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MONITORING TECHNIQUES AND SYNTHETIC ANAYSIS IN MECHATRONICS AND ENGINEERING EDUCATION

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***Abstract*—** Anxiety has become endemic by the 21st century, as all members of society are exposed to it irrespective of their age. It typically emerges at work or at school. Undoubtedly, performance at school is largely affected, especially by anxiety about Mathematics.

Our study has focused on reasons triggering off anxiety in BSc and MSc students in a school of higher education. To evaluate the results of the research, statistics and main component analysis was used..

***Keywords*—** anxiety about Mathematics, performance, analysis of the main component, higher education

I. INTRODUCTION

ANXIETY exists irrespective of the culture and level of development of a nation or person. What changes is only the object of anxiety that almost always leads to anxiety, and, on the other hand, the means and modes of acting applied to tackle anxiety " [1]. Anxiety has become endemic by the 21st century, as all members of society are exposed to it irrespective of their age.

Compulsion of accomplishment is closely related to the emergence of anxiety, most typically at work, or at school, leading to decreased performance, but more rarely it can also have a positive effect.

Most students do not like Mathematics due to its complexity, which can even be observed outside the school knowledge of this kind, is required.

It is the goal of our study to identify the background causes triggering off anxiety about Mathematics, based on research carried out with the BSc and MSc students of a school of higher education in 2013.

II. DEFINITION OF ANXIETY

Several sciences, such as Medical Science and Psychology have tried to define anxiety. The former suggests that it can be caused by changes in the life of an individual gaining new experiences, as well as facing unfamiliar situations as is interpreted by medical science. Anxiety has been defined as follows: "anxiety is a paradoxical reaction of the human organism, with individuals evoking the most feared involuntarily, and worries about an unpleasant make the event more likely to happen".

This field of science distinguishes anxiety and fear. While the former involves an uncertain, indefinite situation, the latter is closely related to a definite situation, which renders fear a cognitive while anxiety an emotional process. In a word, fear can be identified with recognizing danger, whereas anxiety is an unpleasant emotional state evoked by fear.

It is argued in psychology that energy stemming from inner tension is to blame for the emergence of an anxious state. To date, anxiety has been researched by several scholars, each coming forth with theories of all kinds. For instance, Freud divides it into two groups, such as real and neurotic.

The former involves a real danger, a natural response to external danger. However, the latter does not involve real danger and yet the anxiety experienced may give rise to a crimpy, long-lasting state of mind [2].

Jenő Ranschburg associates this with an aspect of the personality including fear as a long-lasting marker. As a result, a kind of reserved attitude may emerge, since this special relationship involves permanent anxiety about the world and about ourselves [3].

Spielberger distinguishes two kinds of anxiety; Trait and State, that is state anxiety. The two kinds can be distinguished by A-Trait and A-State sub-charts in the STAI questionnaire developed by the scholar. Trait anxiety can be characterized by the question "how is (s)he feeling now?, while the State-type by the question "how does (s)he feel?" [4], [5].

The 21st century has seen the appearance of complex models of anxiety, which focused on the dynamism of anxiety.

III. THE CORRELATION OF ANXIETY AND PERFORMANCE AT SCHOOL

As has been seen, Riemann's definition suggests that anxiety is present in everyone irrespective of their culture and mental capacity. Based on this definition, it can be pointed out that anxiety is a real phenomenon among students. The most typical place where it can be manifest is the school. The main goal of our study is to examine which factors may lead to the emergence of anxiety. To do so, it has to be examined how performance is influenced by anxiety as is demonstrated by Yerkes – Dodson's model.

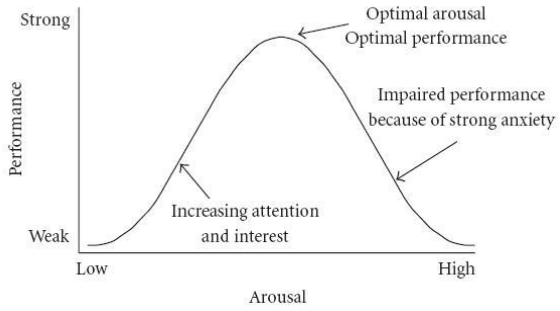

Fig. 1. Yerkes-Dodson model [6].

