriculum architecture, the importance of competency, areas of learning, teaching methodology and strategies, assessment, and monitoring and evaluation. Drawing upon these elements to synthesize a more refined national curriculum framework, five criteria have been elaborated to be applied for national curriculum analysis: rationale (includes part of 'introduction',

'curriculum vision', 'aims and objectives', and 'values and principles'), scope and component of the curriculum framework (includes part of 'introduction' and 'curriculum architecture'), curriculum approaches (includes 'importance of competency' and 'area of learning'), teaching and learning methodology (includes 'philosophy of teaching and learning' and 'teaching methodology and strategies'), and assessment (includes 'assessment' and 'monitoring and evaluation'). This national curriculum framework can be used to review, compare and analyze the curriculum of various countries around the world comprehensively.

3. Methodology

3.1 Analytic Framework

Reviewing previous literature enables the researcher to develop and propose an analytic framework from both the national level and curriculum level, attempting to attain a comprehensive perspective by covering all the aspects of the curriculum development process.

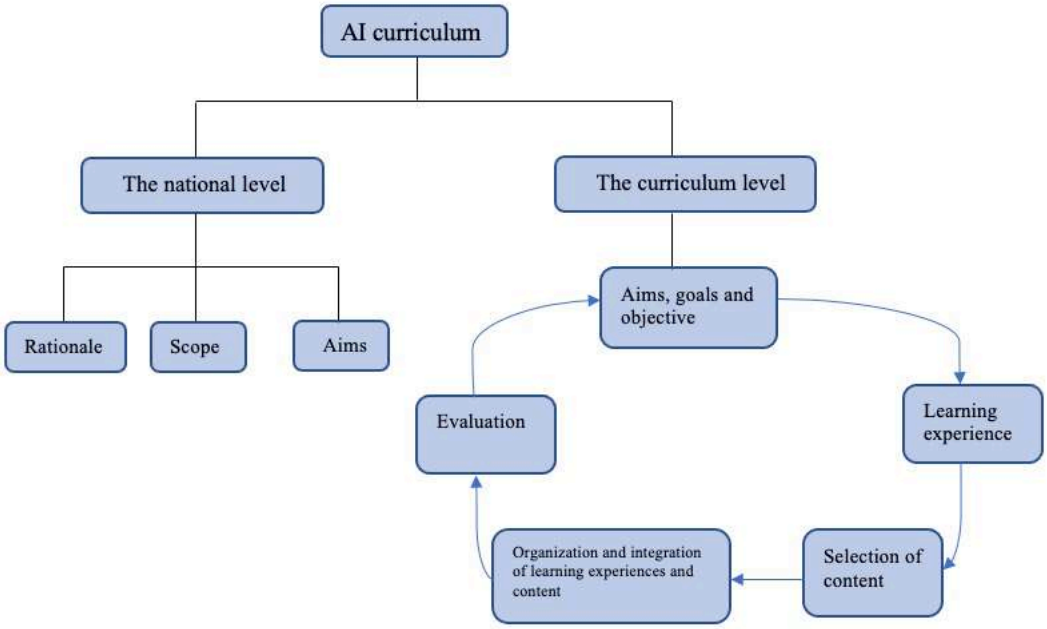

Figure 2. The analytic framework applied in this research

3.2 Data Analysis

The process of data analysis includes the qualitative part and the quantitative part. The qualitative part of data analysis is presented in three phases. First, to attain an understanding of the AI curriculum on the national level, the researcher examines curriculum documents across countries and analyzes authoritative curricular policies and proposals. Based on nation curriculum frameworks stated in previous literature, three elements are emerging from national policy data via scanning the curriculum documents: rationale, scope, and aims. These components serve as one dimension of comparison for the study. Following this, all eight countries are examined more closely using Wheeler's Model to form a second dimension. These two stages use comparative analysis and help in obtaining a general understanding of the different curricula and identifying both common and unique features of these different curricula. Based on the first two phases, a basic organization and analysis of original data have been formed and then, a series of theme-based discussions will be elicited through thematic analysis in the third phase. Firstly, open coding was conducted to generate an initial idea about the features of codes and organize data into meaningful groups (Tuckett, 2005). Next, a focused coding was moved on to refocus the long list of the different codes, sort the different codes into potential themes and collate all the relevant coded data extracts within the overarching themes. Finally, reviewing these themes to check

whether they appear to form a coherent pattern and define the themes presented in the following analysis. In essence, the coding process was more recursive where movement is back and forth, rather than linear from one phase to the next (Dai, Lu & Liu, 2019). Reading original data, comparing multiple codes and refining identified themes are cycled and developed over time. For the quantitative part of data analysis, a scale consisting of these elements from the national level and the curriculum level will be designed and provided to measure the score of AI curricula around these eight countries. Both the results of qualitative part and the quantitative part of data analysis will be checked and examined between the experts of the AI education area.

4. Preliminary Findings

This research selects eight countries, namely the United States, Finland, Australia, Singapore, India, China, South Korea, and the United Kingdom to conduct a comprehensive analysis to understand the differences and similarities between their AI curricula and capture emerging AI curriculum trends. To achieve this goal, an analytic framework is developed as an instrument for the researcher to observe, review and probe the curricula of eight countries. In this sector, one example of the AI curriculum in Australia is shown as an attempt to employ this analytic framework to conduct the analysis work.

Table 1. *The First Phase: The National AI Curriculum of Australia*

	Rationale	Scope	Amis
Australia	The curriculum is based upon the rationale that the technologies curriculum provides students with opportunities to develop capacity for action and a critical appreciation of the processes through which technologies are developed and how technologies can contribute to societies	Designing technologies curriculum in each year levels (Foundation to year 2; years 3 and 4; years 5 and 6; years 7 and 8; years 9 and 10) as two subjects: Design and Technologies and Digital Technologies	Aims include the development of knowledge (technology concepts), understanding (ethical use of technologies), and skills (creativity, collaborative ability and so on)

Table 2. *The Second Phase: The AI Curriculum Development Model of Australia*

The AI curriculum development model of Australia	
Aims, goals and objectives	understanding core concepts and to develop solutions using these concepts
Learning experience	experimental and ethical experiences
Selection of content	machine learning algorithms
Organization and integration of learning experiences and content	Using unplugged activities to connect learning experience with content knowledge
evaluation	Combining formative assessments with summative assessments

The first and second phases of analysis of the AI curriculum in Australia provide the basis for the third phase of emerging discussions. One of the emerging discussions is stated as there is a gap between nationwide curriculum guidelines and AI curriculum lessons. AI curriculum practice lacks the focus on how to develop the students' ability to understand AI knowledge and operate AI applications which are emphasized in the national AI curriculum guideline.

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