AN ATTEMPT AT OPTIMIZING THE ORGANISATION AND METHODOLOGY IN THE SEMINARS ON MATHEMATICAL ANALYSIS

Lilyana Karakasheva – Yoncheva
"Bishop Konstantin Preslavski "University of Shumen, Bulgaria,
115, Universitetska str., 9712 Shumen
lkarakasheva@mail.bg

ABSTRACT

Taking into account the specificities of Mathematical Analysis and the psychological characteristics of students nowadays, the article discusses a change in both organizational and methodological aspects of the seminar on mathematical analysis based upon the main principles of andragogic approach.

INTRODUCTION

Research in higher education could be envisaged as a process concerning the operation of a system containing three major components:
• Knowledge, skills, norms of behavior, etc. acquired and developed by society at a certain stage of its development;
• Students whose mentality has to be developed to a certain level based on the mastery of some social experience at a given stage;
• Academic staff /instructors/ who manage and facilitate gaining this social experience [3, p. 25-29].
This system is represented graphically in Figure 1.

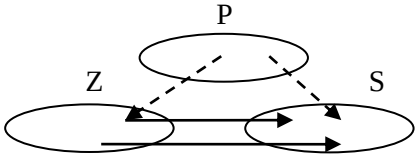

Fig.1

In the figure, Z represents the set of knowledge, skills, beliefs, etc., to be mastered and internalised by the students; S is the set of students, and P- the set of academic staff /instructors/. The continuous arrows directed from the elements of Z to the

elements of S represent the utilization of relevant knowledge, skills, etc., already mastered by some students without the direct intervention of the teacher, i.e through the use of textbooks alone or through the use of educational materials and books, and appropriate educational software. The broken arrows also represent the utilization of knowledge, skills, etc., acquired with the help of the instructors. Since this article focuses on a university training course in Mathematical Analysis (MA), some further specifications are necessary. Hereby, Z will represent the system of mathematical knowledge in MA, corresponding to the curriculum for the respective course; P will be the set of instructors in MA, and S - the students in the first year of their studies at the university.

The optimal functioning of this system could be achieved by optimizing all components of the didactic training and research process in higher education. These include lectures, seminars, exercises and self-study. However, in the university course of MA the basic forms of instruction remain lectures and seminars.

My discussion of the instruction process in higher school is based on the concept of university education as an activity with a double-entity subject [12, p. 40]. The functioning of the first subject /the instructor / significantly influences the functioning of the second operator /the student/.

MAIN PART

In search of opportunities for improving the organization and methodology of the seminars, I have taken into account the specificity of the main elements of the above system (Fig.1).

1. Features of mathematical knowledge in MA

The university course in Mathematical Analysis is described as a logical system of definitions, axioms and theorems. The main method of instruction for university students is the abstract deductive approach. However, first year students find it difficult to adapt to it since in their previous education in the secondary school the prevailing form of instruction was the intuitive visual approach. Furthermore, the amount of acquired content knowledge per certain unit of time is much smaller. Gyudzhenov [3, p.31-35] examines in detail the specifics of mathematical knowledge in higher education. And since the definition of concepts, proving theorems and solving mathematical problems in MA as mathematical activities are the same in terms of their structure as in other mathematical disciplines in higher education, we can assume that the requirements for teaching Mathematics at university apply to teaching MA as well.

In the organization of seminars I have followed the five basic requirements enlisted by Gyudzhenov [3, p.33-39]. I have specified and adapted some of them for my seminars in the following way:

a) Ensuring the understanding and rationalization of the basic concepts defined in the lectures, by using meaningful examples - illustrative and counterexamples as well as problem solving;

b) Use of various means of developing skills for multi-purposeful use of definitions and theorems;
c) Creating conditions for the detection of relationships, laws and building skills for their application in a purely mathematical activities, and in the application of mathematical knowledge in situations not related to mathematics;
d) Use of various techniques, both traditional and new ones, for creating possibilities to present knowledge and skills as an important component of the professional preparation, and as a factor in intellectual development and self-study.
Compliance with these requirements helps to:
a) attract and retain students' attention;
b) facilitate the process of understanding of acquired knowledge;
c) facilitate the process of consolidation and storage of the knowledge;
d) develop skills to operate with the knowledge.
2. Psychological characteristics of the individual student
It has been proved that the level of interest and attention decline after the 20th minute [13, p. 122]. This leads to a need for rotation of different activities in order to recover the attention to the initial level. Therefore, during the seminar, the instructor can use a computer or a slide projector to visualise some of the concepts or give students some additional historical background related to topics discussed in the seminar, as well as some curious facts from the life of a scientist, etc.
The process of improving the storage and memory capacity in students is supported by creating conditions for structuring and systematization of educational content. Large amounts of scientific information in the MA course, however, could be learnt and remembered only if there is strong motivation for this. Taking this factor into consideration can lead to improving students' active participation and concentration in various mathematical and educational activities in the seminars.
3. Characteristics of the instructors conducting seminars
The seminars are usually conducted by an assistant professor.
Assistant professors get a position at the university after successfully passing an exam in the relevant speciality. Some of the assistant professors have a PhD or other academic titles, although the majority of the teaching staff have not been formally trained to be teachers/instructors, i.e. they do not have a pedagogical qualification, including disciplines such as psychology, pedagogy and methodology of teaching mathematics in secondary school. None of my colleagues at the higher institution where I work, namely "Bishop Konstantin Preslavski" University of Shumen, has studied methods in teaching mathematics at university or has some formal training in psychology or andragogy.
In recent years, higher education has become widely accessible and the composition of the student group is heterogeneous. A lecturer/ instructor at the university, therefore, must possess a rich arsenal of tools and approaches for ensuring an effective learning process. S/he definitely needs knowledge of age psychology and differential psychology, which deal with individual differences. This is so because "the modern understanding of the professionalism of the

