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RESEARCH PAPER

A Recursive Constructive Alignment Curriculum Development Model

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ABSTRACT

This paper presents a revised curriculum model with a flexible structure enabling academic instructions to equip graduates with the knowledge, skills, competencies, expertise, dispositions, and values in line with today's global knowledge-driven society. Recursive constructive alignment along with some new meta-processes has made the model more flexible, open, and recursive. It is believed that the new technology integration meta-process will allow educational institutions to extend the reach of their teaching-learning process beyond conventional classroom environments for their students' overall development and institutional branding essential to survive in today's competitive world.

Introduction

Curriculum as a tool to increase student academic rigor and academic achievement has always been a subject of great concern among researchers, educationists, and policymakers. It has been viewed differently by different scholars. For example, Grundy (1987) sees the curriculum as a set of organized human cultural, and social construction practices. Smith & Ragan (2005) describes the curriculum as classroom practices for the achievement of certain objectives, including communication of information, student-teacher interaction, classroom activities, etc. However, the significance, relevance, and usefulness of curriculum contents are considered to be essential components of an effective curriculum. Several curriculum models have been proposed in the literature to enhance student skills, academic achievement, and intellectual control, including Tyler (1949), Taba(1962), Wheeler(1967), Walker(1971), Biggs (1996), Bell &Lefoe(1998), Parker(2003), Smith & Ragan (2005); Pasha & Pasha (2012).

As a common practice, curriculum development focuses on the identification of the content knowledge, pedagogical practices, threshold standards. However, the review of the literature reveals that the prevailing curriculum models fail to meet the demands of todays needs (Plate, 2012).

Computing Education: As a Case Study

Computing education is a dynamic and rapidly expanding field. Time-to-time, national and international bodies from the computing domain provide guidelines for standardizing computing education (ACM/IEEE, 2001; ACM/IEEE-CS, 2012; ACM/IEEE, 2016; ACM/IEEE, 2017).Usually, these curricula are developed following the Tyler (1949) performance-based model, which is highly structured, systematic, and follows rationality rules: predictability, methodological, quantifiability, non-biased, and scientific (Dennis, 2002).

Tyler's (1949) model is considered effective in public education (Hussey & Smith, 2008; O'Neill, 2010). However, its linear nature of sequence order, pre-set objectives, pre-selected contents, and target-oriented assessment have made it inconsistent with today's educational requirements (Doll, 1993; Knight, 2001; Pasha & Pasha, 2012).

The computing domain is rapidly expanding. This rapidly evolving nature, along with the changing needs of today's technology-driven society, calls for an effective but generic curriculum that could embrace rapidly emerging new fields of computing (ACM/IEEE-CS, 2012). This paper presents a revised version of the Pasha & Pasha (2012)curriculum development model to address such research issues.

An Overview of Computing Disciplines

From its inception, computing education has been confronted with the challenge of continuous evolution. The availability of personal computers in general public reach revolutionized the usage of computers. Personal computers and the Internet appear to beessential tools (Kotkin, 2000). The growing use of computers in every aspect of human life has brought many innovations in communication and computing technologies and has led to a paradigm shift from data processing to information processing (Thomson, 2007); possesses new challenges(Samuelson, 1999, Cohen, 2002).

Nowadays, computing is used in every aspect of human society, ranging from trade, commerce, pharmacy, medical, physical systems, security, defense, education, social networking, etc. Many significant developments have been made in recent years, introducing new concepts such as Computational Lens (Karp, 2011), ternary computing (Li, 2010), etc. Besides, the application of computing in multiple domainsintroduces new disciplines; making curriculum development a daunting challenge (ACM/IEEE, 2012).

Curriculum Development Models

Curriculum development has always been an important research agenda for both school and higher education Pasha & Pasha (2012). Several issues have been identified from stockholders, including lack of coherence, practicality, openness, quality, integrity, overload, lack of skills development, and the disengagement of graduates from civic life (HEC, 2012; UNESCO, 2012;Tatlah,2014; Kerr &Blenkinsop, 2005). Many deliberations have been reported to make the curriculum more robust, relevant, and effective. The latest research has identified three key areas that can increase the effectiveness of curriculum: Instructional methods, Curriculum coherence & integration, and Evaluation & assessment. The integration of the latest research findings can also make the curriculum more rigorous and coherent for students' learning. For example, following constructivist learning theory (Bruner, Goodnow, & Austin, 1956) and instructional design (Seels & Glasgow, 1990), Biggs' (1996) proposed constructive alignment. Constructive alignment substitutes students' learning with students' attainment (Biggs, 2002). The key idea of conventional instructional alignment is based on a precise match between contents, evaluation, learning outcomes (Talbot, 2004). Whereas, constructive alignment stresses students' level of understanding rather than students' rote learning. Similarly, Eisner (1991) suggested the integration of behavioral principles with aesthetic components in curriculum development.