The model suggests that the best performance can be achieved by medium-intensity anxiety, as it encourages one to perform better. However, if one is pressurized to achieve better and better results, the anxiety experienced will become negative and we will face an adverse effect [6]. However, anxiety does not always decrease performance. The rate of performance is determined by anxiety and the level of complexity of the task to be carried out. Also, the level of anxiety can be determined by personal traits too. This means that anxious people perform well, when they are supposed to do well-structured, strictly-regulated tasks, whereas less anxious individuals prefer active tasks allowing bigger freedom. [7], [5].

The importance of this model depends on what performance arousal level can involve. Emotional state can sometimes energize, but, it can also have a disturbing effect. However, this depends on the intensity of the experience, the individual and the length of the state. As far as intensity is concerned, we can say that a medium-level emotional arousal can best facilitate maintaining alertness and interest. On the other hand, too intensive emotion may either lead to pleasant or unpleasant disturbance. Also, performance is relatively poor at a low level of emotional arousal (for example, after waking up).

Performance is optimal at a moderate level of arousal, but it starts to decline at a high level, probably because the individual is incapable of focusing enough cognitive sources on the task. It can also be observed that the optimal level of arousal and the shape of the shape of the curve may be different with the different tasks. The main reason is that the arousal level is a less elevated than with more complex tasks requiring more complex thinking.

What exactly raises emotional arousal depends on individuals. It may even happen that the emotions do not disappear quickly, but they remain for a long time. The existing situation may evoke anger, and anxiety. However, if these emotions are sustained permanently, they can drain our resources, and can even damage our organs. That is, intensive arousal may even cause harm to the body [8].

IV. ANXIETY ABOUT MATHEMATICS

The influence of the traits mentioned above can be observed in the case of anxiety about Mathematics. It is corroborated by studies that students do not like Mathematics, the reason being that it is a complex field of science, with all its sections interrelated, and students are also expected to apply it in doing exercises at school.

Several theories of research have emerged in the field of anxiety about Mathematics. It was pointed out by Richardson and Woolfolk that the science of Mathematics often evokes anxiety due to the logic, precision, abstract operations and the problem-solving skills it requires [9].

Dreger and Aitken observed the emotional responses of students while they were doing mathematical exercises, and they identified a special Mathematical anxiety factor based on the results [10].

Richardson and Suinn believe that "anxiety about Mathematics is a feeling of pressure mingled with anxiety while dealing with numbers and doing Mathematical exercises both in simple situations and at school". Their theory is that we face similar examples of anxiety [11].

Aschcraft and Faust suggested that anxiety about Mathematics is nothing else but "tension, concern, as well as helplessness, mental problem, fear and fright felt while solving Mathematical problems and manipulating numbers. Aschcraft later specified the definition saying that anxiety about Mathematics is an emotional and behavioral response to facing simple Mathematical examples. [12], [13].

Another theory elaborated by Wang és Luo suggests that "anxiety about Mathematics is a passive learning experience that is the emotional imprint of studying Mathematics". This response, however, is considered harmful due to the disturbing symptoms caused by it that may decrease cognitive capacity and attention [14].

It is borne out by research that the motivation of students related to school is permanently decreasing as years are passing. The main reason is that students are less motivated to study, which leads to anxiety. This can, in fact, be observed in each subject as well as in

Mathematics. As a result, studying this subject has been researched in Psychology for a long time.

More and more research has been done into this phenomenon concerning Mathematics, as it is present in school education even in our days. It is no wonder that anxiety affects Mathematics due to its peculiarities. It is pointed out by more and more researchers that Mathematics makes you inclined to be anxious due to the precision, logic and problem-solving skills it requires. [5].

