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Application of Spiral Programming Model in Medical Education: A Review

Khatereh Shariati[1], Sahar Peikani[2], Hossein Karimi Monghi[3], *Masoumeh Ghazanfarpour[4]

[1]MSc Student in Medical Education, Department of Medical Education, Mashhad University of Medical Sciences, Mashhad, Iran.

[2] MSc of Epidemiology, Network Development Expert of Mashhad Health Center, Mashhad University of Medical Sciences, Mashhad, Iran.

[3] Professor, Department of Medical Education, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran.

[4]Student Research Committee, Kerman University of Medical Sciences, Kerman, Iran.

Abstract

Background

The spiral approach is a technique often used in education where the initial focus of instruction is the basic facts of a subject, with further details being introduced during learning progresses. In the present study, the findings and results of various research studies are reviewed in a proper structure and the components of the concept of spiral curriculum, its features, advantages, and disadvantages are extracted and reported.

Materials and Methods: For conducting this review, online databases, including Medline, Scopus, ProQuest, Web of Science, SID, CIVILICA, and Google Scholar were systematically searched with no time limit from inception up to December, 2020. Based on the searches, 14 papers that concentrated on the spiral educational design model were identified. Of these, spiral educational design model was applied for educational planning of students in nine studies. These papers were extracted by the research team under close examination and their results.

Results: In various steps of repetition that increase the depth of contents at every stage, the results and consequences of applying the model in the spiral curriculum of the subjects from easy to hard are mentioned. Applying this significant approach, the spiral curriculum leads to a deep understanding of knowledge, proficiency in performance, building confidence, strengthening long-term memory and thinking skills, problem solving, and decision-making in the learner. This type of curriculum includes several characteristics and advantages.

Conclusion: The spiral curriculum reinforces learning by linking new knowledge to learners' prior cognitive construction. Spiral curriculum model could be applied at various levels of university education (general and specialized).

Key Words: Application, Curriculum Planning, Design, Medical Education, Spiral Model.

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Corresponding Author:

Masumeh Ghazanfarpour, Student Research Committee, Kerman University of Medical Sciences, Kerman, Iran.

Email: masumeh.ghazanfarpour@yahoo.com

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1- INTRODUCTION

Efficient learning is required for achieving learning objectives. Experimentally tested educational theories in the 20th century and mentioned in articles indicate that efficient adult learning takes place when there is a cycle of experience, feedback, thinking, and planning. When deep learning is put to the test rather than superficial learning, efficient learning could be achieved. Moreover, when the students' past learning is combined by novel learning materials, an efficient learning is observed (1).

As one of the subsets of education, educational design is placed alongside producing educational materials and implementation, management, and assessment of educational programs and is one of the most significant aspects of each curriculum. Medical education is no exception; in reality, it can be demonstrated that a beneficial and effective educational design is a significant contributor to successful education in a way that some believe that educational design is the heart of every educational attempt (2).

There are many questions waiting to be answered before designing a training program. A large amount of attention has been paid to purposes, curriculum content, teaching methods, assessments, and educational strategies such as problem-based learning and community-based integration and learning. Hence, the issue of content organization and the overall structure of curriculum remains a relatively forgotten area (3); therefore, plans for assessing the curriculum design must be considered to ensure coordination among students' perceptions, educational purposes, strategies, and other components of a curriculum (1). In the traditional curriculum design, a series of courses and a range of subjects and lessons are separately planned and tests are held for evaluating the competence of learners in each topic or course at the end of every year. There is little emphasis on how these knowledge or skills will be applied in subsequent courses and subjects. Thus, the students just enter each course with the objective of passing the exams. Therefore, there is a growing tendency to remove the boundaries between courses and subjects and have a more comprehensive look at the special purposes and overall goals of the curriculum. A spiral curriculum concept finds a special relevance here (3-6). Basic sciences, applied preclinical sciences, and clinical sciences are isolated in traditional layered method. In the conventional method, the students finds little connection between what they learn and what they are supposed to perform in clinical settings. The limited clinical experience leads the student to be challenged by serious limitations in knowledge, attitude, clinical reasoning and skills, and decision making after graduation (5).

