A Framework for Designing Information Technology Programmes using ACM/IEEE Curriculum Guidelines

O.D. Adegbehingbe, S.D. Eyono Obono

***Abstract* - The aim of this paper is to present a framework for the design of Information Technology (IT) curriculum programmes. This aim is achieved by identifying key models for curriculum design in general. The identification of these models was the result of a systematic literature review of existing work on designing and renewing curricula in various disciplines. The main result of this paper was obtained by merging the above mentioned curriculum models, and by incorporating ACM/IEEE-IT curriculum guidelines into the merged model. The resulting model includes the following six key phases for IT curriculum design: Information Collection, Goal Identification, Design, Model Testing, Implementation, and Evaluation. These key phases were finally designed in terms of the core aspects of ACM/IEEE-IT curriculum guidelines, the various options presented by these guidelines, and their ability to be customized. The novelty of this study can be credited to its use of systematic review of existing literature to achieve its aim.**

***Index Terms*— Information Technology, ACM/IEEE-IT, Education, Curriculum**

I. INTRODUCTION

Information technology (IT) education is constantly challenged by rapid technological and economical changes [1]. Hence, IT educators always need to build effective and dynamic curricula as a blueprint for providing direction for student progress in the quest to mould efficient and versatile IT graduates. Furthermore, IT is a discipline that transcends various fields and it is used in different aspects of life such as health, economy, and education. Therefore, IT graduates need to be prepared for various challenges, including working in different organizational domains and providing solutions to a range of IT problems [2]. These challenges can be surmounted by viable curriculum models able to equip IT students with the necessary technical and generic skills [3] [4].

In order to address the challenges of these issues, efforts have been made in various fields to build viable curriculum models that helps graduates keep in line with technological innovations [3][4].

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II. PROBLEM STATEMENT

Existing literature depict educational institutions as being seriously challenged with regard to curriculum design and renewal [5]. For example, IT educators are faced with the challenge of adapting ACM/IEEE curriculum model to the technical, cultural and natural environment of their institutions [6], and to the different circumstances, characteristics, and needs of their immediate society [7]. Nevertheless, it is important to lessen educators' difficulty of designing a viable curriculum. This can be achieved by developing a framework that shows the important phases of IT curriculum design.

III. RESEARCH AIM

The aim of this study is to develop a framework for designing sound IT curricula by answering the following research questions: 1) what are the major steps in the design of an IT curriculum? 2) How can the ACM/ IEEE – IT 2008 guidelines be effectively used by IT curriculum designers?

3) How do the core, optional and customizable aspects fit into the major phases of designing an IT curriculum? The use of ACM/IEEE–IT in this research is justified by its global status as the standard for the design of IT curricula.

IV. LITERATURE REVIEW

The aim of this section is to provide an overview of existing literature on the design of IT curriculum [1][2][5][8][9]. [2] proposes a two phase model that can be useful in building versatile IT graduates. Phase one of the model proposed by [2] encompasses the formulation of the program mission, a statement of how does the program meet the requirement of accreditation bodies, the definition of the program career goals, and the removal of inconsistencies and contradictions from the program. Phase two of the model focuses on the design of the foundational and courses. Furthermore, [2] asserts that IT professionals should possess both technical abilities in IT and technical expertise in other domains. This is in line with [5] which emphasize that curriculum models need to include technical and generic skills that will enable graduates to function efficiently in different work situations.

ISBN: 978-988-19251-6-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

On the other hand, [1] propose a model consisting of four phases: collect, evaluate, design and implement. [1] also highlight the necessity of building continuous processes to support curriculum activities.

Finally, [1][8][9] insist on the need for education stakeholders such as students, industry, professional bodies, government, alumni, accreditation bodies and employers to be involved in curriculum design especially when developing the learning outcomes of the program.

V. RESEARCH DESIGN

The strategy adopted by this paper is to identify key models for curriculum design in general. The identification of these models was the result of a systematic literature review of existing work on designing and renewing curricula in various disciplines [10]. The main result of this paper was obtained by merging the above mentioned curriculum models, and by incorporating ACM/IEEE-IT curriculum guidelines into the merged model. The main hypothesis behind this approach is that general curriculum renewal steps are also applicable to the field of computing. According to [10], the following steps are recommended for a systematic literature review: formulation of the main review question, definition of the review selection criteria, and the definition of the quality of the criteria for the review selection.

A. Review Question

The systematic literature review conducted by this study was guided by the following main review question: what are key phases of a curriculum renewal project?

