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A Program Development Model for Information Technologies Curriculum in Secondary Schools

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Information technology (IT) is used in numerous fields today, from health to education. This situation has brought about the need to train individuals toward using technological knowledge efficiently. IT education plays an important role in training individuals to become qualified in this field. Therefore, the IT curriculum should be designed to meet the said needs of students. This study then aims to provide a program development model for the information technologies curriculum at the secondary school level that can be adapted to the conditions of the day. To develop the model, the authors examined the relevant literature and information technologies program development processes and teaching programs of different countries. In addition, the opinions of academicians and teachers were obtained/taken into account. The results of the research led to the design of the "Development Model for a Sustainable Information Technologies Curriculum (DEMSITEC)". This model includes the planning and sustainability of an information technology curriculum with a dynamic structure that allows for continuous development. The model will provide teachers with a detailed road map for shaping the curriculum for their teaching environment. The study findings demonstrate that the model is useful for information technology education. It is suggested that this model be used for other grades alongside secondary schools for longer periods and the repetitive process be tested.

Introduction

In the last few decades, many studies focusing on innovative approaches to information technology (IT) education have been conducted, though there is continuing debate about the deficiencies in developing a curriculum that can adapt to the speedily changing conditions of the time (Al-Ahmad, 2010; Grassian, 2017; Mardis, Ma, Jones, Ambavarapu, Kelleher, Spears, & McClure, 2018; McManus & Costello, 2019; Voogt, 2008).

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As conditions change, individuals need new skills to use the information and communications technology both outside of school (for example, making an appointment at a hospital…) and in education (doing homework or preparing a project, receiving distance education…). Moreover, children are now exposed to abundant uncontrolled internet content that they may not know how to deal with (Florez, Casallas, Hernandez, Reyes, Restrepo, & Danies, 2017). This creates pressure on the IT curriculum to be constantly updated and improved, meaning the curriculum development process needs to be well-planned and dynamic (DET, 2021; Liu, Li, & Han, 2021; Nijenhuis-Voogt, Bayram-Jacobs, Meijer, & Barendsen, 2020).

In the literature, curriculum development models are divided into three different categories according to the logic of progress in the process: rational (linear), circular, and dynamic models. It will be helpful to examine these categories in the literature to guide the model development process. The rational model (the Taba and Tyler models) starts with goal setting and is based on the logic of progressing other curriculum development steps according to the appropriate order of operations (Hassanien & Dewhurst 2005; Knight, 2001). The circular model (Wheeler and Nicholls and Nicholls' models) expresses a logical and sequential progression in a more advanced structure than rational models. In this model, there is a continuous cycle of updating (Hassanien & Dewhurst 2005). This allows curriculum developers to review the situation in the current curriculum and correct it again and again (Pawilen, 2012). However, there is a further requirement to fully adapting a model to the current world. The constant change of knowledge requires a dynamic, experimental, and open-to-development curriculum (Walker, 1992). A dynamic curriculum development process refers to a curriculum that is constantly being structured and developed (Dutta, 2009; Keating, 2015; Wiles, 2008). Also, the dynamic model (like those of Skilbeck and Walker) is flexible, interactive, and changeable (Kim, Choe, & Kaufman, 2019). For example, Netherlands and Canada-Alberta developed their constantly developing curriculum models to be compatible with knowledge and flexible (Nieveen, Folmer & Vliegen, 2012; Parsons & Beauchamp, 2012). With these aspects, dynamic curriculum development model can meet the technology education needs.

Technology education includes knowledge of technology, technological skills, and technological literacy (Sade & Coll, 2003). With technology education, students have the opportunity to use technical applications and integrate IT-based solutions into technological problems with deeper critical thinking (Ekstrom, Gorka, Kamali, Eydie, Lunt, & Miller, 2006; Zhao, Xiao, Min-kun, Jie, & Yu-dan, 2013). Another important issue in the design of a curriculum is the quality of teachers (Scherer, Siddiq, & Tondeur, 2019; Watkins, 2006). In a flexible curriculum, teachers should be able to transform the curriculum by themselves (McCormick, 1992; Roehrig, Kruse, & Kern, 2007) due to the differing needs of technology knowledge in terms of culture and even local variables (Zhao et al., 2013). This need could be met by basing curriculum on standards that are suitable for the target population. For instance, the United States has introduced the obligation for teachers to write the content of a curriculum within the framework of the national standards.

A standard-based curriculum expresses the relevant knowledge, skills, and interests that students must exhibit and that will meet the predetermined standards. Activity suggestions (NL Canada, 2021) can be also made to help achieve the standards. With a flexible curriculum, all or some of those activities that are not useful in achieving the goals for various reasons can be eliminated by teachers. An advantage of the standard-based curriculum is that teachers can clearly see what goals they need to achieve and students get an idea of how much they can achieve those goals (Lund & Tannehill, 2014). After examining various curriculum

development models, ideas, and opinions in the field, Pawilen (2012) came to the conclusion that the curriculum development model process could not be separated from the standard development process (Liu et al., 2021) and the opinions received from teachers, school administrators, and experts (Wiggins & McTighe, 2005). The results of the research show that information technologies education, the informatics skills that students should have, are determined by standards, and these standards are constantly updated by some important institutions or a commission in the field (Pawilen, 2012).

