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ANALYSIS OF INTERDEPENDENCIES BETWEEN STUDENTS' EMOTIONS, LEARNING PRODUCTIVITY, ACADEMIC ACHIEVEMENTS AND PHYSIOLOGICAL PARAMETERS

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Abstract. A sufficient amount of studies worldwide prove an interrelation linking students' learning productivity, interest in learning, emotional and psychological state to physiological parameters. Emotional states and the interest in learning affect learning productivity, while physiological parameters demonstrate such changes. Different authors‘ research results are discussed and systematized in this article. The article analyses how positive and negative emotions affect learning productivity and which physiological parameters have to be discussed to estimate students‘ productivity. After indentifying interrelations between these above mentioned parameters, their analysis could be used to improve students‘ academic achievements.

Keywords: learning productivity, emotions, academic achievements, physiological parameters.

Introduction

Academic settings abound with achievement emotions such as enjoyment of learning, hope, pride, anger, anxiety, shame, hopelessness, or boredom. These emotions are critically important for students' motivation, learning, performance, identity development, and health (Schutz & Pekrun 2007). A sufficient amount of studies worldwide prove an interrelation between students' emotions, productivity and physiological parameters.

Dettmers *et al.* (2010), Daniels *et al.* (2009), Pekrun *et al.* (2009), Carnegie (2004), Kay (2008), Jaques and Vicari (2007), Kaklauskas *et al.* (2010), Hadfield (1924) and Brill (1946) analysed the interdependence linking academic achievements with students' emotional state, motivation to learn and the interest in learning. Their research proved that high spirits, motivated learning and appealing studies improved the efficiency of learning and, in turn, led to better academic achievements.

Scientists from all over the world study the interdependence between students' physiological parameters and their mental stress (arithmetic stress). Kobayashi *et al.* (2003), Kamei *et al.* (1998), and Fechir *et al.* (2009) analysed changing skin humidity parameters caused by changing intensity of mental activity. Fechir *et al.* (2009), Harris *et al.* (2000), Vuksanović and Gal (2007), Murata *et al.* (1999), Sloan *et al.* (1991), Turner *et al.* (1987), Szabo *et al.* (1994), Tanida *et al.* (2004), Furedy *et al.* (1996) examine the interdependence between the heart rate and the mental stress (arithmetic stress). Fechir *et al.* (2009), Harris *et al.* (2000), Sloan *et al.* (1991) investigated the changes in blood pressure caused by changing intensity of mental activity.

In this article different authors' researches are analyzed and their studies results are compared. In the first section interdependence between emotions and academic achievements of students is discussed. After that we analyze the interdependence linking physiological parameters of students to their learning productivity and the interest in learning. In the third chapter all investigated parameters are summarized and their relations are evaluated.

Analysis of Interdependence between Emotions and Academic Achievements of Students

Emotional and psychological state of students determines their learning productivity. Researchers found out, that the productivity could be high after a working day of eight or twelve hours, if the person is fully satisfied and in great emotional and psychological state. Carnegie (2004) and Hadfield (1924) confirm in their works, that working (in our case learning) productivity depends on how the person feels psychologically.

Interdependence between emotions and productivity is analysed by Pekrun *et al.* (2007). Scientists affirm, that positive emotions stimulate self-motivation, increase the rate and capacity of proper information. Vice versa, negative emotions disturb information processing and results systematizing. These interrelations are shown in Fig. 1.