A. Reasons for anxiety about mathematics and its components

Opinions are divided as to what leads to anxiety about Mathematics. Several views can be read in special literature. The reasons are grouped by Baloglu and Kocak the following way:

1. situational factors such as reasons emerging from specific situations outside the personality;
2. social factors, that is factors emerging from social relations;
3. temperamental factors evoking individual traits [15].

Newsetad lists several factors which are the following:

1. internal characteristics of Mathematics;
2. early experiences related to Mathematics;
3. failure in studying Mathematics;
4. characteristics of Mathematics as a science;
5. teachers' anxiety [16], [17], [18].

In the literature, not only anxiety about Mathematics plays a definite role, but its components too, involving two factors; affective and cognitive. The affective factor means the negative emotions experienced while dealing with Mathematics. The cognitive factor includes views, insight, attitude, characteristics and behavior concerning Mathematics [19], [20], [11], [21].

V. EXAMINING STUDENTS' ANXIETY ABOUT MATHEMATICS IN AN INSTITUTE OF HIGHER EDUCATION

In our research BSc and MSc students' anxiety was examined in an institute of higher education. The test was carried out in the second term of the 2013/14 school year, where 800 technical, mechatronic, project, environment and mechanical engineer students were tested.

A questionnaire of 4 parts was used for the research: SILL, SQ2, me and lessons of Mathematics as well as STAI questionnaires. SILL can be expressed in terms of numbers, it is a self-evaluating questionnaire suitable to handle a high number of data measuring strategies of learning Mathematics. The questionnaire measures the students on a five-degree Likert-scale and its validation and reliability are excellent.

The SQ2 questionnaire also measures students' typical strategies during the process of studying. The main goal of the questionnaire is to reveal activities done by students while solving mathematical examples and studying Mathematics. No wonder, there are questions about specific compensation strategies too in the questionnaire, which allows for strategic classification in the Oxford taxonomy.

The questionnaire Me and Mathematics classes consists of 33 questions measuring anxiety experienced during the classes. The questionnaire comprises three subject matters: communicational anxiety, examination anxiety, and anxiety about negative evaluation. Response is given on a five-degree Likert-scale. Nine of the questions are negative, while 24 are positive.

The STAI questionnaire measuring anxiety defines two constructions: state-anxiety (A-Trait) and trait-anxiety. The questionnaire asks 20 questions concerning both groups [22].

To evaluate the results after the questionnaire was filled in statistical and main component analysis were used.

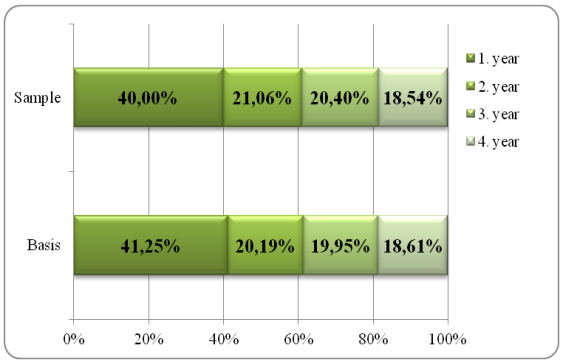

Fig. 2. Division by university years (Based on the author's databank)

In figure 2 the yearly division of questionnaire fillers can be seen.

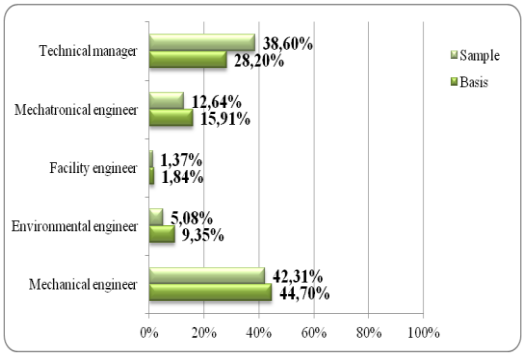

Fig. 3. Division by university department (Based on the author's databank)

We use Chi-square statistics to tested the difference between the two distributions but we didn't find a

significant difference (Chi 2: 0.089; p = 0.993). As we can see, the rate of the year and the students taking part in the research was inversely proportional. 18,61% of those filling in the questionnaire were in the fourth year, 19,95 % were third year, 20,19 % second year and 41,25% first year. This proportion reflects the statistics of the Faculty, which shows that most of the students study in the first year.