instructor must include knowledge and skills for planning, organizing and controlling the learning process so that students receive maximum knowledge, skills and satisfaction from their working together with the academic staff " [6, p. 26].

The strive to improve the quality of higher education in order to achieve higher learning outcomes and continuous self perfection, implies a constant process of improvement for the university lecturer both in his specialty and in psychology and didactics "in accordance with the changed nature of the academic profession and the new profile of students" [4, p.53].

Taking into account the particularities of mathematical knowledge in MA and complying with the psychological characteristics of the modern student, after a thorough examination of the available literature in the field and based upon my considerable educational experience [8], I have changed some of the organizational and methodological aspects of the seminars in MA.

The changes are as follows:

• In search of balance between the best traditions and achievements of the national higher education, and given the requirements and needs of society, I have changed some organizational aspects;

• In the methodological aspect, based upon the achievements of the methods of teaching mathematics at secondary school, adapted to the specificity of university education (where possible), I have introduced didactic changes in certain topics from the MA syllabus.

The organization of seminars is based on some fundamental aspects of the andragogic approach to teaching adult learners, whose essence and basic principles are depicted by Gurova [5]. I have developed a model for teaching first year students which is presented in Karakasheva [9].

In my model, the first seminar has purely organizational functions. It contains the following main points:

• The teacher/instructor introduces her/himself and talks to the students. S/he may use different introduction techniques [14]. My experience shows that this approach is a good ice-breaker, helping the teacher and the students to get to know one another, thus creating favourable conditions for an environment which enhances the communication between the students and teacher.

• The teacher/instructor presents the curriculum /the contents or the list of topics/ for the studied discipline. It is visualized on a screen. Students' attention is drawn to the main sections that will be studied and the relations between them;

• Each student receives a thematic plan of the seminars;

• The teacher/instructor explains the organization of work, i.e. how the seminars will be conducted and why they are essential for the professional preparation of each student;

The organization of the work students have to do is presented in the following scheme (Fig. 2).

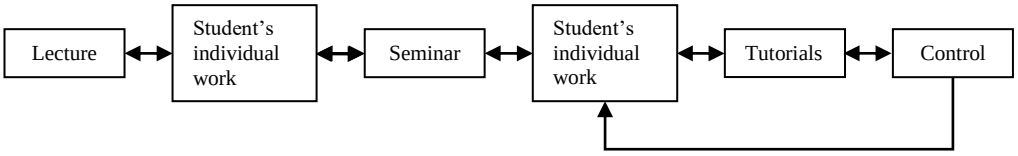

Fig. 2

• The teacher/instructor clarifies what is expected of students in their preparation for each seminar;
• The teacher/instructor gives detailed guidance on the criteria and forms of assessment;
• The teacher/instructor announces the number of tests to be taken and their duration;
• The teacher/instructor explains the criteria for the final assessment of the current control;
• The teacher/instructor explains the requirements for admission to taking examination and exemption from written examination involving solving mathematical problems;
• The teacher/instructor gives out samples of exam tests and topics.

Thus, from the very first seminar the students know what is expected and required of them in their preparation for the seminars and how they will be working during the semester. They realize the importance of attending seminars and being motivated for work

The achieved results, of course, depend very much on the preparation and implementation of each seminar.

The stages of the learning process in the rest of the seminars are presented in Figure 3.

