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Design, Implementation, and Evaluation of Integrated Educational Module of Applications of Nanotechnology in Curriculum of Neuroscience Residents in Tehran University of Medical Sciences, Tehran, Iran

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Abstract
Background & Objective: The use of nanotechnology in neuroscience research is considered as an essential requirement while neuroscience students have little information in this regard and their educational program less addressed the applications of new technologies in research. Considering this need and by relying on the development of new educational methods, we aimed to design and implement an elective and integrated educational course for neuroscience students in Tehran University of Medical Sciences and then, assessed the level of satisfaction of learners with the course.
Materials and Methods: In order to design the curriculum, the Kern's six-step model was applied for curriculum development. In total, 15 neuroscience PhD students were entered into the research, educational needs of whom were determined. After determining the learning goals and outcomes, the educational contents were established and presented in the form of a workshop. In addition, the degree of satisfaction with the method was evaluated by a structured questionnaire designed by the team of lecturers using the Likert scale.
Results: Analysis of the results obtained from the questionnaires showed that more than 80% of the learners were satisfied with the course and recommended it to other students in the field. Furthermore, the professors emphasized the unique experience of individuals and superiority of the method to traditional teaching techniques in discussions.
Conclusion: The results of the program indicated that the module was successful in attracting the student satisfaction, and can encourage educators to use new educational strategies in neuroscience curriculum to help the researchers of the field. The continuation of implementation of this module is suggested for the target group in various educational years.

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Specific Objectives of the Project

- Designing an integrated program for the training of nanotechnology applications in neuroscience
- Providing integrated learning content
- Holding the integrated course for the target group
- Evaluating the opinions of students regarding the course
- Asking for the opinions of professors at the end of the course in the form of in-person interviews

Introduction

In the peripheral and central nervous system, communication and reaction of key biomolecules occur at the nanoscale (1). In modern neuroscience, the benefits of nanotechnology have been considered (2-4), which is so necessary that several articles have reviewed the dimensions of the relationship between nanotechnology and neuroscience. The use of nanotechnology is not only helpful in studying the structure and function of the nervous system in natural conditions but also is beneficial in identifying functional defects in diseases of the nervous system (3-4). Nanotechnology has spread not only in neuroscience but also in clinical neuroscience. The use of gene nanocarriers for the treatment of neurological disorders is an example in this regard (5). Nanotechnology also has the potential to provide new solutions to transfer drugs to inaccessible parts in some of the tumors of the nervous system (6). The use of nanoscale materials and new equipment in nanotechnology has promoted electrophysiological recordings and their integration (7, 8).

Nanotechnology has made significant progress in providing neuromolecules that play a role in monitoring the activity of the nerve cell membrane (9). To expand the use of nanotechnology in the field of neuroscience, both aspects of nanoscience design and engineering and our understanding of neurophysiology are crucial, which certainly require the collaboration between neuroscientists and nanotechnologists. The need for this collaboration has been presented in various ways not only by the professors but also by students in the field of neuroscience. Using nanotechnology in neuroscience will definitely lead us to a new world shortly in understanding the underlying neuropsychiatric diseases and ways to deal with them. In this respect, the first step is to identify nano application potentials in neuroscience and neurology, which requires interdisciplinary collaboration (2, 3).

Today, despite the presence of different opinions on education, integration has been accepted as an important educational strategy. Integration can occur in the content, methods, and the process of training and all subjects. Content-integration means establishing a link between students' knowledge of different subjects and disciplines. The presentation of the integrated discussions is not merely the concept of adding different information. In fact, its design must be such that it can motivate learners to in-depth learning (10, 11). We should highlight that, integration in the training program, is a strategy rather than an objective.