B. Study Selection Criteria

Firstly, studies were included if they were focusing on curriculum design or renewal. Secondly, they had to include curriculum renewal strategies, irrespective of the academic discipline of the curriculum.

C. Quality Appraisal Criteria

A set of pre-determined quality criteria was used to appraise the studies found by the literature review in order to only select credible, reliable and valid studies. Also, it was ensured that such studies needed to have a clear research question, and a sound theoretical or ideological perspective.

VI. RESEARCH RESULTS

This section presents a general curriculum framework obtained by merging existing curriculum models from various academic disciplines as per the above described systematic literature review. This section also shows how this merged model can be customized using ACM/IEEE-IT curriculum guidelines.

A. Existing Curriculum Models

Existing literature shows that various studies [3][4][11][12] have been dedicated to the design of curriculum frameworks in different academic fields. These frameworks were merged in this study in order to produce a new framework. Due to space constraints, only three of the four frameworks are represented in this paper by their diagrams, and the fourth framework is simply described.

According to [11] (Figure 1), strategic curriculum development should reflect the changing nature of society and it should consider the needs of students, industry, faculty, and government. They propose four stages curriculum development framework designed as a cycle with the aim of learning from the results of other phases. First, there is an establishment phase for the collection of information on the department initiating the curriculum renewal exercise (history of curriculum design project, barriers to curriculum change, and the available faculty expertise). Next, the necessary stakeholders are consulted during the dissemination stage in order to determine the program goals and outcomes. Afterwards, in the design and development stage, tasks are assigned and coordinated among faculty and staff, task timelines are allocated, and available resources are investigated. Finally, upon the completion of the design stage, the new courses are implemented. Students' performance is then evaluated, and later, staff and students' perceptions on the new curriculum model are investigated.

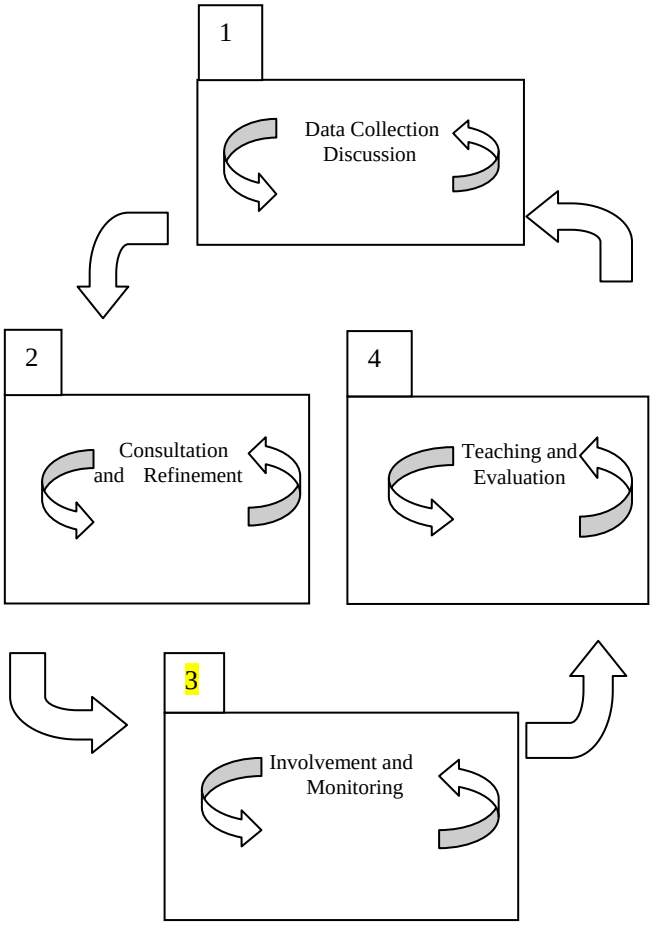


Fig. 1 Walkington et al (2002) curriculum framework

According to [4] (Figure 2), the design of an undergraduate curriculum should be initiated by identifying key graduate attributes. These attributes can be used to formulate programs learning objectives. They also

ISBN: 978-988-19251-6-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

emphasize that curriculum design should shift focus from content based education to outcome based education, to ensure that educational programs are tuned to global, community and environmental issues. Thereafter, learning activities are designed in line with learning objectives. Next, assessment tasks are designed for these learning activities. Finally, assessment criteria standards are formulated.