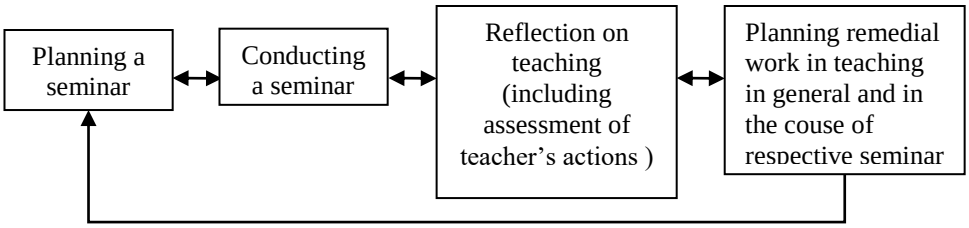

Fig. 3

The seminar itself is carried out in an environment of mutual respect, support and cooperation. The andragogic approach requires creating and maintaining a learning environment free from criticism to trainees and giving them the opportunity to express their opinions freely.

For each of the topics to be studied I offer students a set of training materials with the following structural elements:
A) A handout for individual work;
B) A handout which includes:
a) Texts of tasks to be solved during the seminar;
b) A set of problems for practice and self study (with answers provided);
c) Tasks for more advanced students willing to learn more;
d) Historical background related to the topic.
At the end of each seminar following the first one, each student receives a set of learning materials for the next topic.
In this way, the teacher is not only a source of knowledge who supports, facilitates and accelerates the process of mastering the skills and habits, but s/he is also the organizer and coordinator of the activities through which students acquire and consolidate knowledge and skills and form habits.
In what follows I will discuss in more detail the way to construct the handout for individual work, since it represents a new element in the set of learning materials. The handout for individual work contains a set of questions and problems on the topic. The order of questions is guided by some requirements for structuring knowledge presented by Ganchev [2]. The questions are arranged so as to help the understanding of new knowledge. The proposed examples provoke a multifaceted discussion of the new concepts which facilitates the process of understanding and helps relate new and old knowledge. This promotes successful internalisation and storage of mathematical knowledge [11, p.69], [15, p. 259], which in turn supports the process of skills development enabling students to operate with acquired knowledge.
Some of the tasks proposed in the handout for individual work are accompanied by guidelines and are relatively easy for the students.
The tasks proposed in the handout are to be solved individually by each student before the seminar on the respective topic.
An important step in planning the seminar is to determine the amount and the complexity of the study material in line with the aims and the time required to achieve them. The study materials to be covered in MA seminars is a combination of concepts, definitions and theorems, which help to clarify these concepts, as well as appropriately selected group of tasks which facilitate the utilization of mathematical knowledge and skills formation.
It is widely accepted that the effectiveness of a seminar depends on the selection, the arrangement and the manner of presentation of the solutions of tasks to the students.
When selecting and ordering the tasks for the seminar, I have taken into account the following requirements stated by Ganchev [1]:
1. The grouping of the tasks should correspond to the method of their solution. They have to be arranged so that the solution of each task (without the first one) should contain solutions of those preceding it.

2. The principle of the so-called triple aim should be observed, so that each task's solution is helped by the solution of the previous one, and subsequently helps to solve the one that follows.
3. The general idea in the solutions of the tasks from each group should be outlined.
4. Each task group should be aimed at achieving a specific goal of training. Moreover, the task should be diversified by type and support the formation of skills of different level.
5. The tasks should be arranged depending on the degree of complexity of their solutions. At that, each task (except the last one, which is central for the group) is seen as a component of the next task, so as to reduce the degree of difficulty.
6. The tasks from the handout should be of the type ZAD (Zone of Actual Development) and those to work on during the seminar should be of the ZPD type (Zone of Proximal Development) [10].
7. Each task should be solved in several possible ways and the most rational solution should be identified.

For example, the task is to calculate the integrals $\int_0^{\frac{\pi}{2}} \sin^2 x dx$ and $\int_0^{\frac{\pi}{2}} \cos^2 x dx$.

The students usually do the calculations in the traditional manner by using the formulas for the reduction of the level. There is, however a better and a more original solution, by using the following dependency: $\int_a^b f(x)dx = \int_a^b f(a+b-x)dx$. This dependency has previously been proved as a separate task. But the students do not normally remember to use it and so have to be directed by the teacher, so that they can use it in solving this problem.

In this case $I = \int_0^{\frac{\pi}{2}} \sin^2 x dx = \int_0^{\frac{\pi}{2}} \sin^2\left(0 + \frac{\pi}{2} - x\right)dx = \int_0^{\frac{\pi}{2}} \cos^2 x dx$.

Thus we get $2I = \int_0^{\frac{\pi}{2}} (\sin^2 x + \cos^2 x)dx = \frac{\pi}{2}$. And therefore $I = \frac{\pi}{4}$.

8. The same tasks should be used to achieve different goals.
9. The attention of the students should be drawn to some typical students' errors, as well as to discussing tasks to detect mathematical errors.
10. Conditions should be created to prepare students for designing tasks of their own.