The ISTE (International Society for Technology in Education) (ISTE, 2021) and ECDL (European Computer Driving Licence) (ECDL, 2021) are among the most well-known standards developed to create specific competencies in the field of informatics. In addition, many countries worldwide such as Australia, Canada, China, Ireland, New Zealand, Turkey, the USA, and the UK have identified standards or basic skills that define their technology competencies at the secondary school level and other levels (ACARA, 2020; Burrill, Lappan & Gonulates, 2015; Department of Education, 2013; DET, 2021; Education Bureau, 2021; ME, 2019; MEB, 2018; NCCA, 2021; NL Canada, 2021; Parsons & Beauchamp, 2012; Richards & Turner 2019; Sparapani, Perez, Gould, Hillman, & Clark, 2014; Wang, 2019). These standards may change according to the conditions of the day.

General steps of the curriculum development process

Many program development models in the literature, such as the Netherlands and Canada-Alberta governments and the Taba-Tyler models, involve a needs analysis (Nieveen, Folmer & Vliegen, 2012; Parsons & Beauchamp, 2012). Needs refer to the gap between the needs already provided for and those that are not (Altschuld & David, 2010). In this respect, it is vital to analyse needs while developing the curriculum to see the difference between those that exist and those that are required (Arah, 2021). The main goal of a needs analysis is first to evaluate the current curriculum, to identify and renew its deficiencies, rather than to develop an entirely new curriculum as it is more beneficial to advance an existing written curriculum (Parsons & Beauchamp, 2012). In addition, the educational and economic goals of countries are important in curriculum development (Fluck, Webb, Cox, Angeli, Malyn-Smith, Voogt, & Zagami, 2016).

When executing the process of continuous change in a curriculum development model, the curriculum professionals should consider what the change will bring, what impact it will have on the country's education system, and what additional resources are available. (Oplatka, 2018; Wiles, 2008). Additionally, in the design of a curriculum, many factors, such as the current targets of other countries, prior knowledge of the students, and the country's possibilities should be taken into consideration for the standards in determining the targets (Oplatka, 2018). According to Plomp (2013), it would be useful to analyze the findings of curriculum targets studies conducted in determining needs. Moreover, an educational design study can be performed as follows: 1. The achievements of the different predetermined countries in education are examined, 2. The similarities and differences between their curriculum and the curriculum of other countries are determined, 3. The strengths or weaknesses of the approaches followed are specified, 4. Predicting the negative consequences that may occur by bringing together conditions and characteristics, and 5. Learning and teaching strategies are determined to achieve the determined attainments.

In summary, a standard-based program development approach focuses primarily on what students should be taught as identified through needs analysis (DES, 2014; Liu et al., 2021).

Accordingly, a gradual approach (with elements from easy to difficult for each attainment or goal) can be adopted, which would benefiting from the opinions of experts in the writing of goals and attainments (DES, 2014). Furthermore, the attainments specified in the curriculum shouldn't be too broad or ambiguous so that students and teachers can fully understand the content knowledge. While determining learning activities, students' opinions should also be taken, and the compatibility of the activities with their individual characteristics should be considered (DES, 2014).

The role of teachers in delivering the curriculum is another important issue. It will be helpful to specify the roles of teachers for outcome-oriented learning activities in the course process as a suggestion (Nieveen et al., 2012). Also, students should discover the predetermined values such as perfection, innovativeness, inquiry and curiosity, diversity, equality, society and involvement, ecological sustainability, honesty and respect (ME, 2019) in the process and reflect them in their behavior, while teachers should know how to make students attain these values or integrate them into the program, and how to observe the results of this process (Nishino, 2017). In addition, countries generally do not recommend a content-specific evaluation within their curriculums. However, it will be useful to present the suggestions of evaluation to meet the current needs as these may provide alternative ways to assess technology knowledge (Fraillon, Ainley, Schulz, Friedman, & Duckworth, 2020). Finally, the duration of lesson times should be recommended and discussed regularly as the subjects will change over time, particularly in a commission including teachers (Parsons & Beauchamp, 2012).

Importance of the study

Technology education provides individuals with the knowledge required to make materials and tools that are suitable for achieving targets by using technical knowledge to meet the needs in daily life (Marc, Stefan, Peter, Martin, Ingelore, Charles, Dieter, Bill, & Johannes, 2016). In this respect, having IT knowledge has become one of the required competencies for adapting to the 21st century (Angeli & Giannakos, 2020; McManus & Costello, 2019). One result of the literature review shows that many studies focus heavily on developing children's IT skills (Mouza, Yang, Pan, Ozden, & Pollock, 2017). In addition, there are many approaches and models that can guide and direct the development of a curriculum (Ornstein & Levine, 2014; Shaari & Shaari, 2013). However, similar results experienced from the past to the present in the curriculum prepared for IT courses indicate that there are problems with the methods used in the preparation, presentation, and implementation of programs (Sabin, Alrumaih, & Impagliazzo, 2018; Shaffer, 2008). In addition, Raigoza (2017) draws attention to the fact that although curriculum have changed over the years, learners' success has not reached the desired level in coding. When considering the changing conditions of the day and the needs of the required workforce, there is clearly a need for an education program that will qualify individuals in the IT area (Campe, Denner, Green, & Torres, 2020; Witherspoon, Schunn, Higashi, & Baehr, 2016). Existing general curriculum development processes are insufficient for IT education (Sabin et al., 2018; Shaffer, 2008). However, there is still no developed model for an IT curriculum in the literature. This study will propose a model to help develop a curriculum that meets IT education needs. This model will be helpful for creating a competent IT education, including the synthesis of the studies, the IT curriculum development process of various countries, and experts' views on this subject. In this study, researchers aimed to develop a sustainable secondary school IT curriculum development model that is updated regularly to meet the individual and social needs arising from change. Since keeping the subject area too broad will

make goal-oriented progress difficult, this study focused on the secondary school level. However, this model can serve as an example for different levels. In this context, researchers sought answers to the research questions below.