If [4] supports outcome based education compared to content based education, [3] goes further by proposing problem based learning curriculum. According to [3], a problem based approach to curriculum design is necessary to enable students develop skills such as the ability to think critically, to solve problems, and to work in teams. This approach can be initiated by gathering information from sources such as: educational theories, globally relevant institutions, professional bodies, industry and students. This information can be used to develop required graduate attributes. Thereafter, obsolete curricula can be reconstructed and their units assigned into the new curriculum.

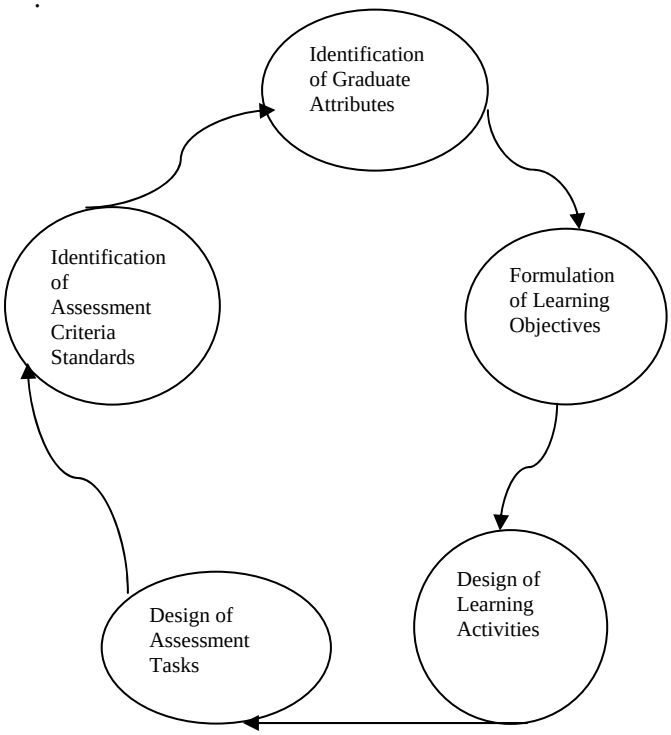


Fig. 2: Crostwaite et al (2006) curriculum framework

Competence based curriculum design is yet another curriculum design approach proposed by [12]. According to [12] (Figure 3), a competence based curriculum framework will assist academic institutions in equipping students both with main competencies and with supporting competencies. This framework can be designed first by evaluating the effectiveness of existing curricula. Thereafter, required graduate attributes in the job market must be investigated. These graduate attributes found are then used to reconstruct existing curricula. It is important to introduce new curricula to all staff and students in order to get their views on how to improve the proposed curricula. Finally, it is also important for curricula to be evaluated at least once a year and to be reviewed once every four years.