Ivan Ganchev in [1, p.155] emphasises the fact that "an important role in the methodology of developing skills to perform an activity is played by the ways of

checking its results". Although this idea is mentioned with regard to secondary school education, I think that it is relevant to higher education as well.
The operation control and monitoring give us information on how students acquire and accumulate knowledge during the semester.
The operational control is carried out mainly by oral testing at the beginning of the seminar and less frequently through written tests including solving task of the ZAD type. Its role is to prepare the students for the upcoming work.
The ongoing monitoring is carried out by means of two written tests. The solutions to the task should be discussed immediately after it, when the students are still agitated and eager to work. The solutions are visualised in a kind of slideshow so that each student can identify and understand his/her mistakes. By doing this, it is possible to make the most of a time which is essential in terms of its psychological value. It is at this very moment that the students are particularly willing and eager to listen to the teacher/instructor's explanations. This approach has been borrowed from Ganchev [1, p.27- 28] and, in my opinion, is appropriate for higher education instruction as well.
The individual work is controlled by way of homework assignments and term papers that are reviewed, corrected, evaluated and returned to the students.
Thus discussed means for receiving feedback can be enriched by use of personal computers and relevant software. Unfortunately, though, such software for MA instruction in University of Shumen has not been developed yet.
The ongoing control and monitoring help students get used to a regular and systematic study throughout the semester, and by doing this they fulfil their main functions – to educate and motivate at the same time.
When well planned and organized, monitoring and ongoing control can link their results to the overall assessment of the study subject in question. It can be obtained as a linear combination of the following components:

a) a_1 – student's average tests' scores;

b) a_2 – student's average homework assignments marks;

c) a_3 – the overall assessment of the student by the assistant professor for his/her work during the semester;

d) a_4 - the exam grade.

These components have different weight, respectively $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{8}$ and $\frac{1}{2}$, so the overall evaluation O_k is calculated with the formula:

$$O_k = \frac{1}{4}a_1 + \frac{1}{8}a_2 + \frac{1}{8}a_3 + \frac{1}{2}a_4.$$

This method of evaluation was proposed by L. Iliev [7, p.8]. In my opinion, it is a good model for evaluation and could be applied in the present context, with the addition that a_2 is the average of the estimates of homework assignments and term papers.

CONCLUSION

The organization of seminars presented in the article can definitely lead to more active students' participation in the educational process and scientific research.

REFERENCES:

1. Ganchev, I., Essential activities in a mathematics lesson, Modul-96, Sofia, 1999, p.196 (in Bulgarian)
2. Ganchev, I., An Idea for a Methodological Analog of Euclid's Elements, Mathematics and Mathematics Education, Sofia 2005, pp 305-315 (in Bulgarian)
3. Gyudzhenov, I., Teaching Methodology in the Higher Schools – Rationale and Potential, South-West University "Neofit Rilski", Blagoevgrad, , 2007 p. 264. (in Bulgarian)
4. Gyudzhenov, I., Framework of Reference for Organizing Teaching and Learning at Academic Level, South-West University "Neofit Rilski", Blagoevgrad, , 2007 p. 168. (in Bulgarian)
5. Gyurova, V. Andragogy, Universal-Drumev, 1998, p.383. (in Bulgarian)
6. Gyurova, V. et al. The Teaching and Learning Process Adventure, Europress Agency, Sofia. 2006, 303. (in Bulgarian)
7. Iliev, L. et al., An Innovative Model for Higher Education in Mathematics, Sofia, 1971, p. 23. (in Bulgarian)
8. Karakasheva, L., On a Specific Organization of Seminars in Mathematical Analysis, Mathematics and Mathematics Education, Sofia, 2006, pp. 407-410. (in Bulgarian)
9. Karakasheva, L., An Andragogic Model for Teaching to University Students, Proceedings of the "Angel Kanchev" Ruse University, v.46, series 6, Russe, 2007, pp. 137-141. (in Bulgarian)
10. Karakasheva, L., Applying Vygotski's Views on Teaching and Learning and on the Cognitive Development in Organizing Sminars in Mathematical Analysis, Theory of Methodology of Teaching Mathematics, Physics, Informatics, issue VII, vol. 1, NMetAU Publishing, 2008, pp. 177-180. (in Russian)
11. Levi, L., Cognitive Psychology, Paradigma, Sofia, 2006, p. 122 (in Bulgarian)
12. Nikolov, P. et al., Psychology of University Education, Neofit Rilski University Publishing, Blagoevgrad, 2007, p. 217. (in Bulgarian)
13. Petrov, P., et al., Adult Education and Traiing, Veda Slavena - JG, Sofia, 2003, p. 255. (in Bulgarian)
14. Race, F., Brown, S., 500 Tips for Teachers, TEMPUS, Sofia, 1995, p.135. (in Bulgarian)
15. Slavin, R., Educational Psychology, Nauka I Izkustvo, Sofia, 2004, p. 680. (in Bulgarian)