Over the last few years, many researchers have proposed new ideas, including inclusive curriculum, McCombs &Whisler's (1997) subject-centered and learner-centered curriculum, Bruner's (1996) spiral curriculum, Parker's (2003) transformational curriculum, etc. However, for making the curriculum more effective, Tinkler, et.al. (1996) urge to integrate new means of information communication. Mitchell & Bluer (1997) demand more flexibility in curriculum to cater to a wider range of students' bodies. Bell &Lefoe (1998) suggest the delivery of content through appropriate media.

This literature review reveals that curriculum development is still a topic of great interest; especially, human aspects (Ornstein and Hunkins, 2009).Evolving nature of computing demands a fluid& flexible curriculum which allows us to embrace the latest research findings and the latest development of the computing domain(Tatlah,2015).

The Revised Curriculum Development Model

The model discussed in this paper is a revised form of curriculum model proposed in Pasha & Pasha (2012). The revised curriculum model has adopted a recursive revision approach with constructive alignment. The revised version of this model has eight meta-processes interconnected with a bidirectional communication channel: i) intension and objective identification, ii) standard formulation, iii) Body of knowledge construction, iv) Curriculum mapping and fine-tuning, v) curriculum execution, vi) curriculum auditing, and vii) curriculum revision, viii) technology integration. It is believed that the integration of three new meta-process (intension and objective identification, curriculum revision, and technology integration) will make this model more dynamic and flexible. These new meta-processes are design to align pedagogical contents, activities, and assessment strategies according to the ever-increasing demands of the employment market. The curriculum revision meta-process of the revised model will help improve the curriculum for strengthening students' academic rigor, skills, competencies, dispositions, and values. Ultimately, helping to produce well-rounded computing graduates ready to work more holistically in the employment market.