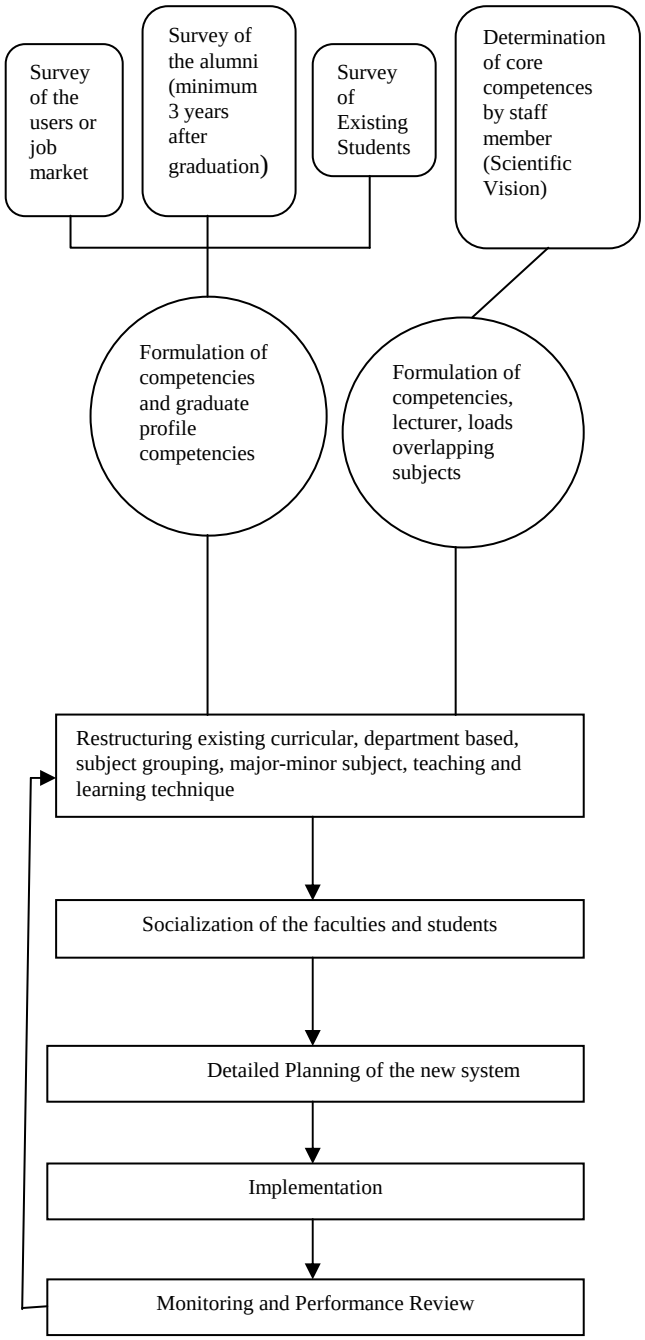


Fig. 3: Sailah (2005) curriculum framework

B. Merging of existing curriculum models

Figure 4 represents the merger of the above described curriculum models, and table 1 indicates how the phases of this merged curriculum model were constructed from existing literature.

First, information is sought from all stakeholders for the design of university curricula. Such stakeholder may include students, alumni, industry, faculty, professional bodies and government bodies. Furthermore, the required competences expected from graduates in terms of interpersonal skills and

ISBN: 978-988-19251-6-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

technical skills are formulated in the goal identification phase. Next, methods of achieving these goals are developed in the design phase. Thereafter, in the socialization phase, proposals for the new curriculum are examined by the curriculum committee to determine its acceptance and consider changes' requests. Furthermore, in the implementation phase, the new curriculum designed is used as the blueprint in imparting the required skills into the students. Finally, in the evaluation phase, the renewed curriculum is investigated to verify its effectiveness in achieving the desired goals. This can be done through feedback from the students that have undergone the new curriculum and also by monitoring the performance of the students after experiencing the new curriculum.

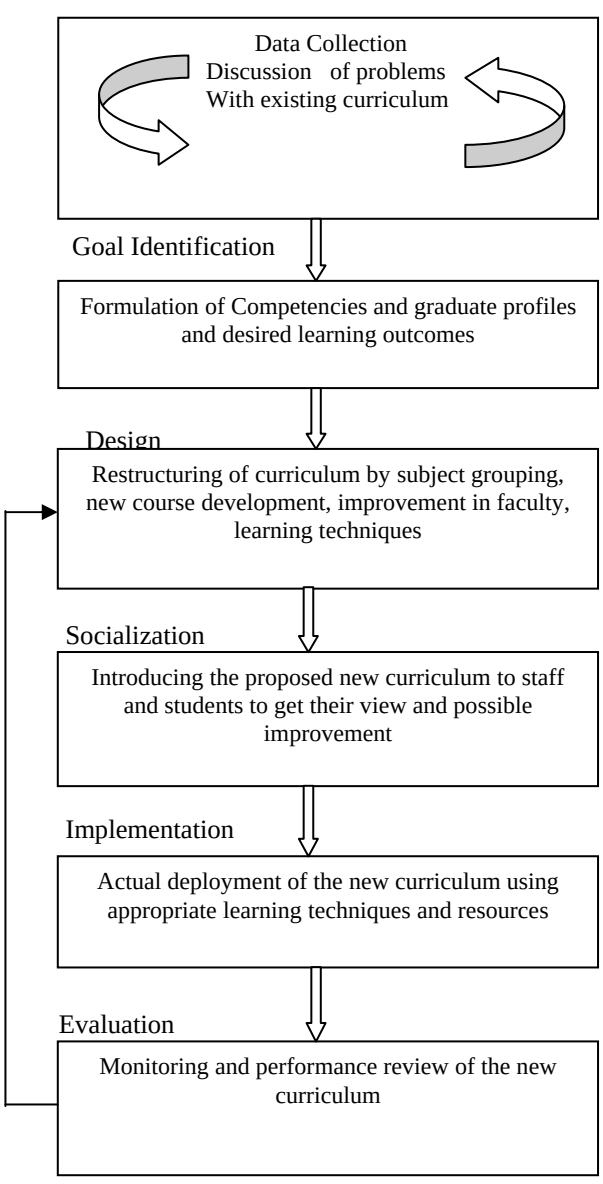


Fig. 4 General curriculum framework

C. Considering the ACM /IEEE Guidelines

The ACM/IEEE 2008 curriculum model was merged with the curriculum framework depicted by figure 4 to make it applicable to the IT context. This ACM/IEEE model was first analysed in order to identify its compulsory, optional, and customizable features.