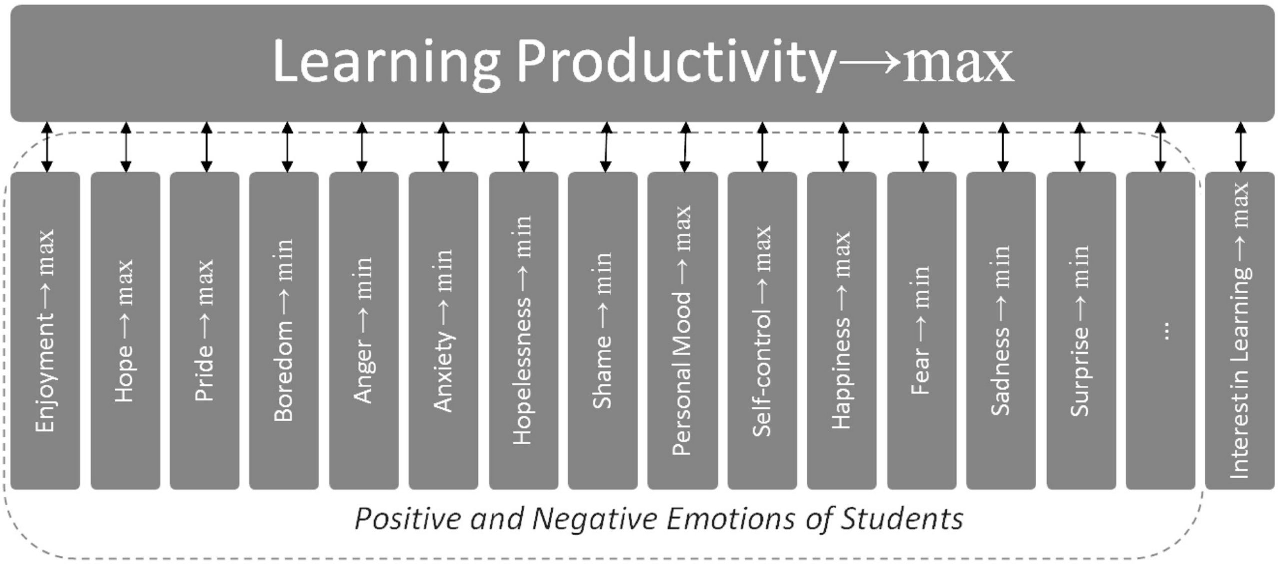

Fig. 1. Interrelation between negative emotions and learning productivity of students

The aim of the study was to extend previous research by examining the antecedents and consequences of student emotions in the homework context. Multilevel analyses of a longitudinal dataset containing 3483 grade 9 and grade 10 students in 155 classes showed that the perceived quality of the homework tasks assigned by the teacher affected students' experience of unpleasant homework-related emotions. Moreover, the experience of unpleasant emotions during homework sessions was negatively related to homework effort and negatively predicted later achievement in mathematics (Dettmers *et al.* 2010).

Affect and emotions are frequently seen as outcomes of mastery and performance goals. In a predictive study (N = 669 first-year college students), Daniels *et al.* (2009) used structural equation modeling to estimate relationships from 2 initial affective experiences to mastery and performance-approach goals, from goals to discrete emotions, and from discrete emotions to final grades in a university course while controlling for prior achievement. Mastery goals positively predicted enjoyment, which in turn positively predicted achievement, and negatively predicted boredom, which in turn negatively predicted achievement (Daniels *et al.* 2009).

Pekrun *et al.* (2009) propose a theoretical model linking achievement goals and achievement emotions to academic performance. This model was tested in a prospective study with undergraduates (N = 213), using exam-specific assessments of both goals and emotions as predictors of exam performance in an introductory-level psychology course. The findings were consistent with the authors' hypotheses and supported all aspects of the proposed model. In multiple regression analysis, achievement goals (mastery, performance approach, and performance avoidance) were shown to predict discrete achievement emotions (enjoyment, boredom, anger, hope, pride, anxiety, hopelessness, and shame), achievement emotions were shown to predict performance attainment, and 7 of the 8 focal emotions were documented as mediators of the relations between achievement goals and performance attainment (Pekrun *et al.* 2009).

Analysis of the Interdependence Linking Physiological parameters of Students to their Learning Productivity and the Interest in Learning

Different scientists (Kobayashi *et al.* 2003; Kamei *et al.* 1998; Fechir *et al.* 2009; Harris *et al.* 2000; Vuksanovic and Gal 2007; Murata *et al.* 1999; Sloan *et al.* 1991; Turner *et al.* 1987 Szabo *et al.* 1994; Tanida *et al.* 2004; Furedy *et al.* 1996) analyse the interdependence between students' physiological parameters and their mental stress (arithmetic stress).