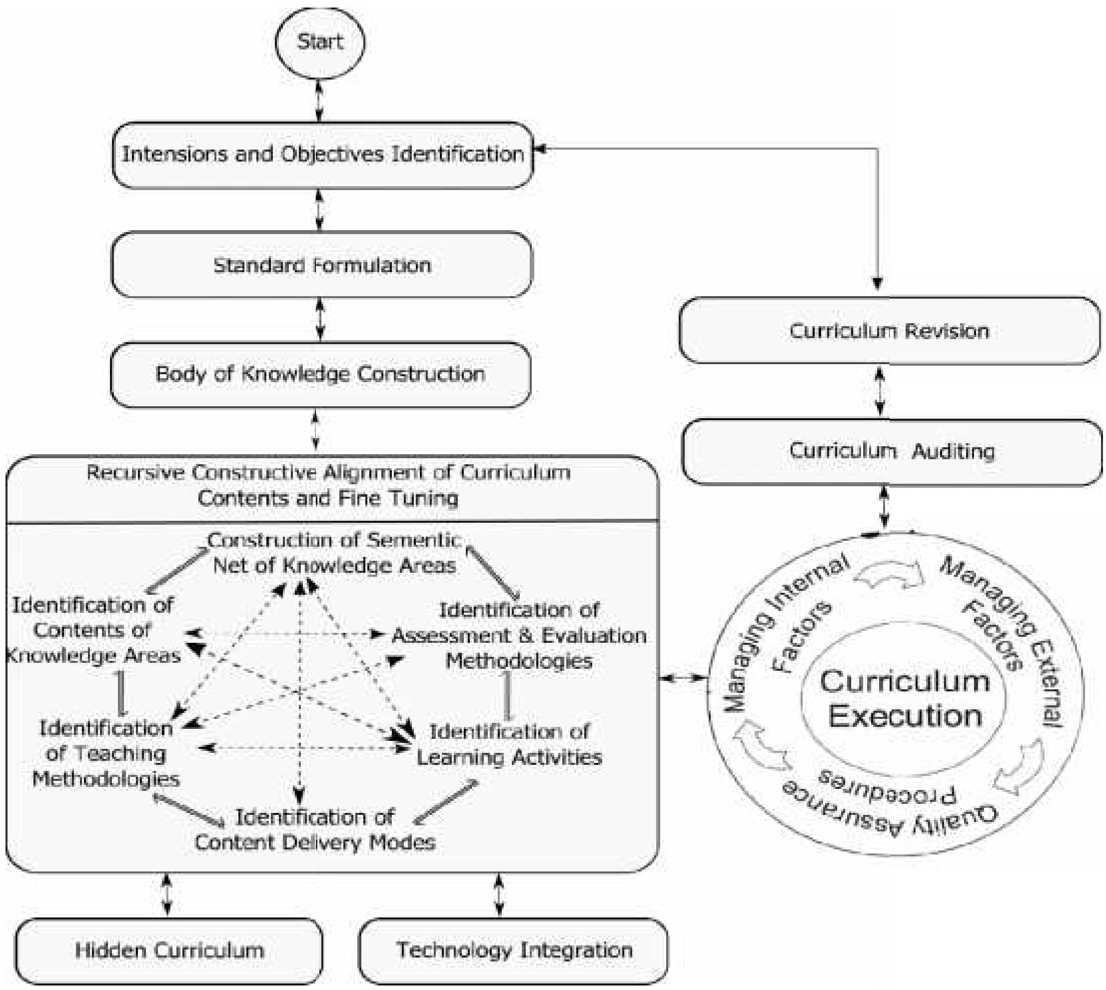

Figure 1: Revised Curriculum Development Model

The revised model is shown in Figure 1 on the following key principles. The curriculum

- Allows to adopt inter-disciplinary, multi-disciplinary, and trans-disciplinary approaches to accommodate future needs;
- identifies the fundamental, supporting, core, and advanced knowledge areas;
- identify the knowledge areas to become independent courses;
- allows to integrate branding and specializations; and
- allows integrating practical and hands-on learning experience.

The model, shown in Figure1, has seven core meta-processes interconnected through bi-directional communication channel: i)Intension and objective identification, ii) standard formulation, iii) Body of knowledge construction, iv)Constructive Alignment of Curriculum Contents and fine-tuning, v) curriculum execution, vi) curriculum auditing, and vii) curriculum revision, viii) technology integration. A recursive approach is suggested for the implementation of these processes. These meta-processes contain many sub-processes responsible for different tasks. Key meta-processes are briefed below:

1. **Intensions and Objectives Identification:** This meta-process is aimed to achieve two goals: (i) identification of the learning objectives focusing on national needs, employment market tendencies, future trends, and the society's expectations about students' characteristics. (ii) identification of key intension behind setting these learning objectives.

2. **Standards Formulation**. This process is aimed to formulate learning standards, in line with national and international standards, based on the following six sub-processes:

    i. Identification *of Knowledge*–of theoretical concepts and principles.

    ii. Identification of skills related to the learned knowledge.

    iii. Identification of required abilities, performance, competencies, and expertise.

    iv. Identification of dispositions/tendencies to respond to the in-hand situation.

    v. Identification of soft skills, professional practices, and values.

3. **Body of Knowledge Construction**. This meta-process identifies the terms and concepts of key knowledge domains, sub-domains, and associated fields.

4. **Recursive Constructive Alignment of Curriculum Contents and Fine Tuning.** This meta-process is based on Bigg's constructive alignment. The process consists of the following sub-processes:

    - Construction of Semantic net of knowledge areas.
    - Identification of contents of knowledge areas.
    - Identification of teaching methodologies.
    - Identification of thedelivery modes,
    - Identification of learning activities,
    - Identification of appraisal strategies. The meta-process deals with assessment and evaluation and addresses: a) students' conceptual understanding. b) Students' academic achievement because of their activity limitations and participation restrictions, c) Teachers' attitude and cooperation, d) administrative support, and e) Accountability.

The sub-process of construction of semantic net of required targets of both formal and hidden curriculum. It will address the following key areas:

- Inter-disciplinary general education and foundation elective courses
- Core compulsory courses
- Multi-disciplinary elective courses
- Trans-disciplinary courses
- Major/Specialization elective Courses
- Fieldwork/Project

The inter-disciplinary general education, foundation elective, multi-disciplinary elective, and trans-disciplinary elective courses are introduced to build solid foundations for studying advanced courses. The proposed model suggests a small common core for all computing degree programs encompassing the essential knowledge areas of the domain.

The hidden curriculum deals with areas related to desired social, moral, ethical, professional practices, values, and dispositions and would be embedded within the formal curriculum through classroom activities, curriculum and co-curriculum activities, and social relationships.

Recursion and fine-tuning are the most crucial aspects of this meta-process. These are shown through dotted arrow lines in Figure 1. Normally, a curriculum is designed for at least two to three years. It seems quite difficult to predict the emerging requirements and the latest development in the field within this period. Recursion and fine-tuning enable instructors to integrate their experience, feedback from stakeholders, and the latest developments in the field. This feature makes this model more flexible and open.

5. **Curriculum Execution.** The contents identified in the curriculum mapping and fine-tuning meta-process are delivered through this meta-process. It associated sub-processes are: i) Handling external factors, including socio-economic conditions, ideological, religious, and cultural aspects, pressure groups, legal constraints, and government policies, etc. ii) Handling internal factors, including, available provisions, teachers' professional practices, students' attitude, learning environment, organizational policies, financial constraints, etc., and iii) Quality management.