The spiral curriculum has emerged in response to the issue that most learnings are static in subject-oriented patterns and these patterns are not suitable for students in a constantly changing world. Accordingly, this model was proposed as a replacement for other subject-based models to teach the subjects more meaningfully and focus on thinking skills more than other curriculum models (7).

Medical students initially pass basic sciences courses involving anatomy, physiology, and biochemistry and then enter the clinical science phase in traditional methods of medical education. The problem with this approach is the lack of connection between the materials taught in the basic sciences courses with the medical practices and clinical settings. Besides, after entering the clinical course, the contents taught in the past sessions are mostly forgotten (6). The spiral curriculum approach is still unfamiliar for teaching in separate departments, and does not possess

the comprehension and coherency to provide courses for medical students. Since the subjects taught to students are planned and performed by a respective department, professors feel that teaching every subject is separately justified (8). To solve this issue, during the last half century, many modern medical education institutions have adapted and applied the "spiral curriculum" concept in medical education. This spiral is applied in various ways in multiple institutions (5, 9).

2- MATERIALS AND METHODS

This research was conducted in 2018 as a comprehensive review of articles by a systematic search of database and search engines, including Medline (via PubMed), Scopus, ProQuest, and Web of Science and Persian databases, including SID, CIVILICA, Magiran, and also Google Scholar without time limit up to December 2020. To find research articles involving spiral educational design, the following keywords were searched: "Spiral", "Instructional design", "Curriculum", "Training", "Integration", "Medical Education", and "Course".

After completing the first search of papers in all databases and search engines, 14 papers that matched the research criteria were extracted based on title and abstract. Of these, one papers was in Japanese and, therefore, excluded. The remaining 13 papers were included in the research. This process was carried out independently and in duplication by two reviewers and any disagreement was resolved by a third reviewer.

3- RESULTS

At the end of the search process, 13 studies were selected. All papers were first reviewed in a comprehensive and thorough manner several times and then all contents were extracted and categorized. The results will be discussed divided in the following sections:

- Defining spiral curriculum model;
- Principles and features of spiral curriculum design;
- The advantages of spiral curriculum design model;
- Issues and limitations of spiral curriculum model;
- Results and consequences of applying the model; and
- Discussion and conclusions.

3-1. Defining spiral curriculum model:

In their study, Wark and Kohen explained the spiral as a metaphor, a pattern, and a concept which may involve aspects of human physical and even intellectual and psychological enhancement (10). Harden described the history and emergence of this concept in education. The concept of spiral model was introduced by Jerome Bruner in 1960. Brunner coined the term "spiral curriculum," and suggested that for effective teaching, the level of complexity of educational concepts and content should be gradually increased throughout the curriculum. The important approach in spiral curriculum is that new teaching content is prepared on the basis of prior knowledge and it is intended to facilitate the understanding of educational content for learners (3).

In the spiral curriculum concept, subjects, principles, and values are frequently reviewed along the way (**Figure.1**). A spiral training program is not a mere repetition of the subject being taught, but it requires the understanding of the subject to deepen with every successive encounter of a past subject (3, 9). A spiral training program supports the induction principle, which states that the whole is larger than the sum of sections. In this approach, students are taught that the way to progress is by putting the pieces of a puzzle together, and without a preview of the completed image, they will find it difficult

to finish the puzzle. Therefore, the research guide provided to students indicates how various sections of the curriculum are matched (4, 9).