These studies maintain, that measured students' psychological parameters (skin conductance, systolic and diastolic blood pressure, heart rate) reveal their learning productivity (efficiency). Table 1 shows structured results of researchers' studies. It follows, how psychological parameters and learning productivity/fatigue interact with each other.

The results of mentioned studies reveal that changing physiological parameters of students over time can help to determine the level of their learning efficiency. Increasing

Table 1. Interdependence linking physiological parameters of students to their learning productivity

	Skin humidity	Heart rate	Blood pressure
Arithmetic calculations, arithmetic tasks	↑ Kobayashi *et al.* 2003 ↑ Kamei *et al.* 1998	↑ Furedy *et al.* 1996 ↑ Sloan *et al.* 1996	↑ Sloan *et al.* 1996
Mental stress	↑ Fechir *et al.* 2009	↑ Fechir *et al.* 2009 ↑ Harris *et al.* 2000 ↑ Murata *et al.* 1999 ↑ Shapiro *et al.* 2000	↑ Fechir *et al.* 2009 ↑ Harris *et al.* 2000 ↑ Shapiro *et al.* 2000
Arithmetic stress		↑ Vuksanović and Gal 2007	
Mental arithmetic		↑ Sloan *et al.* 1991 ↑ Turner *et al.* 1987 ↑ Szabo *et al.* 1994 ↑ Tanida *et al.* 2004	↑ Sloan *et al.* 1991

skin conductance and rising systolic and diastolic blood pressure, for instance, lead to decreasing learning efficiency of students (see Fig. 2). The studies of the aforementioned scientists are briefly reviewed below.

Kobayashi *et al.* (2003), Kamei *et al.* (1998) analysed the interdependences linking arithmetic calculations with human palm humidity and sweating, while Fechir *et al.* (2009) analysed the interdependencies linking mental stress to sweat rate. The said authors point out that arithmetic calculations and the intensity of mental stress cause an increase of human palm humidity and sweating. For example, Kobayashi *et al.* (2003) examined the effects of repetitive mental stimulation such as arithmetic calculations with sequential subtraction on active palmar sweating responses in humans. The mental stimulation caused a rapid and oscillatory response of active palmar sweating during operation of the stimulation or tasks. The research of Kamei *et al.* (1998) also indicates that the sweat rate significantly increased during mental arithmetic. Fechir *et al.* (2009) argue that the effect of "stress" on emotional sweating revealed that difficult mental arithmetic induced stronger emotional sweating than the easy task. Emotional sweating increased during mental arithmetic tasks.

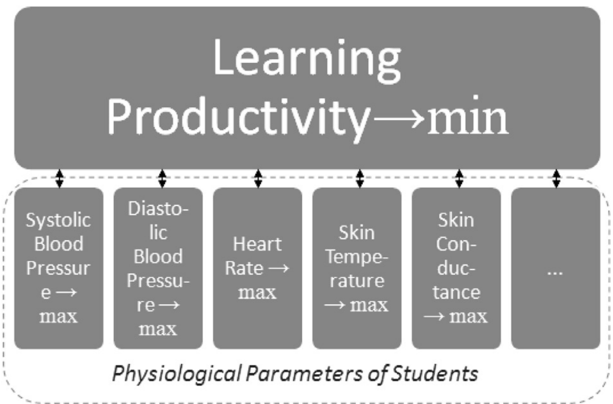

Fig. 2. Interrelation between learning productivity and physiological parameters of students

A number of scientists examined the interrelations linking mental, arithmetic stress and arithmetic tasks to the human heart rate. All authors confirm that the said factors make the heart rate increase.