Table 1: Grouping Curriculum development phases

Phase	**References**
Information Collection	Information gathering [13][14], Data Gathering [15], Stakeholder's Survey [12], Drivers for change identification [16], Data Collection [4][17][11], School Survey [18], Stakeholder input [19], School Scan [20]
Goal Identification	Need Analysis [15], Assimilation [13], Graduate Attribute Mapping [4], Program goal identification [21], Goal identification[12] [22] Competence Analysis [24]
Design	Design and Development [11], Revamping [19], Convergent Phase [13], Refinement [24], Methodology and Approach [15], Design [25],[26][27], Detailed planning [12], Reformulation [28], [29], Curriculum transformation [4]
Socialization	Socialization [12], Accommodative phase [13]
Implementation	Implementation [23][13],[12][11], Communication of Framework [24]
Evaluation	Impact Assessment [30] Evaluation & Control[23],[31], Course Evaluation [32], Assessment & Evaluation [3], Outcomes and Analysis [4], [13], Evaluation[29][20], Assessment [33], Monitoring and performance review[11]

Compulsory Features of the ACM/IEEE curriculum model

The ACM/IEEE curriculum model defines a set of core learning outcomes and a comprehensive body of knowledge compulsory (ACM/IEEE 1, Fig. 5), to all IT programmes subscribing to that model, both in terms of core IT concepts and in terms of the relationship between IT and other disciplines. It is also expected from such programmes to adhere to the following compulsory flexibility attribute: a flexible structure (ACM/IEEE 2, Fig. 5), a flexible content with regard to rapid technological changes (ACM/IEEE 3, Fig. 5)

Finally, it is also compulsory for ACM/IEEE curricula to be assessed using feedback from student and faculty and other relevant stakeholders (ACM/IEEE 4, Fig. 5) [34].

Options offered by the ACM/IEEE curriculum model

The ACM/IEEE curriculum model gives to its users options: a) to choose advanced IT courses (ACM/IEEE 5,

ISBN: 978-988-19251-6-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

Fig.5), b) to design core IT specializations (ACM/IEEE 6, Fig.6), c) to design IT application domains specialization (ACM/IEEE 7 Fig. 5) [34].

Customizable features of the ACM/IEEE curriculum model

The following aspects of the ACM /IEEE curriculum model can be customized based on the needs, situations and characteristics of the institution: the structure and format of the courses (ACM/IEEE 8 Fig. 5), methods of providing experiential learning (ACM/IEEE 9 Fig 5), strategy of curriculum implementation (ACM/IEEE 10 Fig. 5), the duration of completion of units within courses (ACM/IEEE 11 Fig. 5) and the method of incorporating and assessing professional practice work(ACM/IEEE 12 Fig. 5) [34].

D. Merging of the new framework and the ACM guidelines

The general curriculum framework and the ACM/IEEE curriculum guidelines were combined into an IT curriculum framework with six phases: Information Collection, Goal Identification, Design, Model Testing, Implementation, and Evaluation.

Information Collection

Data is gathered from different IT education stakeholders including professional bodies, industry, and scholars during the information collection phase. This is done with the purpose of identifying the limitations and strengths of the current curriculum in terms of the following ACM/IEEE curriculum features: coverage of ACM/IEEE body of knowledge and learning outcomes, curriculum flexibility with regard to its structure and to the ever changing nature of Information technology, the suitability of existing advanced courses in the curriculum as well as of existing core IT and application domain specializations, the suitability of the current implementation strategy of the curriculum including experiential learning issues, incorporation of professional practice into the curriculum, and courses duration.

Goal identification phase

This phase is concerned with determining the goals of new IT curricula by ensuring that these goals are in line with the ACM/IEEE core body of knowledge and learning outcomes. It is also important for IT curriculum designers to consider programmes' goals that will cover ACM/IEEE curriculum options on core IT specializations and on IT application domain specializations, and on professional practice.

Design phase

This phase is concerned with the design of courses grouping, new courses, faculty improvement plans, and learning strategies, in line with ACM/IEEE curriculum features following guidelines similar to the ones described in the goals identification phase of this model.