To the best of our knowledge, the curriculum determines educational strategies to achieve educational goals. In the SPICES model for curriculum design, the integration strategy is the opposite of the discipline strategy (10). In integration strategy, the related parts of a subject are taught alongside. In addition, students learn better, and subsequently have a better attitude toward their future career (12, 13). Moreover, among the curriculum planning models, we can refer to the Kern model, which is a six-stage approach consisting of needs assessment, identification of general and specific goals, program content preparation, educational strategy selection, as well as program execution and evaluation (14). According to the needs assessment performed, there are no elective and integrated courses in the neuroscience curriculum focused on new technologies.

In a survey of neuroscience assistants, they declared their tendency to use these methods in their research phase due to the development of new technologies in neuroscience. Nonetheless, they could not enter this field due to lack of familiarity with the paradigms and applications of these technologies. The importance of addressing this issue in postgraduate education has also been raised in other countries. Moreover, this is a necessity even at the level of American neuroscience schools (15). Considering the above requirements, based on the view that the integrated educational strategy increases the attractiveness and applicability of the basic sciences and emphasis on the development of new educational methods, we aimed to develop an integrated and elective educational module for PhD assistants in neuroscience in the School of Advanced Technologies in Medicine, and evaluate the satisfaction level of the target group. The implementation of this project will provide a good basis for the design and implementation of new educational methods and will be in line with the policy of higher education to improve the quality of post-graduate education.

Materials and Methods

In this study, Kern method was used to design the curriculum of the course. Accordingly, the need for using new methods in research stage was first determined through conducting a needs assessment with neuroscience assistants. However, lack of familiarization with the examples and applications of nanotechnology in this field was an obstacle for these individuals to use nanotechnology in their research. Considering the mentioned need, educational requirements of the target group were determined by expert opinion (Expert Idea Method) in a multidisciplinary team (neuroscience, nanotechnology, physiology, and pharmacology). Then, based on these needs, the learning outcomes related to the presentation of the lesson were determined. In total, 12 main outcomes were developed and educational topics were identified based on these categories, briefly including the basics of nano, neuroscience in nano dimensions, introduction to various nanoparticles and application of quantum dot, use of nanoparticle properties to limit neurological diseases, application of polymers and nano scaffolds in regeneration of the nervous system, and bypassing the blood-brain barrier and nano research dimensions in neuroscience. According to the topics presented, the educational content was provided to the learners in the form of a booklet.

Students were informed about the project in various ways, including poster, negotiating with the representatives of PhD students, sending emails and introducing a website, followed by providing a list of interested students. In fact, the academic semester was not considered an inclusion criterion and students of any semester were able to register for the course. If a student attended at the research stage, the information of this educational plan could be used in his future research works. Therefore, limiting the academic semester was not a criterion. In a briefing session, the necessary information regarding the course was presented to the students. It should be noted that since this educational course was held optionally, students were not obligated to attend any of the sessions and they would participate based on their personal interest. Given the allocation of the final stage of the Kern model to assessment, the level of satisfaction of students with the course was determined at the end of the program. In general, evaluation was carried out in a formative and summative manner and included asking the opinions of students through focus group discussions and completion of a questionnaire, as well as asking the opinion of professors at the end of the course via in-person interviews.

In order to achieve the objectives of the plan, firstly, interdisciplinary team members, including a neurophysiologist, nanotechnologist, and neuropharmacologist, were invited to collaborate based on the program needs and goals, their interest in participating in new educational strategies, and their expertise. After the start of the project, the interdisciplinary team conducted a meeting each week with the invitation of the project manager. During the various meetings, the purpose of and expectations from the course were discussed. Based on the evaluations conducted at the initial stage (i.e., determining the outcomes of the course) of a meeting attended by all members, faculty members were requested to write the educational goals, obtain the opinions of others and decide on the extent of communication with the goals. In total, 12 outcomes were formulated from summing up of educational objectives and based on the learning needs announced by the professors. Afterwards, the importance of each outcomes was categorized in three parts of better to know, must know, and nice to know in order to be used for future decisions made on the development of specific educational goals and selection of appropriate teaching methods. Following that, the implications of each discipline were announced to the relevant specialist, who was asked to develop specific educational goals (objective specific behavior) related to each outcome.