Heart rate was monitored while 20 young males completed MATH, a computer-operated mental arithmetic task specifically designed for use in experiments involving subjects of heterogenous numerical ability, and a standard mental arithmetic task used in this laboratory on several occasions. Both tasks elicited sizeable increases in heart rate Turner *et al.* (1987). Sloan *et al.* (1991) studied heart rate responses of 10 subjects to 2 different versions of mental arithmetic and a control condition in which vocalization of answers was manipulated. Heart rate was measured. Results indicate that, the two task conditions produced similar heart rate increases. Mental arithmetic has been shown to produce significant increases in heart rate. Szabo *et al.* (1994) studied combined effects of exercise and mental challenge on heart rate. Subjects performed a series of mental arithmetic problems for one minute each time: two min before cycling, 10 min into low intensity cycling, 10 min into medium intensity cycling, and two and 20 min, respectively, after cycling. During both exercise workloads, the mental arithmetic elicited significant additional increases in heart rate. In one Furedy *et al.* (1996) experiment, 20 subjects performed 1-min arithmetic and combined arithmetic -with-cycling tasks, with heart rate being measured. In another experiment, 18 males performed 1 min arithmetic tasks, before, during, and following sustained low and moderate intensity cycling. The results showed that heart rate increased reliably to all challenges. Sloan *et al.* (1996) measured heart rate and blood pressure during the 5-minute baseline and 5-minute arithmetic task periods. The arithmetic task produced significant increases in heart rate. Murata *et al.* (1999) recorded simultaneously the two rhythms during finger tapping as a simple model of rhythmical motion for identifying whether spontaneous cardiac rhythm and voluntary motor rhythm are modified in parallel or influenced separately when imposing mental stress. Mental stress was given intermittently three times for 10–15 s at intervals of 40 s during tapping for 150 s. Heart rate and tapping rate and their variations (standard deviation) during finger tapping with and without mental stress were compared. Heart rate and tapping rate increased significantly in response to mental stress during tapping. After mental stress was ended, heart rate returned rapidly to the initial level, but tapping rate remained at a higher level. The present results indicate that the cardiac and motor rhythms are influenced simultaneously by mental stress. Harris *et al.* (2000) used two-dimensional ultrasound to measure brachial artery flow-mediated vasodilation before and after mental stress (provoked by a standard arithmetic challenge). During mental stress, heart rate increased on average by 29.6%. Shapiro et al. (2000) results shows that heart rate was greater in the arithmetic task condition compared with the control voxels, condition, suggesting that the arithmetic task was associated with withdrawal of vagally modulated slowing of heart rate. Tanida *et al.* (2004) study evaluated the relationship between asymmetry of the prefrontal cortex activity and the automatic nervous system response during a mental an arithmetic task. Employing near infrared spectroscopy, Tanida *et al.* (2004) compared cerebral blood oxygenation changes in the right and left prefrontal cortices during a mental arithmetic task with heart rate changes. During the mental arithmetic task, eight subjects (high- heart rate group) showed large heart rate increases (14.2 ± 3.0) while eight subjects (low- heart rate group) showed small heart rate increases. Vuksanović and Gal (2007) stated that investigations on arithmetic stress with verbalization showed that spectral measures of heart rate variability did not assess changes in autonomic modulation, although the heart rate increased. Fechir *et al.* (2009) determined that stress co-activated heart rate.

Boutcher and Boutcher (2006) state that increasing the difficulty of a mental task may produce higher reactivity response. Brown *et al.* (1988) found that increasing the difficulty of a mental arithmetic task resulted in a higher heart rate response.

Sloan *et al.* (1991, 1996) Harris *et al.* (2000) and Fechir *et al.* (2009) examined the interdependencies linking mental stress and mental arithmetic with blood pressure. In their research, Sloan *et al.* (1991) determine that the mental arithmetic stress has been shown to produce significant increases not just in the heart rate but in the blood pressure, too. Harris *et al.* (2000) determined that during mental stress, blood pressure increased on average by 17.9%. Fechir *et al.* (2009) confirm the results achieved by Sloan *et al.* (1991), Harris *et al.* (2000) arguing that the stress co-activated blood pressure, too. Sloan *et al.* (1996) also confirms the arithmetic task produced significant increases in systolic and diastolic pressures.