Research Question

In the research, answers were sought to the following question and three sub-questions: What kind of a development model should be used in the process of designing the curriculum of the secondary school IT course?

(1) According to studies on IT curriculum in the literature, what should an IT curriculum look like?
(2) What are the steps and approaches of the IT curriculum development process used in different countries?
(3) How are the opinions of teachers and academicians regarding how an IT curriculum should be prepared?

Method

This study is a Design-Based Research including designing, developing, and evaluating (Herrington, McKenney, Reeves, & Oliver, 2007). According to Wang and Hannafin (2005), a design-based study includes systematicity and flexibility, repetitive stages in its structure, and the cooperation of researchers and participants involved in the application. By using the document analysis technique to form the theoretical framework of the study, a review was done on curriculum development processes (the secondary school IT curriculum development processes of Australia, Canada, China, Ireland, New Zealand, Turkey, the USA, and the UK) and models were examined in the field (Canada-Alberta - Parsons & Beauchamp, 2012; NL Canada, 2021; Netherlands - Nieveen et al., 2012) developed for their own general programs. Models of Taba-Tyler, Wheeler and Nicholls and Nicholls, and Skilbeck and Walker, which are frequently mentioned in the literature, are examined. In addition, the opinions of subject-matter experts were taken to enrich the data on how an IT curriculum should be prepared. Model development stages are shown in Figure 1.

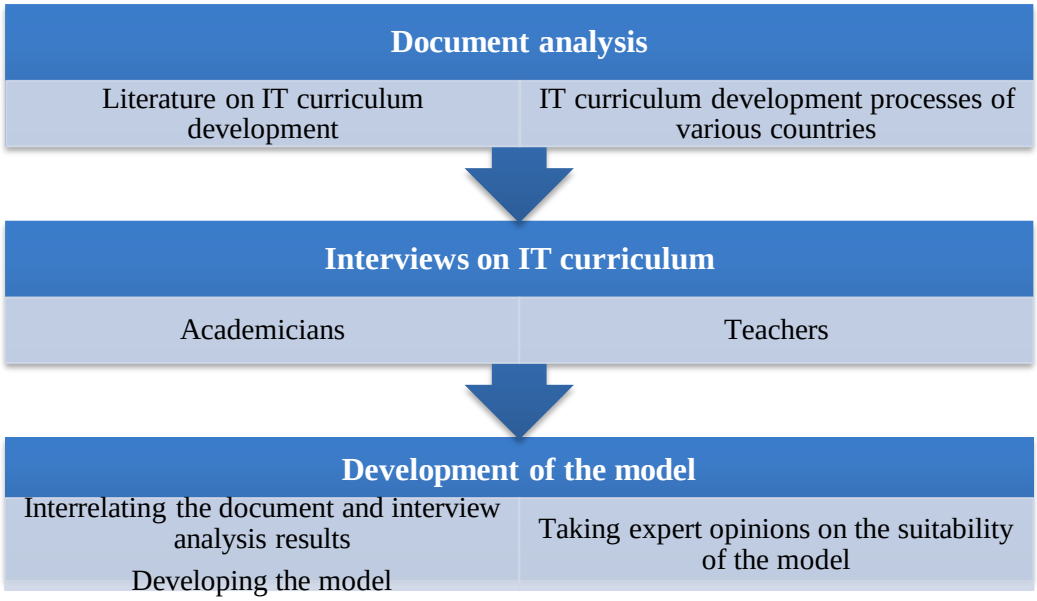

Figure 1. Development process of DEMSITEC

After conducting interviews, researchers examined all the data obtained. By examining the data, the characteristics of a model that can meet the needs of the secondary school IT curriculum, its steps, and the content of these steps were decided. Detailed information on this subject is given in the results section. The data collection process is summarized in Table 1.

Table 1. The data collection process

Method	Type	Detail
Document analysis	Analysis of secondary school IT curriculum development processes of various countries	Australia, Canada, China, Ireland, New Zealand, Turkey, the USA, and the UK. Examining the countries' curriculum development models to understand how countries prepared and developed their secondary school IT curriculum.
	Literature analysis	Examining the studies on the subject in the field. The common points and the characteristics of IT curriculums.
Interviews	Taking the opinions of the teachers	What are their expectations from the secondary school IT curriculum?
	Taking the opinions of the academicians	What a secondary school IT curriculum should look like. What an IT curriculum development model should look like.

As a result of the document and interview analysis, the "Development Model for a Sustainable Information Technology Curriculum (DEMSITEC) " was created. The DEMSITEC model suggests an iterative process that occurs during and throughout each phase of a curriculum. The model provides no specific sequence of phases determined as mini development processes. The development process can be started in whichever phase is required. In this way, quality products will be obtained in a short time by testing the prototype continuously (Parsons & Beauchamp, 2012). After developing the model, academicians opinions of the model were sought. The model was finalized in line with the opinions received.