In separate meetings, the goals were assessed in terms of accuracy, comprehensiveness, relevance to the relevant outcomes, and the relationship with different disciplines. In addition, repetitive specific objectives were removed and overlapping issues were corrected as far as possible. Moreover, some goals were merged or changed on the basis of content convergence. Ultimately, consensus was reached on all the items by the design team. After determining the learning objectives and consequences related to the presentation of the module based on the opinion of the experts and determining the educational issues necessary for the design of the course, the methods of teamwork training and planned lectures in the form of a workshop were used for implementation. A variety of teaching aids, including slideshows, boards and brochures, were also used. A total of 15 PhD candidates in neuroscience, who volunteered for participation, were enrolled in the order they were registered. The effect of training was determined by conducting a pre-test before the presentation and a post-test at the end of the course. At the end of the course, a visit was carried out on nanotechnology labs and research work, and the degree of satisfaction with the way they held and the views of the students were evaluated by a questionnaire. Items of the test and structured questionnaires were designed based on multiple meetings in the working group of the teachers, and Likert scale method was used for scoring. Moreover, structure reliability was confirmed using Cronbach's alpha index.

In order to select the target group, students were informed about the course using a poster, through the representatives of the students and by designing a relevant website. Afterwards, registration was carried out among the interested students. In general, the first 15 students were contacted for attendance in the module, and if the student was able to attend the day and the hours mentioned, his name was placed on the list. As a result, 15 students were put on the list. The demographic characteristics of the participants are presented in Table 1. In order to comply with ethical issues, and since the module was elective, only students who were willing to attend were enrolled in the study. Therefore, the subjects had an intentional tendency to participate in the module. In addition, the results of pre-test and post-test had no impact on the scores and student's grade average.

In this course, team teaching and planned lecture were used for course content training. For example, the less prioritized educational goals were presented through planned lecture methods and were limited to providing information on the subject. On the other hand, the highly prioritized goals were introduced using the methods of interactive training, brainstorming and providing targeted questions that, in addition to knowledge, affected the attitudes and intellectual and practical skills of students. With regard to the space and educational facilities, and the possibility of better interaction between the teacher and the students, the number of students was considered to be 15. By considering the total number of neuroscience students at run time, we had needed more than 50% of student’s participation, to catch the number of 15 people in the module.

The structured questionnaire was designed based on multiple sessions in the working group of teachers, and the Likert scale was used for scoring. In addition, the reliability of the questionnaire was evaluated in terms of content and structure. In order to quantify the students' opinions, the items of the questionnaire were scored using the Likert calculation method. The degrees of this spectrum included completely disagree=1, disagree=2, no comment=3, agree=4, and completely agree=5. The contents were discussed by experts, and the structure reliability was confirmed at the Cronbach's alpha of 0.764. The questionnaires were provided to the students immediately after the end of the project by the executive staff (other than the course's instructors), who analyzed the questionnaires after completing the delivery. The percentage of students' satisfaction with the course was also calculated using the following formula that was used in previous studies (16). In this regard, satisfaction was reported to be 87.2%.

$$\text{Percent of construct} = \frac{Sum\ of\ construct\ score - Min\ construct\ score}{\text{Max construct score} - \text{Min construct score}} \times 100$$

Results

In total, 86% of the subjects were female, which, given the higher number of female, compared to male assistants in all entries, the percentage of male participation was significantly considerable. While this integrated approach with the subject of nanoscience applications in neuroscience was first held at the school and university level, integrated projects with other topics had already been held at the university level. Nevertheless, about 80% of neuroscience assistants reported lack of experience of participating in an integrated program (Table 1).