Figure 3 shows the distribution of the population and the specialization pattern. We use Chi-square statistics to tested the difference between the two distributions but we didn't find a significant difference (Chi2: 7,543; p=0,109). The maximum rate of the sample, about 42% of mechanical engineers created, while the lowest was the installation engineers who (1.37%). A relatively high proportion of the technical managers in the sample (38.6%). Sample size was 755 people, the basic population is 2,160 people. The sample proportion within the basic population is about 35%, and can be said to be representative of the grade and department basis.

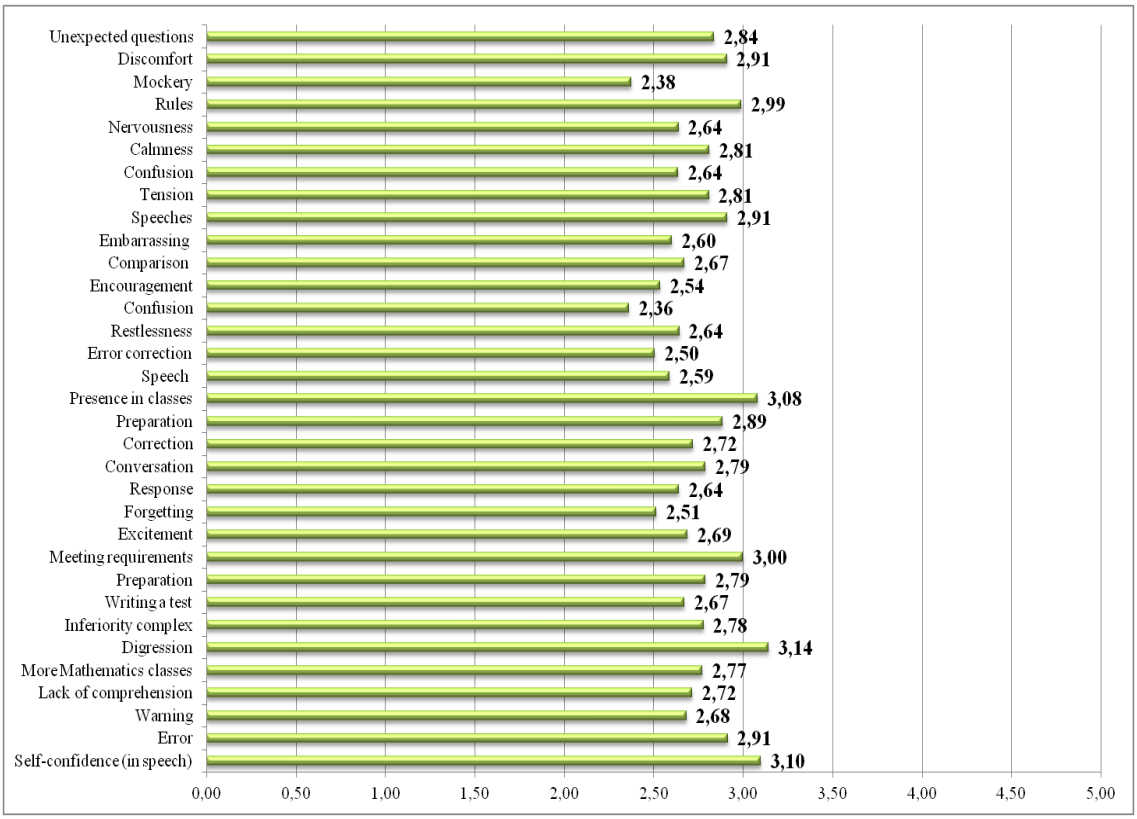

Fig. 4. Anxiety about mathematics (Based on the author's databank)