Study group

Interviews were held with 15 experienced teachers and seven academics for their opinions on what the IT curriculum should look like and how it should be prepared. Fourteen academics were consulted on the suitability of the developed model. Information on the study group is given in Table 2. The study was carried out following all ethical rules.

Table 2. The research study groups

Study Groups	Participants	Female	Male	Years of Seniority	Knowledge	Total
Opinions on the secondary school IT Curriculum Development	Teachers	7	8	2-10	Teach Information Technology (IT) in secondary school	15
	Academicians	1	2	8-14	Field experience in computer education and instructional technology (CEIT)	3
	Academicians	2	2	14-28	Education programs and teaching	4
Expert Opinion for the Model Proposal	Academicians	4	7	4-14	CEIT	11
	Academicians	2	1	13-14	Education programs and teaching	3

Data collection tools

Semi-structured teacher and academician interview forms were used. The first researcher conducted the interviews. The teacher form was used to reveal problems and requirements of the information technology education curriculum. The academician form was used to reveal problems and requirements of the information technology education curriculum and the preparation processes. The interview form questions prepared by the researchers were examined by the subject-matter experts. Pre-interviews were conducted with one teacher and academician who took part in the data collection processes to test the understandability and functionality of the form. The researchers found that the forms were usable.

The teacher interview form includes questions about what they expected from an IT curriculum considering the negative and positive aspects of the official information technology curriculum in Turkey: Needs, suggestions on flexibility and adequacy of the teaching method, how often the curriculum should be updated, how the curriculum can be delivered and explained to the teacher, and the necessity of the evaluation suggestions. The sample questions are as follows:

(1) What are your positive and negative thoughts about the secondary school information technologies and software curriculum?
(2) Should the curriculum consist of fixed subjects or flexible subjects? (Should decisions on which subjects and how they are taught be left to the teacher?)
(3) Do you think the way the course is taught in the program is appropriate? In what kind of environment should the course be taught and what methods used?

In the academician interview form, in addition to the questions asked in the teacher interview form, other questions covered the preparation processes of the IT curriculum, what makes a dynamic curriculum, and how can teachers be competent in this regard if a new curriculum is prepared. The sample questions are as follows:

(1) How should an information technologies curriculum be developed?
(2) What kind of content should a new IT curriculum cover? What should the approach be? (Open-ended or fixed). After the model draft was prepared, academicians' opinions were taken to give the model its final form.

In the document analysis, first of all, countries from different parts of the world, where possible, that have explained their IT curriculum in English and detailed were selected.

Documents regarding the IT curriculum development processes of these countries were obtained from the official government websites. In addition, the researchers investigated whether an IT curriculum has been developed before using the keywords "IT curriculum development" and "IT curriculum development model" with the Google Scholar search engine. Well-known general curriculum development models in the literature were examined and their curriculum development approaches were revealed.

Data analysis

Content analysis was carried out on the data obtained from the interview forms. After the data was coded, the codes were reconstructed by one subject-matter expert in order to check credibility (internal validity). It was concluded that there is a 95% consistency with the codes created by the researcher and the subject-matter expert (Patton, 2002). Finally, to ensure the reliability of the study, the codes were re-encoded by the same person after one month. Furthermore, another subject-matter expert checked the correct expression of the codes. To ensure the transferability (external validity) of the study, criterion sampling, a purposive sampling method, was used (Palinkas, Horwitz, Green, Wisdom, Duan, & Hoagwood, 2015). Then, the codes were presented in frequency tables (Mayring, 2014). Sample statements obtained from the interviews are also included in the paper. After bringing together the document and interview results, the researchers brought them together and decided on the structure that the model should have. This comparison is presented in Table 4. As a result, a draft model was created. The opinions of the academicians were taken on this draft and, finally, the model was finalized. However, triangulation was not performed since no other data were obtained in the limited time available (Patton, 2002).

Results

The study took the opinions of the academicians and teachers on how an IT curriculum should be prepared after document analysis. In the light of the obtained data, a new model was created, following which opinions about the created model were sought. The results of the document and interview analysis are presented below.

Document analysis results

First, the researchers carried out a detailed analysis of secondary school IT curriculum development studies in the literature and covering various countries. These are the studies on IT curriculum requirements, well-known models (Rational model: Taba and Tyler models, Circular model: Wheeler and Nicholls and Nicholls' models, Dynamic Model: Skilbeck and Walker model), and IT curriculum development processes in Australia, Canada, China, Ireland, New Zealand, Turkey, the USA, and the UK.

According to the data obtained, a common theme was that the IT curriculum should adapt to our ever-changing world and, therefore, needs to be flexible. Also, the model may be in a dynamic structure and based on standards. These standards will guide teachers as they form their curriculum.

The curriculum development models in the literature start with a needs analysis. Also, the research emphasizes the importance of taking stakeholders' opinions on the curriculum while performing the needs analysis. In addition, the educational policies of other countries should be examined in determining the objectives of a curriculum.

Australia, Canada, China, Ireland, New Zealand, Turkey, the USA, and the UK have developed their own IT standards. ECDL and ISTE standards are the most well-known IT standards worldwide. In addition, there are studies stating that following development standards, outcomes that accord with them need to be determined. In addition, learning activities and materials need to be designed. Finally, in general, countries did not recommend a content-specific evaluation within their curriculum. However, there is a need to suggest methods for evaluation.