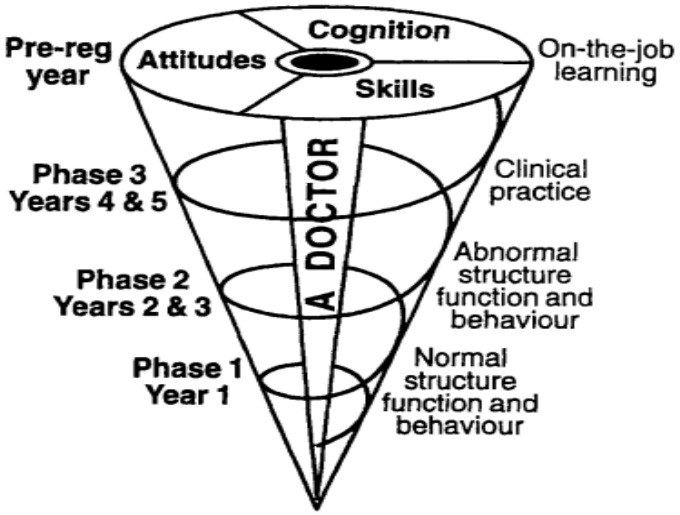

Fig.1: The Spiral Model.

3-2. Principles and features of spiral curriculum design:

The spiral educational model has special principles and features explained below:

- The initial objective, that is, providing high-quality learning experiences to students via an integrated helix educational program, is accomplished by combining learning with a deep understanding of knowledge not only through assessments, but also continuously (1).
- In this model, students review subjects, patterns, and objectives in a few steps over several periods (3, 6).
- Each review can involve new and more enhanced knowledge or skills considering a subject learned via practical experience (3).
- New learning is due to past learning; novel information and skills are based on past knowledge and skills and are a direct result of learning in past phases of spiral. Past learning is a prerequisite for later learning, as new knowledge and skills are repeated in subsequent lessons (3, 6).
- The level of difficulty increases in steps. It means the reviewed subjects and content become harder at successive levels. Every review adds purposes and proposes new learning situations which result in achieving the final objectives (3, 6, 8).
- Transparency and full understanding of subject at every step is required for students to retain intangible information (1).
- A logical arrangement is present in various steps and phases of spiral curriculum. It is necessary to pay attention to both aspects, i.e., the extent and breadth and the order of the topics. The spiral curriculum can help bring order to the complex nature of medicine and medical education (3).
- A spiral training program must have a spiral form; so, every novel cycle of this spiral must expand learning and not merely repeat past topics (1).
- A spiral curriculum must be designed so that in the transition between courses, the gap in expectations of consecutive semesters of students must be

covered so as to prevent learning problems for students (11).

- The instruction guide must be given to students at the beginning of a spiral curriculum. Also, this guide is a beneficial resource for the professors and staff involved in spiral training process. Combining learning outcomes in the guide and describing how individual academic conditions can help students achieve optimal and efficient learning outcomes will lead to major progress in education process (12).
- Assigning counselors and supporters to provide personal recommendations, reinforcement, and guidance to students before and during spiral curriculum is recommended (12).
- At the beginning of a spiral curriculum, a thematic content of science philosophy and clinical science sequences, including human thinking, communication, problem solving skills, judgment, and decision-making skills must be provided (5).
- In this model, knowledge structure is focused, and curriculum content is organized around knowledge to be taught. The knowledge structure encompasses all concepts, facts, and teachings (7).
- The content in this model is organized in a way which is sequentially proportional to the gradual intellectual enhancement of students (7).
- The spiral curriculum content is organized around two issues: one is major expert opinions and beliefs and the other is study methods in various subjects (7).
- In this model, knowledge is more suited to the cognitive and mental enhancement of students and is less presented in the form of isolate subjects (7).
- A spiral training program needs a complex process to run and think to determine how the end user, that is, the learner understands this process (1).
- The horizontal integration includes increasing the complexity of threads over a time period. In that period, all subjects are repeatedly taught in an educational program with increased complexity/difficulty, until full understanding and competence is achieved (1, 3, 4, 13).
- The vertical integration of topics enables students to deepen and expand the topics learnt in past years (1, 3, 4, 13).
- The spiral curriculum is highly flexible. In this model, the students can directly advance to the second spiral if they master the subject in a spiral (3).
- The spiral method is ideally used not only during the study course but also during people's lives (5).
- This model is a completely scientific approach of learning (8).
- Harden notes that it is important "not to underestimate the potential input of students into the curriculum. They are significant shareholders, they can play a significant role in designing the educational program and they can drive changes" (1).
- Students' skills and competency increase with every review and investigation. Until the final, overall objectives are reached. This forward enhancement in competence can be tested via assessments and evaluation processes (3, 6).
- One of the features of this type of curriculum is that students support other students and those of previous years (12).
- In this model, the conceptual knowledge provided from an informative lecture must be associated with clinical knowledge (1).