In the next part of our research anxiety about Mathematics was examined among students. The test is based on the results of the questionnaire Me and classes of Mathematics, and is illustrated by Figure 4. None of the statements got a score higher than 3,5, which means that there is no factor to be linked to classes of Mathematics that could evoke an extremely high level of anxiety. However, there are factors which got higher values than the other ones (3-3,5), evoking higher levels than average. Such factors include keeping too many rules, recalling them later, presence in the classes, digression from the curriculum as well as lack of self-confidence in the classes while talking. There are other factors as well that received lower values than the average (2,3-2,4), that is lower levels of anxiety in students. Such factors include fear of being mocked during speech, forgetting the learnt the material and confusion in direct proportion with the amount of curriculum. All the other statements got average ratings, which mean that they caused average anxiety to students. Statements of this kind included: I'm not worried about making mistakes in the classes , I am trembling to face having to answer questions in the Math's classes, I am frightened when I do not understand what the teacher is saying in the classes, I would not be worried at all to have to have more Mathematics classes, I realize that I have irrelevant ideas on mind that have nothing to do with Mathematics, I keep thinking that the other students know Mathematics better than me and I am usually calm when I have to write a test.

In the following part of our research we examined the values of each component based on level of training and year. To carry out tests main component analysis was applied.

Math anxiety factor of 33, the STAI State Anxiety and Trait Anxiety Trait 20-20 factors was performed by

factor analysis using the SPSS 22 software. The analysis in particular types of data can be used to scale. In order that the ordinal level of measurement data the method can be used, starting with the Spearman's rank correlation matrix analysis was performed. we were able to preserve all the anxiety factor of about 70% of the variance and explain the established factors. Bartlett test carried out during the analysis was significant, and the Kaiser Meier Oldkin index value (0.948) implies a very high model fit. In order to properly explain the structure factor varimax rotation was performed, during seven factors were identified, the anxiety factor 33 will focus on these factors. The factors influencing the effect of actually hiding behind the series and latent interpreted as follows: Excitement, calmness, with arrears presumption unrest due to mistakes, lack of interest, also knows better than inferiority. The elements associated with factors, are highly correlated with the factor is generally the element factor weighs more than the 0.6 value. We were able to preserve all the STAI Trait and about 60% of the variance and explain the established factors. The analysis carried out in Bartlett test was also significant, and the Kaiser Meier Oldkin index value (0.925 and 0.915) also refers to a very high model fit. In order to properly explain the structure factor varimax rotation was performed in which the 4 factors were identified in both indices. If the trait of a tense and anxious, feel good, carefree, relaxed factors were found, while in case of the stain and the calm and happy, excited and anxious, discouraged, lack of confidence factors. The Stain with 4-4 and Trait factors examined the Pearson correlation between math anxiety factor of seven.

The main components are 0 average and 1 dispersion normal division variables. The value 0 marks the situation when the person answering the questions gave a value close to the sample average for all the components belonging to the Main component or, at least for most of them. The value of the main component may vary between +1 and -1 depending on how significant the items belonging to the main component are in the main component and what evaluation they got. The variables belonging to the main component with a positive weight increased the value of the main component, if the surveyed people gave a higher value than the average. This approach allows evaluating whether groups of the surveyed people agreed relatively better or less with attitudes or whether they were relatively more or less satisfied with the factors. There was no item in our analyses that belonged to the main component with a negative weight.

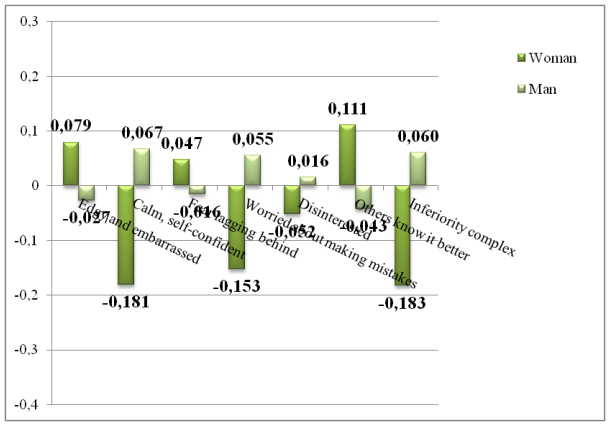

Fig. 5. Division of components by gender (Based on the author's databank)

The division of components by gender can be seen in Figure 5. Based on the results it can be seen that the value of each component is largely different in the case of men and women.