Opinions on the preparation process of the IT course curriculum

Academicians' opinions

Academicians are of the opinion that a model needs to be developed for the preparation of an IT course curriculum based on a philosophy and including flexibility. Also, the curriculum should have a spiral structure and adopt a life-centered approach.

A2: "Because the computer is something that they will mostly use in their daily life and they will use in their school life, I think that life-centered programs should be addressed and developed since these communication technologies are a field in which they will be constantly involved."

According to the academicians, before creating the curriculum, teachers' and students' opinions should be taken. Also, suggestions for activities should be prepared with specific approaches for each one. In addition, the newly prepared or rewritten curriculum should definitely be introduced to teachers. This introduction should be accommodated face-to-face where teachers are present. Furthermore, they suggest providing extra support through a website, where teachers can communicate to share their experiences on curriculum issues, or booklet. Selected statements are presented below.

A5: "... For example, products of information and communication technologies, various hardware and software technologies, it should be clear what they are. The teacher wants to use the book, but he does not have the book."

A5: "…I think the curriculum should be presented in a digital environment because there should be something that can be constantly updated and added to continuously… If there are improvements regarding the outcomes and standards here, there should be an online system so that these can be monitored continuously… Also, people can relate their experiences about tools and processes, saying 'I explained this in this class, in this geography, in this way', and can also share materials."

Teachers' opinions

According to the teachers, the IT curriculum should have a flexible structure, include outcome and evaluation suggestions for different student and grade levels, and support teachers in various ways such as in implementing and delivering the program and informing them about innovations.

Sample statements on the subject are as follows.

T12: "We cannot deliver the program to students at all levels of readiness. Therefore, we teach the parts that are suitable for the student. However, it can be said that you can do it

by choosing among the following issues available...” The following remarkable statement considers content.

T1: “The absence of teachers' guidebooks and students' workbooks adversely affects the teaching of the course. This causes serious difficulties in content. Content information should be provided”. The results obtained are presented in Table 3.

Table 3. Teachers' opinions on the issues to be considered in the preparation of an IT course curriculum

OPINIONS	F
It should be flexible within certain limits	1
There should not be rote understanding	1
The curriculum should be developed with teachers	1
The curriculum should remain up to date	1
There should be different durations at each level	1
There should be a teacher's guidebook	7
There should be a student's workbook	5
Support should be provided with in-service training with an expert	3
Evaluation suggestions should be given	5
Total	13

Teachers also suggested that they would like to receive information about the curriculum and changes made in the curriculum in various formats. Teachers recommend obtaining this information from the Ministry of National Education (f:9), a booklet (f:4), a special website (f:4), distance education (f:3), e-mail (f:2), via SMS (f:2), and an IT platform available on Facebook (f:1).

Document analysis and general results

DEMSITEC has been developed in line with the studies and models in the literature and through opinions sought through interviews. Following the results of the analysis of the data obtained, the model has been planned as sustainable, flexible, and standards-based. Table 4 provides a comparison of the findings obtained from document analysis and interviews on developing IT curriculum and the general results.

Table 4. Document and interview results on IT curriculum

Document analysis	Interviews (Academicians/Teachers)	Results
IT curriculum should be up-to-date and adaptable to the conditions of the day (Australia - DET, 2021; Canada- Parsons & Beauchamp, 2012; Hong Kong- Education Bureau, 2021; Liu et al., 2021; Nijenhuis-Voogt et al., 2020).	Adopt a life-centered approach.	Should be update
Should be flexible (Hong Kong - Education Bureau, 2021; Parsons & Beauchamp, 2012). Netherlands and Alberta have developed their general curriculum models dynamic and flexible. Teachers should be able to shape the curriculum according to the changes in technology and school-student circumstances (USA - Sparapani, Perez, Gould, Hillman, & Clark, 2014; Zhao et al., 2013).	It should be flexible enough not to leave teachers in uncertainty.	Should be flexible
Should be dynamic (Parsons & Beauchamp, 2012). Netherlands and Canada have developed their general curriculum models dynamic. Canada suggests examining the educational outputs for revisions (NL Canada, 2021).	-	Should be dynamic