6. **Curriculum Auditing.** It involves the auditing of the curriculum including goals, visions, objectives, control, connectivity & equity, contents, pedagogy, assessment, administration, relevancy, etc.

7. **Curriculum Revision**. This process ensures the effectiveness of the curriculum through revising the curriculum revisiting the prosed meta-processes recursively.

8. **Technology Integration**. The advancements of information technologies, particularly the Internet and socializing, technologies have revolutionized the pedagogical aspects of the teaching-learning environment. Search engines, social networking, computer games, and other online services have emerged as a significant element of young people's routine life (Kotkin, 2000). This global change demands innovative practices to utilize these sophisticated technologies for promoting cooperative learning, implementing differentiated curriculum strategies, and applying diverse instructional practices through exchanging information in a wide variety of forms. This meta-process identifies teachers' and students' technical skills and means of technology integration to strengthen their communication and knowledge management skills.

It is important to mention that all meta-processes including sub-processes have a bi-directional inter-process communication channel. All feed-back messages and suggestions can be accommodated to make the curriculum more effective according to the emerging trends and needs of the market and society.

Conclusion &Recommendations

Computing has become a mature discipline. However, the high paces of knowledge exploration, the emergence of new technologies, and the appearance of new application domains have introduced new challenges to academia offering computing degree programs. It has been argued that the product curriculum development model is not suitable for meeting the emerging needs in computing education.

Today's rapidly evolving society along with technology-driven emerging knowledge economies has introduced new dimensions in human society. For example, science and technology bonding has become stronger, lifelong learning has become an important element of job security, intellectual capital has become more valuable than fixed capital (Drucker, 2006). Intangible assets, knowledge workers, technology, and innovation have become key pillars of economic growth and competitiveness (Kogut& Zander, 1992; Nonaka& Takeuchi, 1995; Zítek & Klímová, 2011). Hence, the curriculum of any degree program must prepare students to face the challenges of today's complex workplaces. Pasha & Pasha (2012) have argued that in today's competitive world graduates cannot just depend on academic knowledge. Their competencies, expertise, disposition, and values will determine their job security. Therefore, a curriculum must target to produce graduates equipped with: up-to-date knowledge; marketable skills; valuable competencies; unique expertise; globally compatible dispositions; and culturally and professionally acceptable values Pasha & Pasha (2012).

In this paper, we have presented a revised version of the curriculum model proposed in Pasha & Pasha (2012). It has been noticed that the adoption of a proactive approach and integration of competencies, expertise, and dispositions among threshold standards would be more practical to extend the reach of the teaching-learning environment beyond the conventional classrooms. The integration of competencies and expertise within the curriculum can also help educational institutions to produce a plug-n-play workforce. However, the growing competition and ever-increasing innovation of new technologies have identified an element of rigidity in the Pasha & Pasha (2012) curriculum model. Therefore, a revised curriculum model has been presented in his paper.

The revised curriculum model has adopted a recursive revision approach with a constructive alignment. The revised version has eight meta-processes: i) intension and objective identification, ii) standard formulation, iii) construction of Body of knowledge, iv) Curriculum contents mapping and fine-tuning, v) curriculum execution, vi) curriculum auditing, and vii) curriculum revision, viii) technology integration. It is believed that the integration of three new meta-process intension and objective identification, curriculum revision, and technology integration) will make this model more dynamic and flexible to accommodate stakeholders' feedback. These new meta-processes will also allow curriculum developers to align knowledge contents, teaching-learning activities, and assessment and evaluation methodologies according to the ever-increasing demands of the employment market.

The integration of these new meta-processes in the revised model and adoption of inter-disciplinary, multi-disciplinary, and trans-disciplinary approaches are based on the realization of the emerging challenges of forthcoming expansion of knowledge domains. It is believed that the revised model will allow institutions to offer different degree programs for the employment market. The meta-process technology integration' will allow the establishment of seamless communication channels for knowledge exchange. It will also help both teachers and students to strengthen their collaborative learning and collaborative development skills. Nowadays, employers give more preference to soft skills than hard skills. The model allows the integration of the desired soft skill as a part of the hidden curriculum. Unfortunately, the existing curriculum model has overlooked this important aspect and only target educational goals progression (Margolis, 2001). Teaching soft skills, professional practices, personal and social attributes, etc. through hidden curriculum makes the revised model more flexible and open. The flexible nature of the revised model allows institutions to produce their own branded graduates (Brunzel, 2007) to differentiate themselves in today's crowded and competitive employment market.

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