Table 1: Demographic characteristics of participants in integrated module of nanotechnology applications in neuroscience

Characteristics of Participants	Data
Educational year (Number of persons)	
First Year	8 (53.3%)
Second Year	4 (26.7%)
Fourth Year	3 (20%)
Gender (Female)	13 (86%)
Be familiar with integrated education (no %)	12 (80%)
Previous participation at integrated modules (no %)	12 (80%)

To collect data, 15 questionnaires were distributed among the students at the end of the course, all of which were completed and returned at the same time and place by the participants, leading to a 100% participation. Data related to the first part of the questionnaire (quantitative) were analyzed in SPSS. Results of descriptive analysis of the data are shown in Table 2, presented based on the frequency percentage of student selection. In order to facilitate the study of the results and their application in the decision-making process of the education authorities, the frequency percentage of the views of "completely agree" and "agree" were collected and determined as positive attitude toward this issue, whereas the frequency percentage of the views of "completely disagree" and "disagree" were recognized as negative attitudes toward this area. The results are shown in Table 3.

Table 2: Questionnaire items for the evaluation of integrated module of nanotechnology applications in neuroscience based on the Likert scales with five response choices ranging from 1 to 5.

Questionnaire Items	Strongly agree	Agree	No comment	Disagree	Strongly disagree
Neuroscience students at educational level are the best group for participation in this module.	8 (53.3%)	6 (40%)		1 (6.7%)	
The place of holding was appropriate.	12 (80%)	3 (20%)			
Facilities quality were suitable.	14 (93.3%)	1 (6.7%)			
Teachers were highly qualified for managing the module and presenting the subjects.	8 (53.3%)	4 (26.7%)		3 (20%)	
All educational objectives were clarified for the learners.	11 (73.3%)	3 (20%)		1 (6.7%)	
The participants were involved in discussions.	2 (13.3%)	7 (46.7%)	3 (20%)	3 (20%)	
The number of the participants in module were appropriate.	11 (73.3%)	4 (26.7%)			
The schedule of the module timely done.	6 (40%)	6 (40%)		3 (20%)	
The considered time were appropriately designed to achieve instructional goals.	12 (80%)	3 (20%)			
The educational strategies were appropriately selected.	10 (66.7%)	5 (33.3%)			
The proper accessory instructional devices were managed to achieve instructional objectives.	4 (26.7%)	10 (66.7%)	1 (6.7%)		
The necessary facilities were taken to hold the course appropriately.	9 (60%)	5 (33.3%)		1 (6.7%)	
This module was able to provide a sufficient knowledge and proper perception of nanotechnology applications in neuroscience.	9 (60%)	3 (20%)	3 (20%)		
I suggest the participation in the module for further neuroscience students.	11 (73.3%)	4 (26.7%)			
I will use the knowledge that I have gained during participation in module in future.	9 (60%)	6 (40%)			

Table 3: Questionnaire items for the evaluation of integrated module of nanotechnology applications in neuroscience. The abundance of students' responses to the Likert scale were calculated into percentages. The strongly agree and strongly disagree responses were gathered with agree and disagree responses respectively.

Questionnaire Items	Agree	Disagree
Neuroscience students at educational level are the best group for participation in this module.	14 (93.3%)	1 (6.7%)
The place of holding was appropriate.	15 (100%)	
Facilities quality were suitable.	15 (100%)	
Teachers were highly qualified for managing the module and presenting the subjects.	12 (80%)	3 (20%)
All educational objectives were clarified for the learners.	14 (93.3%)	1 (6.7%)
The participants were involved in discussions.	9 (60%)	3 (20%)
The number of the participants in module were appropriate.	15 (100%)	
The schedule of the module timely done.	12 (80%)	3 (20%)
The considered time were appropriately designed to achieve instructional goals.	15 (100%)	
The educational strategies were appropriately selected.	15 (100%)	
The proper accessory instructional devices were managed to achieve instructional objectives.	14 (93.3%)	
The necessary facilities were taken to hold the course appropriately.	14 (93.3%)	1 (6.7%)
This module was able to provide a sufficient knowledge and proper perception of nanotechnology applications in neuroscience.	12 (80%)	
I suggest the participation in the module for further neuroscience students.	15 (100%)	
I will use the knowledge that I have gained during participation in module in future.	15 (100%)	