Australia, Canada, China, Ireland, New Zealand, Turkey, the USA, and the UK developed their own standards for IT education (ACARA, 2020; Burrill et al., 2015; England - Department of Education, 2013; DET, 2021; DES, 2014; Education Bureau, 2021; ME, 2019; MEB, 2018; NCCA, 2021; NL Canada, 2021; Parsons & Beauchamp, 2012; Richards & Turner 2019; Sparapani, Perez, Gould, Hillman, & Clark, 2014; Wang, 2019). ECDL and ISTE standards are the most well-known IT standards worldwide (ISTE, 2021; ECDL, 2021). There are studies stating that there is a need for developing standards (Liu et al., 2021; Lund & Tannehill, 2014; Pawilen, 2012). Standards should be updated by institutions or a commission (Pawilen, 2012).	Should be based on a philosophy	Should be standard-based
Netherlands and Canada-Alberta curriculum models (Parsons & Beauchamp, 2012; NL Canada, 2021) and the Taba-Tyler models (Nieveen et al., 2012; Parsons & Beauchamp, 2012) have needs analysis. In the literature, the importance of needs analysis has been emphasized (Arah, 2021; Fluck et al., 2016; Parsons & Beauchamp, 2012; Plomp, 2013). The opinions should be received from stakeholders (Australia - DET, 2021; Bound, Rushbrook & Sivalingam, 2014; New Zealand – ME, 2019; Wiggins & McTighe, 2005).	Needs analysis should be done while developing the curriculum. Student, teacher and expert opinions should be taken.	Needs analysis phase is required. At this stage, stakeholder opinions should be taken and studies of other countries should be examined.
Outcomes in accordance with the standards should be determined (Ireland - DES, 2014). In this process, it is also important to consider the goals set by examining the education policies of other countries (China - Education Bureau, 2021; Oplatka, 2018). Achievements should progress from easy to difficult (Ireland - DES, 2014).	-	The expected outcomes should be determined in accordance with the standards.
Should determine the learning activities. Student and teacher opinions regarding these activities should be obtained in advance (Ireland - DES, 2014). Determining the materials with considering what additional resources are available (Canada- NL Canada, 2021; Oplatka, 2018; Wiles, 2008). The materials should be up-to-date (Ireland - DES, 2014). The activities and materials prepared should be compatible with the student and the teacher. Should determine the role of teachers in learning activities (Nieveen et al., 2012; Nishino, 2017).	Activity suggestions should be prepared with specific approaches for each of them	Activities and Materials should be decided to suit teachers and students. Teachers and students should be consulted. Teacher roles should be determined.
Countries generally didn't recommend a content-specific evaluation within their curriculums. It is important to suggest assessment methods (Fraillon et al., 2020).	Assessment suggestions should be given according to different grade levels.	Assessment suggestions should be given according to different grade levels and subjects.
-	The subjects in the curriculum should be well explained by an expert, and developments and curriculum should be conveyed to teachers in the best way, for example, via a web site. Teachers should be able to share among themselves in this environment.	Delivering curriculum and updates to teachers through an environment. This environment should allow for the exchange of ideas.

The duration of lesson times should be recommended (Parsons & Beauchamp, 2012).	Suggestions for the time to be allocated for the outcomes should be given.	Outcome times should be recommended
Students should discover the predetermined values in the IT education (ME, 2019)	-	Values should be included in the IT content.

Taking expert opinions on the DEMSITEC model proposal

After the model was developed, opinions were taken from academicians who are experts in the field. The model was finalized in line with the opinions received. The findings are given below.

Academicians' opinions on the DEMSITEC model proposal

Academicians generally found the main components of the DEMSITEC model and the flow chart of the model useful and efficient in terms of developing a curriculum in the field of information technologies. Furthermore, the model was found to be appropriate and functional in regard to addressing the planning and development process and the implementation process together. However, some suggestions for model revisions were not met. These issues are discussed in the chapter providing a detailed analysis of the overall study findings. The final version of the model after the last revisions is as follow:

The development model for a sustainable information technology curriculum (DEMSITEC)

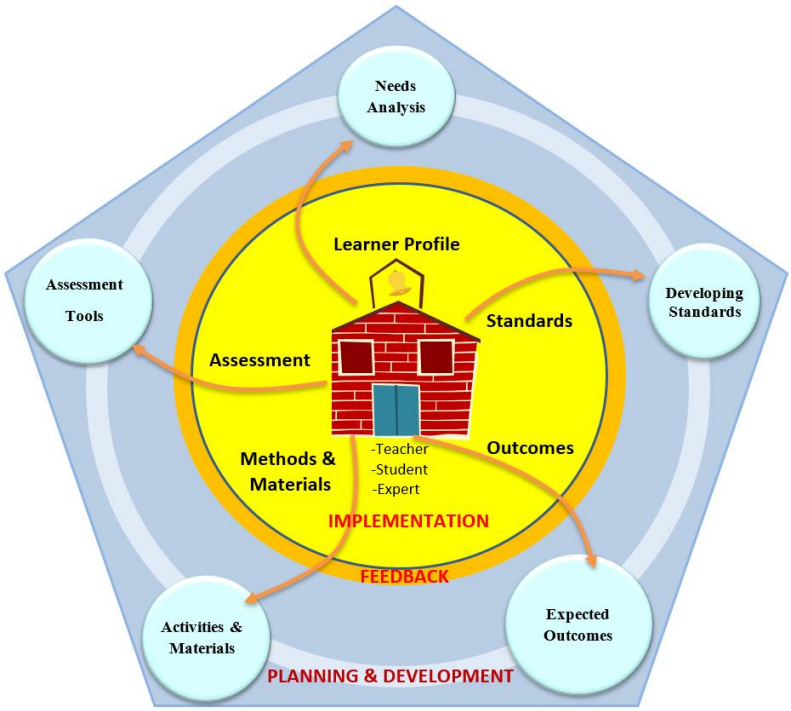

Figure 2: *Development Model for a Sustainable Information Technology Curriculum (DEMSITEC)*

Components of the DEMSITEC

This model includes the planning and sustainability of an information technology curriculum, in other words, its continuous development. The model therefore provides a planning and development process and an implementation process. In the Figure 2 diagram, the outer circle indicates the planning and development processes, while the inner circle indicates the implementation processes, and the structures inside the inner circle are regularly updated with feedback during implementation. The orange arrows indicate that the data obtained as a result of the evaluations made in the process are transferred to the outer circle as feedback.