- This model requires a deeper understanding of subjects and disciplines by the teacher (7).

3-3. The advantages of spiral curriculum model:

- The spiral curriculum is a proven motivational instrument to improve students' learning as it incorporates prior knowledge, initiates interest, and strengthens learning (1, 5).
- The opportunity to consolidate and combine past knowledge is a demonstrated prominent advantage in this method. Rereading and revisiting topics help deepen students' understanding and learning (1, 3).
- In this model, the students' learning habits are changed from memorizing content (1).
- This model leads to enhancement of long-term memory, understanding, and self-confidence in the students (1).
- The educational approaches applied in this model encourage students to be more responsible for their learning (4).
- Knowledge sharing among beginners and professionals through reviewing and investigating the subjects in a spiral training program results in profession socialization which has been significant for adult learning in the last century (1).
- In the spiral curriculum, the students are encouraged to achieve higher objectives of the learning pyramid (3).
- This pattern teaches students learning approaches. It helps them better understand what they are learning, enabling them to utilize it in the future (7).
- During the implementation of spiral curriculum, novel insights are made in the students on the value of spiral thinking (10).
- This model proposes alternative routes for students with various backgrounds and objectives (8).
- Experience with this program has shown that successful changes in people participating in the program are achieved (8).
- The enhancement of clinical experience and practices for the students is one of the major advantages of spiral curriculum (5).
- The five steps of multi-theory adult learning model are disharmony, refinement, organization, feedback, and consolidation. In a spiral training program, it is facilitated with re-recalling and integrated learning, overcoming uncertainty and achieving full understanding. Thus, it may take several rings of this spiral to realize itself (1).
- Significant enhancement in medical education will be achieved via the integration of a low-cost curriculum like the spiral educational model which will result in medical education evolution (14, 15).
- Task-based learning is a highly profitable method of medical curriculum coherence or at least an effective and inexpensive method to enhance skills, attitudes, and competence related to the profession (12).
- In medical education, the spiral curriculum is an enhanced mixture of basic sciences and clinical activity which helps students to identify the cognitive, emotional, and functional skills needed in clinical settings and connect basic sciences to clinical activities (5).
- The majority of students would not be confused in the spiral curriculum. The students who might be confused are those who probably have a low understanding of its advantages (1).

- Instructors who enter the teaching process later in the course will be familiar with the objectives and content of their previous colleagues (10).
- Instructors who are new to continued teaching can handle a favorable review before moving to higher levels of this spiral (10).
- The instructor is encouraged to regard all levels of education passed during one class session (10).
- This model does not require a change in professors' behavior (8).

3-4. Issues and limitations of applying spiral curriculum model:

- The additional burden of information may arise due to high expectations in this period (1).
- The learner does not know where and when to drop learning, which part will be reread, or when the depth of training is enough for them to be qualified (1).
- When using this model in online courses, the practice of replacing past online courses, rather than supporting student learning, may inhibit students from learning efficiently (9).
- Teaching the major principles as well as study approaches may require a lot of time and result in many basic facts that are not acceptable for classroom teaching (7).
- Despite fundamental differences with other subject-oriented patterns, this model is highly reliable on subjects and, therefore, not in harmony with students' interests and might feel abstract for many students (7).