At the end of the course, the opinions of the professors of the course were asked through an in-person interview. The professors who participated in an integrated project for the first time emphasized the importance of this different experience and its superiority to traditional teaching methods. Teachers who have already experienced the implementation of integrated educational modules also acknowledged that the integrated training strategy for each educational subject was a new and unique experience. Despite the fact that they had a lot of time was dedicated to the design and implementation of the course, they were willing to repeat this experience for other target groups.

Discussion

In the present study, more than 80% of the students were satisfied with holding the course and recommended it to other students of the field, which showed the acceptable success of this integrated educational plan in attracting the attention of learners and achieving the educational goals determined. The educational module was designed using six stages of educational planning in Kern model, which have been applied in several other studies (16, 17). For instance, Ejtemaei Mehr et al. (2011) used the Kern model to design an integrated educational program on brain basal ganglia for medical students (16). In this regard, Goudarzian et al. applied the model to design the curriculum of diabetes nursing (17). However, the design of an integrated training module requires the formation of an interdisciplinary team while taking into account the required disciplines. It is evident that in the formation of such a team, the team members face various facilitating and inhibiting factors, referring to which as practical experiences is significantly important in bringing different disciplines closer to each other. Some of the facilitating factors during teamwork include the interest of team members in the integration approach for curriculum designing, collaboration with faculty members from different disciplines as a new experience, and having a shared point of view in this area. On the other hand, some of the inhibitors can be the coordination problems of the group to hold meetings in the hours that all members are present, conflict of interest in the perspective of individuals to choose core topics from non-core issues, lack of full financial support for the relevant research unit and relevant constraints in choosing appropriate educational strategies.

In the current study, the students were first asked to determine the percentage of integrated or optional topics or student-oriented educational programs. In total, 90% of the subjects reported that their educational program was based on discipline, there was no optional item, and the courses were mostly teacher-oriented. It seems that time has come to make changes in the decision-making process in the field of higher education in order to improve the quality and use of modern teaching methods. One of the reasons for lack of welcoming modern teaching methods and changes in teaching methods by teachers is the problems of implementing these educational projects, including lack of sufficient facilities and equipment and appropriate educational environment, uncertain student feedback and the possibility of decreasing popularity of teacher to learners and its impact on assessing teachers' teaching quality, lack of support from higher education officials and other unpredictable cases.

The necessity of attention to these needs and challenges has been pointed out in other studies (18). In the research by Synman and Kroon, a model for the longitudinal and transverse integration of information and skills for dental students was presented. They reported that from the perspective of the course instructors, the model was presented for operational integration (19). The use of a longitudinal integration model in American medical education has also received a great deal of attention, and further studies are required to analyze its effectiveness on proposed educational returns (20). In addition, the experience of using integrated methods for medical education in Iran has been reported, where the horizental integration method was used to provide basic science courses to undergraduate medical students. They presented the basic science courses of an organ simultaneously (21).

It seems that the barriers and challenges occurring due to the implementation of integrated education topics commonly appear to who enter this field. In the present study, coordination between the team of experts to write the scenario of the program and review of the operational implementation procedures was extremely difficult due to a different weekly schedule of the colleagues, which led to a prolonged design period. Moreover, since the specialists in the field of neuroscience and nanotechnology had no in-depth recognition of each other's specialized field, a lot of time was spent on obtaining a common language among the team of experts. These challenges were observed in efforts made by Ejtemaei Mehr et al. as well (16), who were faced with similar challenges in design and implementation of longitudinal and transverse integrated educational module for medical students (16). In another study by Siverthorn et al. (2006), the barriers and challenges existing in the execution of an integrated educational program in the field of physiology were assessed. These researchers reported various challenges of presenters from interacting with educational managers to time and space constraints and dealing with different tastes of learners to personal barriers of individuals (22).