Women show significant correlation between the anxiety experienced and the fear of making a mistake (-0,153). Also, high values could be observed concerning inferiority complex (-0,183) compared to others, and about the fear that others knew Mathematics better (0,111). Simultaneously, restlessness and self-confidence appeared with women (-0,181), which may allow us to draw the conclusion that although women are anxious about the factors mentioned above; they still try to remain calm and conceal their fears with self-confidence. Only three factors on the basis of the variance analysis resulted in a significant difference between women and men. The women are relatively less common in confidence and calmness (F: 8.71, p = 0.003), and the inferiority complex (8.359; p = 0.004). Women are relatively less uneasy because of errors (6.089; p = 0.014) than males.

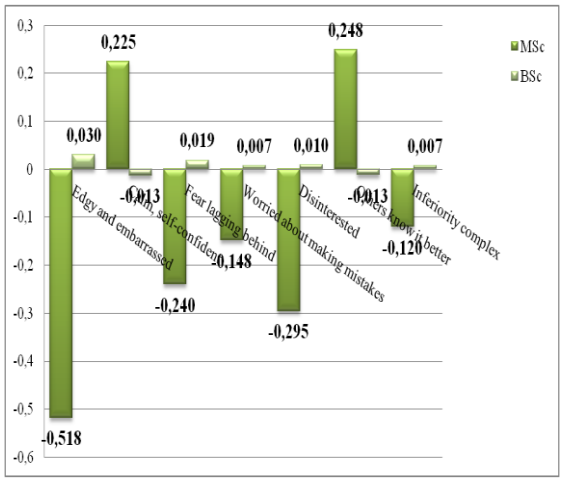

Fig. 6. Components divided by educational level (Based on the author's databank)

The components can be seen by gender in Figure 6. As can be seen in the figure, none of the values is high in

the case of BSc students, which means that neither factor causes a high level of anxiety. The highest levels were being edgy and embarrassed (0,029). The results of the MSc students were quite different from those in the training. Anxiety was mainly caused by being edgy and embarrassed in their case too (-0,517). In addition, the fear component that others knew the material better also had a high value (0,248). Another factor, disinterest, which had not had a high value before also appeared in their case. (-0,295) This result shows that lack of interest in MSc students largely caused anxiety. In addition, fear about lagging behind (-0,240), and restlessness about making mistakes (-0,148) also appeared, but to a lesser extent than earlier factors. Based on the analysis of variance only nervous, embarrassed the factor had a significant difference between the MSc and BSc students. For the MSc students are relatively less common in izgulás and confusion (F: 10.529, p = 0.001), because we have a kind of routine mastered during the BSc course.

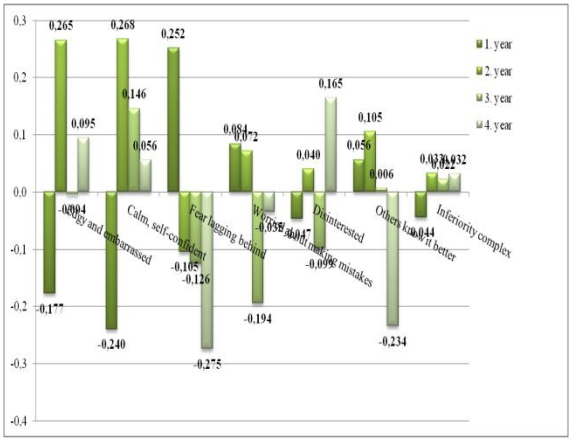

Fig. 7. Division of components by year (Based on the author's databank)