Socialization phase

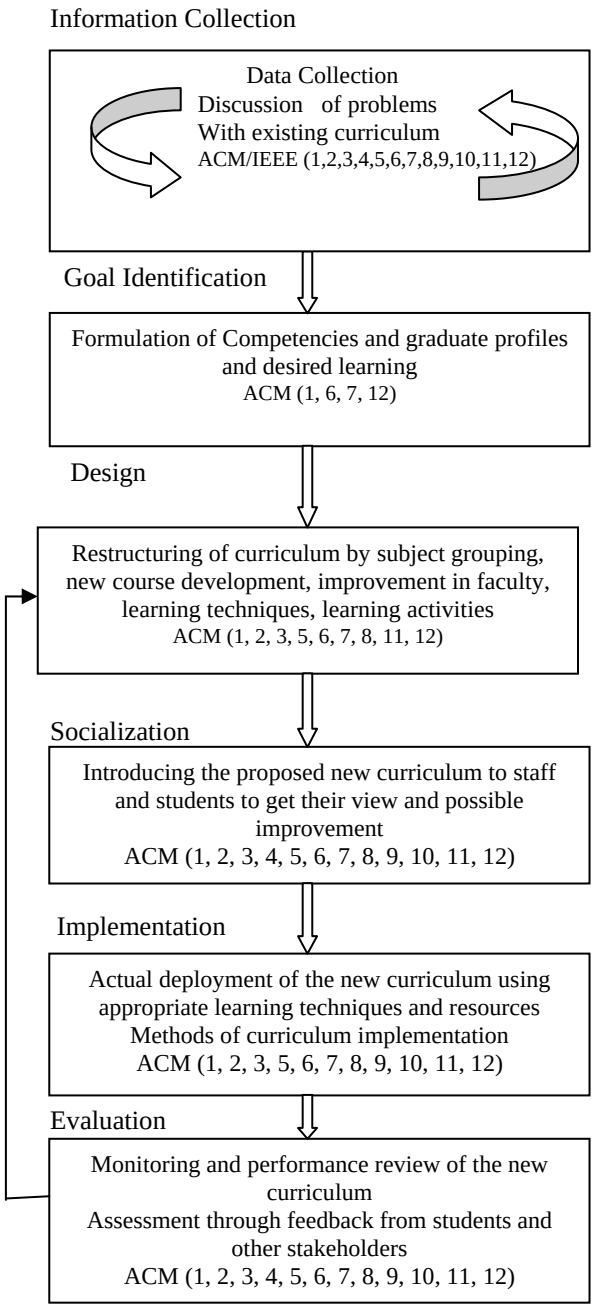
This phase is concerned with engaging relevant stakeholders with the novelties in the new curriculum in line with ACM/IEEE curriculum features following guidelines similar to the ones described in the goal identification phase.

Implementation phase

This phase is concerned with implementing the new curriculum in line with ACM/IEEE curriculum features following guidelines similar to the ones described in the goal identification phase.

Evaluation Phase

This phase is concerned with evaluating the new curriculum with purpose of getting feedback for improving the new curricula, in line with ACM/IEEE curriculum features following guidelines similar to the ones described in the goal identification phase.



ACM/IEEE 1: Body of knowledge and learning outcomes
ACM/IEEE 2: Curriculum structure's flexibility
ACM/IEEE 3: Technology Change flexibility
ACM/IEEE 4: Curriculum evaluation with stakeholders
ACM/IEEE 5: Advanced Courses
ACM/IEEE 6: IT core specializations
ACM/IEEE 7: IT application domain specializations
ACM/IEEE 8: Structure and format of courses
ACM/IEEE 9: Method of providing experiential learning

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ACM/IEEE10: Strategy of curriculum implementation
ACM/IEEE11: Duration of course units
ACM/IEEE12: Method of incorporating professional practice
Fig. 5 Information Technology curriculum framework

VII. DISCUSSION AND FUTURE RESEARCH

The similarity between this paper and existing literature on IT curriculum design resides on the use of ACM/IEEE model recommendations. However, none of the reported existing curriculum design models was based on a systematic literature review of existing work. Future research can be conducted on the empirical evaluation of the curriculum framework proposed by this study.

VIII. CONCLUSION

Educational institutions are faced with the challenge of designing effective curriculum to prepare students for the workplace. It is hoped that the framework presented in this paper will aid educational institutions in the design and renewal of the IT curriculum. This framework was designed as a merger of curriculum models from existing literature on the design of curriculum frameworks in various fields, and this merged model was then modified by the inclusion of ACM/IEEE recommendations.

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ISBN: 978-988-19251-6-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)