In a research by Mortaz et al. (2018) conducted to review medical education, the challenge of resistance to change was pointed out. These scholars suggested that new educational methods (e.g., integration) be assessed and applied to draw a better future (21). In the present study, results shown in Table 1 demonstrated that approximately 80% of participants of the course were in the educational stage, and more than 90% of the participants believed that these students were the best group for participating in this course, who recommended this type of education to other students in the field of neuroscience. The reason the learners presented in the group discussion was, increased attitude and awareness for choosing a research project before the start of the research phase. Today, the use of new technologies in neuroscience is a necessity. Therefore, most PhD students in this field are interested in using modern technologies in their research, which requires the knowledge of the alphabet of these technologies that can be provided through the implementation of educational projects.

Obviously, acquiring the satisfaction of all learners is not easily possible due to the different background fields at the time of entrance, as well as their various talents and research interests. Nonetheless, we can increase the percentage of satisfaction by knowing and eliminating the weaknesses in this regard. A high percentage of learners believed that the instructors had the ability to handle the sessions and present the content. In re-test, the learners referred to the weaknesses of the course, including the long duration of presenting the basic issues of nanochemistry, low allocation of time to applied cases, the low level of presenting examples in this area, and the high rate of presentation of materials. However, the learners referred to providing the possibility of a brief overview of the nanotechnology in a short duration as a strength, regarding it a unique opportunity. These individuals explicitly announced that a window has been opened to nanotechnology for them.

According to the statistical valuation of results of questionnaires and based on an equation presented in the “materials and methods” section of the present research, it was determined that about 87.2% of the students were satisfied with the course. In 2014, Rafique reported that 74% of the subjects announced the superiority of the integrated method over traditional techniques, and 86% marked that the integrated methods facilitated learning. In the mentioned research, the students demanded continuous use of such educational methods in the future (23). It seems that the continuous holding of these courses for the target group of this study can lead to more precision in judging the necessity of holding these courses. It is obvious that by reducing the weaknesses, increasing the learner's satisfaction and creating an initial attitude towards the design of applied research projects in the field of nanotechnology in neuroscience in line with the university's macro-educational policies, we can move toward more elective modules for graduate students. It is hoped that the reports presented in the current study will be an even small prototype example for implementing future integrated training plans to encourage groups to use new teaching methods in graduate education programs. In the end, it is suggested that in order to confirm the impact of this intervention and the new program, higher levels of Kirkpatrick's model, such as changing behavior in learners, be also evaluated.

Conclusion

In the current research, the results were indicative of the acceptable success of this educational program in attracting the attention of neuroscience students and achieving the educational goals determined. Therefore, it can be an even small prototype and model for implementation of integrated educational programs in the future. Moreover, the level of satisfaction of the target group can encourage educational authorities to use new technologies in neuroscience for researchers in this field. The continuation of its implementation in different periods is recommended to achieve a more concise conclusion.

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References

1- Andrews AM, Weiss PS. Nano in the brain: nano-neuroscience. *ACS Nano*. 2012; 23;6(10):8463-4.

2- Silva GA. Neuroscience nanotechnology: progress, opportunities and challenges. *Nature Reviews Neuroscience*. 2006;7(1):65.

3- Suh WH, Suslick KS, Stucky GD, Suh Y-H. Nanotechnology, nanotoxicology, and neuroscience. *Progress in Neurobiology*. 2009;87(3):133-70.

4- Cooper DR, Nadeau JL. Nanotechnology for in vitro neuroscience. *Nanoscale*. 2009;1(2):183-200.