Planning & development:

The diagram shows, in the outer circle, how the stages of needs analysis, developing standards, specifying expected outcomes, developing suggestions for activities and materials, and determining assessment tools are included in the design of a curriculum. These stages are carried out with continuous feedback from the implementation stages, and the curriculum is constantly improved by revision of each stage through consideration of the consistency between the stages. In this way, a continuous forward feed is realized. The following describes in detail the elements of each phase of the development process.

Needs analysis: Initially, a needs analysis is performed. In the needs analysis, if there is a previous curriculum, this curriculum is first examined. Evaluations and suggestions about the process are collected by discussing the curriculum with curriculum development experts, subject-matter experts, teachers, and students. Afterward, new technology that has had an effect on society are investigated. Worldwide accepted standards are examined and learning outcomes combined. Then, the targets of the countries that have conducted successful studies in information technology education are examined. The available possibilities as to which the country can teach the new information technology are investigated. The relationship between the contents of the information technology course and other courses are determined. Finally, students' pre-learning is determined. Afterward, needs and goals are written based on the data obtained from the needs analysis. By comparing these goals with the current curriculum goals, missing goals can be identified and added, the existing goals that require change can be corrected, and any unnecessary goals that do not address the needs of the current environment or students' prior learning can be eliminated.

Developing standards: The latest state of technology which is specified with the needs analysis process, worldwide accepted standards, and standards determined or preferred by other countries are examined. Following this investigation, the standards that the country needs are identified and developed in association with the outcomes obtained from the needs analysis.

Expected outcomes: Sample outcomes are created before the implementation process for each standard. They should be written at three levels, from easy to difficult, to provide for the differences in school and student levels, when necessary. Afterward, they are presented to teachers as a guide. The outcomes are determined in accordance with Mager's ABCD model, taking into account the outcomes that previously emerged in the needs analysis and the specified standards. With Mager's ABCD model, the outcome sentences are created by considering the target audience, behavior, condition, and level logic. Teachers can use the sample outcomes directly, change them, or create their own outcomes. Then, how long each

outcome will take in the lesson process is planned. While writing the outcomes, any values students are expected to acquire are also taken into consideration and included where necessary. When teachers choose sample outcomes or create outcomes that are suitable for the standard, they should pay attention to the fact that these outcomes should be in accordance with school conditions and students' characteristics.

Activities & Materials: Learning activities that should be carried out to achieve each outcome are revised or planned. The methods that can be used to carry out the determined activities are written. Learning can be realized with different activities according to the teacher's skills and students' interests. In addition, the roles of teachers and students in the course process and learning activities are determined. Afterward, the materials required to achieve the outcomes are determined by considering the country's opportunities. If the material necessary to achieve the outcome is not available, this should be stated in the curriculum so that the relevant outcome can be eliminated or changed. A guide textbook and website that includes information on how to use the curriculum should be prepared, especially for the teacher. Teachers should be able to access ready-to-use materials from a website prepared for teaching and learning activities and where they can share.

Assessment tools: The assessment tool that will be used for each outcome is determined. Since the information technology course includes using technology products, it is a course that needs practice. Therefore, how to measure and evaluate the practices performed in the course should be given as suggestions when deemed necessary.

Implementation

The curriculum prepared following the planning and development stages is used in the information technology course. In the implementation process, learner profiles, standards, outcomes, activities, methods and materials, and assessments are improved by referring to the opinions of teachers, students, and experts. The following describes in detail the elements of implementation.

Learner profile: At this stage, students' characteristics and needs are reported to curriculum developers as feedback to the needs analysis stage.

Standards: At this stage, the feedback on the compliance of the previously determined standards with the students and the teaching and learning process and the new standard recommendations which could be added to the curriculum is transferred to the developing standards stage.

Outcomes: At this stage, feedback regarding the suitability and comprehensibility of the outcomes is transferred to the stage of determining the outcomes.

Methods & materials: At this stage, the feedback on the suitability and usability of the activities, application methods, and materials to the teaching and learning process is transferred to the activities and materials stage.

Assessment: At this stage, feedback and new suggestions on the functionality of the assessment tools are transferred to the stage of determining measurement tools.

Taking opinions on the curriculum and making corrections

The opinions of the teachers, students, and subject-matter experts should be taken to revise the curriculum, and any necessary corrections should be made in the relevant steps. This process continues constantly during implementation.

Sharing the curriculum with teachers and orientation training

Curriculum developed should then be shared with teachers through various environments, and orientation training provided. In this training, how to carry out the implementation process and the introduction of the new technology that is part of the curriculum should also be included. As far as possible, this training should be provided face-to-face by experts to make the orientation training more understandable for teachers and to ensure their participation.

Discussion

This study investigated a curriculum development model for IT education. The data obtained are as follows: A curriculum development model for IT education should be based on a philosophy and include flexibility (Education Bureau, 2021; Parsons & Beauchamp, 2012). The curriculum should have a spiral structure (Ching, 2009) and a life-centered approach (Zhao et al., 2013). Teachers' and students' opinions should be taken in the process of curriculum development. Also, activity suggestions should be prepared with specific approaches for each one. For different student and grade levels, outcome and assessment suggestions should be presented. Teachers should have the competencies to write their own curriculum and implement it (Fraillon et al., 2020). After the development of the curriculum, it should be introduced teachers in various ways such as thorough face-to-face explanations or websites.

According to the academicians, the model developed in this study is suitable for the development of an IT curriculum. In addition, some further suggestions were obtained for the model and an IT curriculum developed. These suggestions and their possible solutions are discussed below.