The correlation between the years is illustrated by Figure 7. Significant correlations were found in the analysis of each year. The results show that the highest level of anxiety is caused by worries about lagging behind in the first year (0,252). The main reason for that is the fact that they had been studying for only two semesters at the time of the survey, when they had not experienced much and had not made friends with each other. The most significant factor leading to anxiety in the second year was fear about other students performing better as well as being edgy and embarrassed. The former was half as much typical (0,105) of the students in the second year as the latter (0,265). Typically, students become more competitive by the end of the second year, so everyone strives to do their best to be granted scholarships and they intend to apply for trainee positions during their summer practice. This typically leads to their being worried about others performing better than them. Obviously, a reason for the appearance of the component of being edgy and embarrassed is the fact that, in the second year, they are supposed to face tasks to be carried out or presented on their own or in a group, which is a new challenge for them. Third-year students are characterized by calmness and self-confidence (0,146), which can be traced back to the fact that they cannot experience the initial worries any more, while the pressure to be linked to graduation do not become manifest yet. The results of fourth-year students reveal that being edgy is the most likely factor to evoke anxiety (0,095). This factor can obviously be linked to writing a dissertation, taking the state-examination and job-hunting.

The next part of the research and STAI Trait 4-4 factors of anxiety in the mathematical analysis of the correlation factor of seven analyzed.

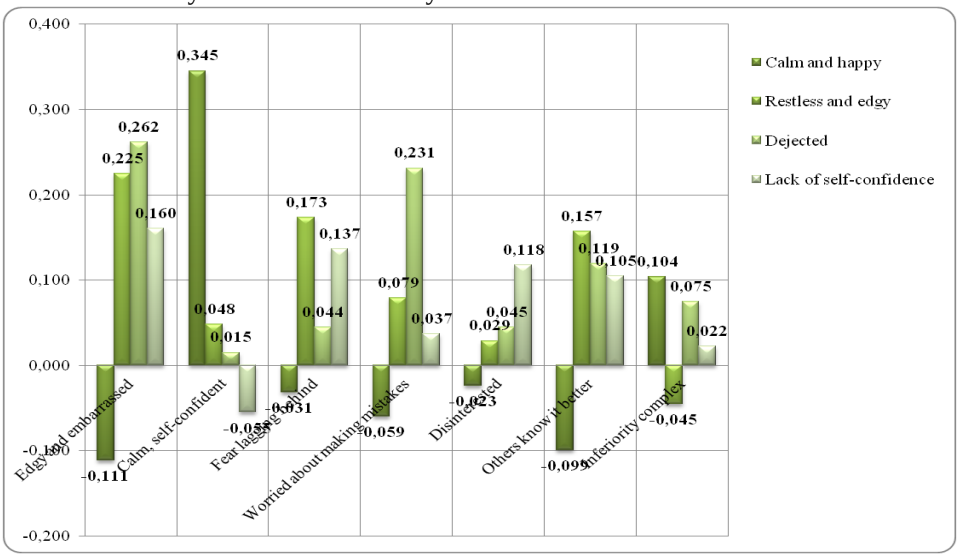

Fig. 8. Correlation between components and individual traits (A-Trait) (Based on the author's databank)

Researchers came to the conclusion while analyzing the correlation between performance at school and anxiety that the rate of anxiety is largely defined by the particular individual traits. That is why the following part of our research is focused on the correlation between other components evoking anxiety and personal traits. The first part of our research was devoted to examining state-anxiety, surveyed with A-Trait questionnaire as is illustrated by Figure 8. It has been corroborated by the results of our research that there is significant correlation between a restless, edgy type of person and anxiety caused by one's being edgy and embarrassed (0,225). There was also significant correlation between dejection and fear about making mistakes (0,231). In this sense, careworn, dejected and unmotivated people are more likely to worry about making mistakes during the Mathematics classes than others. Lack of confidence correlates with the fear of lagging behind others (0,137). People with little self-confidence are more likely to face anxiety about lagging behind others. Finally, the results show that calm and happy people are also calm during the Mathematics classes (0,345).