Analysis of Interrelations between Stress and Anger, Academic Achievements and Physiological parameters of Students

Analysis of worldwide studies suggest that the higher stress students feel, the higher is their systolic and diastolic blood pressure and heart rate, which, in turn, means a decline of learning efficiency. Decreasing motivation to learn and appeal, analogically, leads to decreasing productivity. For instance, the same mathematical operation performed within the same period but with a different level of productivity demands for a different level of mental stress.

Examples from other authors‘ studies suggest that the higher the stress, the less productive is the student and the more passive the person is and unable to concentrate. The direct connection between stress and blood pressure (systolic and diastolic) and the indirect connection between stress and the efficiency of studies. There is also an indirect connection between the interest in studies and the experienced stress. The less a person is interested in studies, the more he/she is stressed. The person needs to put more effort to concentrate, this increases the stress, and the blood pressure (systolic and diastolic) goes higher.

The interrelations discussed above may be expressed as follows:

If: *Stress* → *max*,
Then: *Productivity* → *min*,
Systolic blood pressure → *max*,
Diastolic blood pressure → *max*,
Heart rate → *max*.

And vice versa

If: *Stress* → *min*,
Then: *Productivity* → *max*,
Systolic blood pressure → *min*,
Diastolic blood pressure → *min*,
Heart rate → *min*.

Working efficiency, blood pressure and heart rate depend not only on stress but also on other positive and negative emotions. For example, the impact of anger on working efficiency, systolic and diastolic blood pressure, and heart rate is shown below:

If: *Anger* → *max*,
Then: *Productivity* → *min*,
Systolic blood pressure → *max*,
Diastolic blood pressure → *max*,
Heart rate → *max*.

And vice versa:

If: *Anger → min*,

Then: *Productivity → max*,

Systolic blood pressure → min,

Diastolic blood pressure → min,

Heart rate → min.

Analysis of worldwide studies suggest that the systolic and diastolic blood pressure is directly related to current emotions, to the interest in learning and to learning productivity. As argued by Harris *et al.* (2000), Sloan *et al.* (1991) and Fechir *et al.* (2009), the higher the mental stress (unappealing and boring work, reduced human productivity, higher fatigue), the higher is the systolic and diastolic blood pressure.

Conclusions

1. In this study mentioned researchers, analysed interrelations between students‘ learning productivity and emotional state, determined, that students‘ emotions affect their goals; negative emotions decrease students‘ achievements. Positive emotions stimulate interest in learning, motivation, assimilation of the information, thus the learning productivity.
2. Different scientists analyse the interdependence between students' physiological parameters (skin humidity, heart rate, blood pressure) and their mental stress (arithmetic stress). All authors confirm that mental stress make physiological parameters increase.
3. Analysis of the literature suggests that if human stress or anger increases, his work productivity decreases and systolic and diastolic blood pressure and heart rate increase and vice versa, if human stress or anger decreases, his work productivity increases and systolic and diastolic blood pressure and heart rate decrease.

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STUDENTŲ EMOCIJŲ, MOKYMOSI PRODUKTYVUMO, AKADEMINIŲ PASIEKIMŲ IR FIZIOLOGINIŲ PARAMETRŲ RYŠIŲ ANALIZĖ

A. Matuliauskaitė, L. Žemeckytė

Santrauka

Daugybė pasaulyje atliktų tyrimų nagrinėja tarpusavio priklausomybę tarp studentų mokymosi produktyvumo, mokymosi įdomumo, emocinės ir psichologinės būsenos bei fiziologinių parametrų. Emocinė būsena ir mokymosi įdomumas lemia mokymosi produktyvumą, o tai matoma iš fiziologinių parametrų kitimo. Straipsnyje aptariami ir sisteminami įvairių autorių tyrimų rezultatai, nagrinėjama, kaip teigiamos ir neigiamos emocijos lemia mokymosi produktyvumą, kokie fiziologiniai parametrai turi būti analizuojami produktyvumo įvertinimui. Nustačius šiuos tarpusavyje susijusius parametrus ir panaudojant jų analizę galima gerinti studentų akademinius pasiekimus.

Reikšminiai žodžiai: mokymosi produktyvumas, emocijos akademiniai pasiekimai, fiziologiniai parametrai.