The first suggestion was that the starting point of the model should be specified. However, since the DEMSITEC model currently has a dynamic structure, there is no specific starting point, and it can be started from whichever step is required (Hassanien & Dewhurst, 2005). In this respect, there is no guidance on the boundaries that should be followed. The second suggestion was that the two-sided arrows in the model might be beneficial in terms of feedback to the problems. The products obtained at every stage of the model can be supported with feedback from stakeholders in the implementation process. Also, the model has a dynamic structure given its continuous development. There is therefore no need for an extra visual two-way progress method. The final suggestion for the model was that an information technology course curriculum created within the scope of the model could be renewed with annual revisions, and the opinions of stakeholders could be obtained continuously during the year. This is also consistent with teachers' expectations. In the dynamic curriculum development process, the issue of receiving the opinions of stakeholders was previously added to the model in line with the literature and the opinions of subject-matter experts (Bound et al., 2014). However, it was not possible to reach a definite conclusion as to the intervals at which this iterative process could be performed. In future research, the processes of reviewing and developing curriculum should be tried and discussed in different periods.

Having different levels of outcomes in the curriculum is beneficial to meeting the needs of different students (Oboho, 1998). In the model it is suggested that subject matter approaches should be used. In the literature, there are several approaches used to develop IT knowledge such as collaborative learning (Cao & Xu, 2005), pair programming (Campe et al., 2020), computational thinking (Florez et al., 2017; Barr & Stephenson, 2011), use of Scratch-like special programs (Bean, Weese, Feldhausen, & Bell, 2015; Burke, 2012; Kalelioglu & Gülbahar, 2014), follow me activities (Bean et al., 2015), and digital stories (Burke, 2012; Zha, Jin, Moore, & Gaston, 2020). For example, learning programming is one of the most difficult areas for students (Raigoza, 2017; Hanks, Fitzgerald, McCauley, Murphy, & Zander, 2011). In their study, Hazar, Akkutay, and Keser (2021) found that programming training is inadequate because of the current design of the curriculum. The computational thinking approach, which helps to solve problems and develop technology competencies, could be used as a solution for teaching programming (Barr, & Stephenson, 2011; Florez et al., 2017). Also, Fraillon, et al., (2015) presented a report that includes 14 countries' IT curriculums and concluded that there are too many approaches used because of different subjects and country needs. Finally, it is found useful to present the assessment suggestions to meet the assessment of technology knowledge.

Overview of the DEMSITEC model

DEMSITEC is a specific model for the field of IT for the first time. It highlights the unique, ever-changing nature of the IT field. In addition, with its dynamic and sustainable structure, it is flexible, and education stakeholders may revise the curriculum with the feedback received from the education processes. Therefore, it provides a system that keeps up with the day's conditions. From another point of view, when we look at curriculum development models, evaluation processes are not included in detail in general. On the other hand, this model guides the making of appropriate evaluations that can meet the different structures of IT content. In addition, standardization supports flexibility, and stakeholders can quickly realize the general objectives with standards. The disadvantages of the model are stated below as limitations.

Conclusion, Suggestions, and Limitations

Technology changes every day and affects every society and the expected educated workforce (Bowman, Jarratt, Culver, & Segre, 2020; McManus, & Costello, 2019). The overall findings of this study show that the DEMSITEC model is useful for information technology education and met the needs of today to a significant extent. It is therefore suggested that the DEMSITEC model is used in the development of curriculum in the field of information technology. In future research, the model can be used in areas other than IT, with revisions made where necessary in curriculum development studies for different school types and disciplines. The study does have some limitations due to its nature. These limitations are listed below.

- The study is limited to secondary school IT education. It is recommended to try the effects of the model by making applications at different grade levels.
- Opinions taken in the study are limited to teachers and academicians. In the future, researchers may conduct studies with a commission that includes researchers, educators, students, and other curriculum stakeholders such as subject/discipline experts and state representatives.
- Only document analysis and opinions were taken in the study, and triangulation was not performed since no other data were obtained in a limited time available. In the

future, data can be collected with different measurement tools such as focus interviews for the model and surveys by reaching a wider audience consisting of all stakeholders.

- The model in this study was not tested through the development of a detailed curriculum. In future research, a complete curriculum should be prepared and evaluated using the model.

Considering these limitations, new studies are recommended for the model. Besides the issues mentioned above, it is recommended that studies be conducted on the competencies of pre-service teachers regarding how they use the curriculum (Davis & Tearle, 1999; Reinsfield, 2019; Watkins, 2006). Pre-service teachers and serving teachers can be trained in curriculum literacy so that they can understand the functioning of the curriculum and use it with a productive approach. Information technology teachers should regularly share their opinions about the information technology course curriculum with the institution that has developed the curriculum to contribute to the curriculum development process (Sentance & Csizmadia, 2017). Furthermore, teachers should be directed to productivity, and rather than using the suggestions offered in the information technology course curriculum, they should use the ones appropriate to the level of the class, and, when necessary, they should draw up their own plan for teaching the course. Therefore, a dynamic process that constantly evolves and develops will be provided.

Note

This study is based on the doctoral thesis titled "Creating a Model for Developing a Sustainable Curriculum of Information Technologies (DEMSITEC) and Examining its Effectiveness" written at Sakarya University, Department of Computer Education and Instructional Technology, by the first author under the supervision of the second author.

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