4- DISCUSSION

Maintaining and promoting public health for having healthy and dynamic people and inhibition and treatment of diseases are among the most significant objectives of governments. Without healthy people in society, other essential objectives cannot be achieved. Thus, teaching the profession of medical sciences is of special significance and sensitivity. In order for a medical graduate to perform their clinical skills and professional duties effectively, they require practicable and efficient training. Beneficial training occurs on the foundation of a strong educational program. Hence, regarding the advantages and disadvantages of spiral curriculum, it can be concluded that applying this educational model can considerably enhance this significant objective. Based on the available knowledge, this study is the initial research to comprehensively survey the features, advantages, and disadvantages of spiral curriculum model. By analyzing the different aspects and determining the factors and components of the spiral curriculum in various studies, the following can be discussed about this educational model.

The definition mentioned about the spiral model by various authors has the same concept and features (3, 4, 9, 10). In general, the features and benefits of the spiral curriculum can be categorized into three categories. One class involves characteristics, advantages, and disadvantages due to the overall nature of curriculum. This educational model could entail the significant principles necessary for a curriculum like strengthening learning at the high levels of the learning pyramid, low expenses and cost-effectiveness, coherence of the contents in the curriculum, creating a logical order and observing the sequence in the presented materials, participation of students in designing and reviewing the curriculum, and involving all three areas of cognitive, attitudinal, and skillful education. In the spiral educational model, other features and advantages of this model for students are as follows: deep understanding of knowledge, creating skill in performance,

strengthening inductive and spiral thinking skills, strengthening problem solving skills and decision making, strengthening self-confidence, and increasing responsibility for learning, self-development, creating a sense of cooperation and socialization in students, strengthening long-term memory, developing clinical experience and practice, and increasing students' awareness and competence with every review and investigation. The third category involves the features and advantages related to the professors and the other factors, including the model not being dependent on the change of behavior in the teachers, encouraging the instructors to regard all levels of education in the sessions, surveying the desired levels before moving to higher levels by the instructor, informing the newly educated professors and instructors of the objectives and contents of past colleagues, and the necessity of proficiency and contemplation of the professors in the subjects mentioned in the curriculum.

4-1. Study limits and propositions for the future

Although an exact and comprehensive search was attempted, several research studies may have been overlooked and not investigated. Different research was conducted on the effect applying spiral curriculum model in different aspects of learning like application in hypnosis, pharmacy, optometry, and medicine. Thus, to further develop, expand, and clarify this educational model, additional research in other scientific fields and disciplines is necessary.

5- CONCLUSION

Based on the results, the spiral curriculum has advantages over other forms of curriculum. The key features of the Bruner spiral curriculum that distinguish it from other curriculum forms are:

- The learner reviews and rereads a topic or topics several times during their studies.
- The complexity of each topic gradually increases with each revisit.
- New learning is associated to old learning and is placed within the framework of old information.
- Each time the learner approaches a topic, their information is reinforced.
- The spiral curriculum follows a logical process from simple ideas to more complex ideas.
- Learners are encouraged to develop their basic knowledge into future course objectives.

As a result, the spiral curriculum model can be applied at various levels of university education (general and specialized) and in multiple fields of medical sciences involving medicine, dentistry, pharmacy, anesthesiology, education, midwifery, nursing, and other fields. The spiral curriculum reinforces learning by connecting new knowledge to learners' prior cognitive construction. Therefore, using a spiral curriculum can improve the quality of training courses in medical schools.

6- AUTHORS' CONTRIBUTIONS

Study conception or design: HK, and KS; Data analyzing and draft manuscript preparation: HK, MG, and SP; Critical revision of the paper: HK, SP, and MG; Supervision of the research: MG and KS; Final approval of the version to be published: HK, KS, SP, and MG.

7- CONFLICT OF INTEREST: None.

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