The highest correlation (r = 0.345, p <0.01) was found between the calm, happy and peaceful happiness factor Trait anxiety math. Whose feature is included in the tranquility, confident in the case of mathematics? However, who is anxious and excited about the features of this math anxiety manifests itself, as the two factors are closely correlated (r = 0.225, p <0.01). The student characteristics whose features of discouragement, it tends to turbulence caused by mistakes in the mathematics regarding (r = 0.231, p <0.01), and the excitement and confusion in reality as well (r = 0.262, p <0.01) . This lack of confidence is associated with the type of the feature arrears fear regarding the mathematical anxiety (r = 0.137, p <0.01).

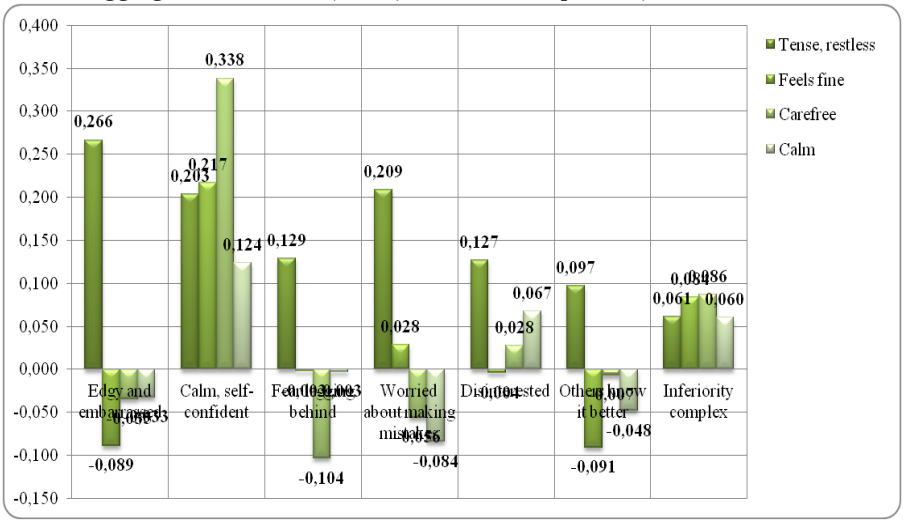

Fig. 9. (A-Stait) The relationship between components and individual features (A-Stait) (Based on the author's databank)

Figure 9 illustrates how our results are continued after testing the relationship between components and individual features. In Figure 1 values related to trait anxiety are illustrated. Values are illustrated in the figure, which were examined by means of an A-Stait questionnaire. It can be seen that those who are rather tense and restless on weekdays due to their personality, will be more likely to be edgy or embarrassed in the Mathematics lessons (0,266). Those people who are usually in high spirits on weekdays and their general condition is good, do not experience anxiety in the Mathematics lessons. Being carefree closely correlated with calmness and self-confidence in the lessons. (0,338). Those who have no problems on weekdays and are satisfied experience less anxiety in the Mathematics lessons than others.

The tense and anxious state is closely related to math anxiety of confusion and anxiety (r = 0.266, p <0.01), who is a state feels good, the mathematics classroom is usually calm and confident occurs (r = 0.217; p <0.01). The state of the light-heartedness with calm and confidence coupled with on the basis of correlation analysis (r = 0.338, p <0.01). Correlation analysis of the stain and Trait factors between them showed that a state feels good, appear calm and happy will be (r = 0.657, p <0.01) in the lineaments, as well as the tense and anxious state of predisposition leading to strokes (r = 0.573; p <0.01).

VI. SUMMARY

Achieving the best possible performance in all walks of life, and at school too is of vital importance. High expectations may lead to a state of anxiety in students.

In our study, we examined the background factors responsible for anxiety about mathematics in students of a school of higher education. The results show that mere presence in the classes itself led to anxiety. In addition, such factors are responsible for the anxiety as knowledge, keeping and recalling too many rules, unexpected questions in the Mathematics classes, meeting too high requirements and digression from the

curriculum.

Further, a significant relationship has been identified between the genders, educational levels, and the factors causing the highest level of anxiety in each year. They were as follows: excitement, embarrassment, fear about lagging behind, and about others being better. Later, the relationship between individual traits and factors causing anxiety were examined and significant relationships were identified.

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