5- Khanh TMT, Wei D, Tran PHL, Tran TTD. Nanotechnology in Neuroscience and its Perspective as Gene Carrier. *Curr Top Med Chem.* 2017;17(12):1379-1389.

6- Das S, Carnicer-Lombarte A2, Fawcett JW2, Bora U. Bio-inspired nano tools for neuroscience. *Prog Neurobiol*. 2016;142:1-22.

7- Dufour S, De Koninck Y. Optrodes for combined optogenetics and electrophysiology in live animals. *Neurophotonics*. 2015;2(3):031205.

8- Scaini D, Ballerini L. Nanomaterials at the neural interface. *Curr Opin Neurobiol*. 2018;50:50-55.

9- Weiss PS. Brain activity mapping project: applying advances in nanoscience and nanotechnology to neuroscience. *ACS Nano*. 2013; 26;7(3):1825-6.

10- Harden RM. The integration ladder: a tool for curriculum planning and evaluation. MEDICAL EDUCATION-OXFORD-. 2000;34(7):551-7.

11- Li L, Tang J, LvJ, Jiang Y, Griffiths S. The need for integration in health sciences sets the future direction for public health education. *Public Health*. 2011;125(1):20-4.

12- Ginzburg SB, Deutsch S, Bellissimo J, Elkowitz DE, Stern JN, Lucito R. Integration of leadership training into a problem/case-based learning program for first- and second-year medical students. *Adv Med Educ Pract*. 2018; 9;9:221-226.

13- Postma TC, White JG. Students' perceptions of vertical and horizontal integration in a discipline-based dental school. *Eur J Dent Educ*. 2017;21(2):101-107.

14- Kern DE, Thomas PA, Hughes MT. Curriculum development for medical education: a six-step approach.

2ed. Baltimore. Maryland: The Johns Hopkins University Press; 2009:253.

15- Ramos RL, Fokas GJ, Bhambri A, Smith PT, Hallas BH, Brumberg JC. Undergraduate Neuroscience Education in the U.S.: An Analysis using Data from the National Center for Education Statistics. *J Undergrad Neurosci Educ*. 2011;9(2):A66-70.

16- Mehr SE, Hassanzadeh G, Zahmatkesh M, Seyedian M, Arbabi M, Mirzazadeh A, et al. Medical students' viewpoint regarding the integrated module of Basal Ganglia. *Acta Medica Iranica*. 2011;49(11):753-9.

17- Goudarzian S, Yamani N, Amini M, Abazari P. Curriculum Development for Postgraduate Diabetes Nursing Program based on Kern's Curriculum Planning Model in Iran. *Iranian Journal of Medical Education* 2017;17(8).

18- McGrath BP, Graham IS, Crotty BJ, Jolly BC. Lack of integration of medical education in Australia: the need for change. *Medical Journal of Australia*. 2006;184(7):346.

19- Snyman W, Kroon J. Vertical and horizontal integration of knowledge and skills–a working model. *European Journal of Dental Education*. 2005;9(1):26-31.

20- Gheihman G, Jun T, Young GJ, Liebman D, Sharma K, Brandes E, Ogur B, Hirsh DA. A review of longitudinal clinical programs in US medical schools. *Med Educ Online*. 2018;23(1):1444900.

21- Silverthorn DU, Thorn PM, Svinicki MD. It's difficult to change the way we teach: lessons from the Integrative Themes in Physiology curriculum module project. *Advances in physiology Education*. 2006;30(4):204-14.

22- Mortaz Hejri S, Mirzazadeh A, Khabaz Mafinejad M, Alizadeh M, Saleh N, Gandomkar R, Jalili M. A decade of reform in medical education: Experiences and challenges at Tehran University of Medical Sciences. *Med Teach*. 2018; 23:1-9.

23- Rafique N. Designing and implementation of vertically and horizontally integrated endocrinology and reproduction module. *Pak J Physiol*. 2014;10(3-4).