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Aspects of Cognitive Ergonomics in Forestry Engineering Education

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***Abstract*—one of the most pressing problems in education in Latvia today is to prepare specialists to participate in the labour market and become specialists who respect and ensure occupational safety for those working in the national economy. The study analysed the aspects of cognitive ergonomics for students in the framework of the professional practice of "Motor tools". Working with a chainsaw can create dangerous situations, significantly endangering a person's health or even life, as well as affecting his or her working capacity. The well-being of the employee significantly affects the quality and performance of work, because cognitive aspects – fatigue, stress - affect a person's working capacity. Different methods were used to evaluate the impact of cognitive ergonomics on students' work abilities: a survey, key indicator method (A, B and C), the method of determining the psychological climate, the method of work ability index, quick exposure check method, expert interviews, as well as the NASA-TLX method. Kendall correlation coefficient calculation methods were used. Work abilities were analysed at the beginning and end of the internship for both full-time and part-time students. The results of the study show that during professional practice students have an increased workload, as well as a significantly increased physical load, causing overload to be possible for individuals with normal physical fitness. Fatigue and reduced performance appear at the end of the practice, especially when it was necessary to make decisions about action in emergency situations. Based on the consensus of experts as characterized by the Kendall correlation coefficient, ($p < 0.05$) cognitive aspects significantly affect a safe work environment, negatively affecting work productivity and human performance, and response to emergency situations. Currently, due to physical unpreparedness, students often face ergonomic overload caused by a lack of experience and knowledge of work safety, which manifests itself in physical fatigue. Instructors need to pay more attention and point out incorrect or non-ergonomic actions and movements in order to promote a more balanced and safer work environment. As well, students themselves need to pay more attention to their work performance.**

***Keywords*— cognitive ergonomics, engineering education, logging industry, work capabilities.**

I. INTRODUCTION

Forestry workers are exposed to work environment risk factors, including the impact of cognitive ergonomics on the performance and health of employees because cognitive ergonomics is related to mental processes: motor response, memory, perception, and reasoning [1]. In line with the International Ergonomics Association's definition of cognitive ergonomics, research analyses mental workload, decision-making, performance quality, human-computer interaction, work stress, and learning effectiveness.

Statistical data indicate that in Latvia in 2022, more than 90% of occupational diseases were related to physical overload, although in 2021, there was a change in work

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environment factors from ergonomic risks to psycho-emotional risk factors [2].

A study [3] found that one of the results of stress is increased sleepiness during work and that employees who have been working for more than eleven years are more susceptible, indicating that age plays a significant role.

Cognitively stressful conditions (interruptions, disruptions, and information overload) are associated with impaired task performance and impaired well-being at work, indicating the need to significantly reduce their harmful effects [4], as labour productivity depends on the cognitive abilities of the working person.

The study [5] indicates that there is a lack of cognitive research in the field of ergonomics, employee burnout research, and comprehensive ergonomics and productivity research in the field of logging during the period 2005-2016.

In turn, an analysis of the study conducted from 2014 to 2023 [6] shows that the main logging risk factors found in the studies are related to workload (23%), noise (20%), vibrations (20%), postural load (16%), and musculoskeletal disorders (7%).

In Latvia, there are few studies analyzing work environment risks in the logging industry or the education of these specialists, especially in the context of cognitive ergonomics.

II. MATERIALS AND METHODS

The study was conducted during professional practice, where knowledge of working with a chainsaw was reinforced, including observance of occupational safety procedures, awareness of personal protective equipment and its use, and obtaining a power tool operator's license after passing the exam at the end of the practice.

The location of the internship is Zemgale region, Jelgava municipality, Ozolnieki parish, (MPS) forest research station forest block 58, section 24, narrow-leaved forest, with an area of 1,920 ha and stand composition 10P 130, coordinates of the research object - 56º42’24.8”N, 23º48’08.3”E. As part of the training, main or renewal felling was carried out.

1st year full-time students and 2nd year part-time students participate in the professional internship. The period for part-time students is from 31.07.2023 to 11.08.2023, and for full-time students, it is from 14.08.2023 to 25.08.2023.

In the internship training, 49 students from the full-time group were scheduled, of whom 44 were men, and 5 were women, in the age group 19 to 21 years old. However, one student did not participate in the professional internship training due to health conditions. Of the part-time study program, 35 students were scheduled to participate in the internship, of whom 28 were men, and 7 were women, in the age group 19 to 43 years old. However, 8 people did not participate in the internship due to personal reasons or health conditions.

To assess the impact of cognitive ergonomics on students' work capacity during the “Motor Instruments” internship, a survey, the main load indicator method (A; B; C), and the psychological climate determination method were used [7]. To determine the interaction of mental and physical workload, the obtained respondent ratings were electronically processed using the NASA – TLX online program [8]. The results of the expert survey were processed using the non-parametric statistical method with Kendall rank correlation, which determines the correlation coefficient W [9], as well as an interactive program for determining (p value) [10]. For more accurate data, non-parametric statistics were also determined – median, mode, and range. Work capacity was analyzed at the beginning and end of the internship for both full-time and part-time students.

III. RESULTS AND DISCUSSIONS

During the "power tool" practice sessions, the instructors observed that students at the beginning of the internship lack theoretical and practical knowledge, which complicates the instructors' work, as they must ensure safety for themselves and others by teaching the basics of work safety, work ergonomics, tree felling, pruning and pruning, as well as ensuring a sufficient level of knowledge so that the students can pass the final exam and obtain a certificate. Students are subjected to a sufficiently high level of stress and hard work that it leads to psycho-emotional and physical burnout.

Since the internship takes place in the summer month of August, regardless of the weather conditions (very hot), the daily schedule must be fulfilled, however, weather conditions have a noticeable impact on the efficiency and duration of work. The work clothes provided are thick, heavy, and for some students do not meet height and size requirements. In hot weather, one can quickly overheat in work clothes, causing intense sweating, which leads to dehydration and fatigue. During the first week of practice, most students experience a strong sense of fear when working with a saw, feel insecure and unsure of themselves, and make many mistakes in violation of work safety regulations. Working in the forest requires great responsibility and precision - you have to make correct cuts and crosscuts, remember warning signals, ensure a safe environment for yourself and those around you, work in a routine, and perform monotonous tasks.

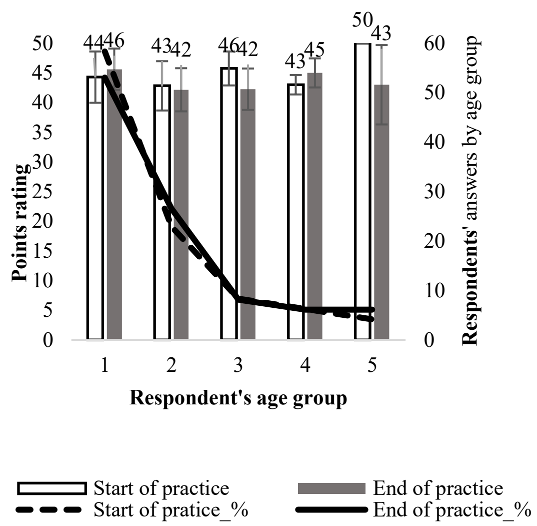
Saw operators have to perform many activities on a daily basis which include lifting, moving and holding, as well as monotonous activities Table 1, which were assessed using the method developed by the Institute for Occupational Safety and Health Protection for assessing ergonomic risks [11].

TABLE 1 WORKLOAD RISK LEVEL FOR THOSE EMPLOYED IN THE PRACTICE OF "POWER TOOLS"

Method	Gender		Indicator							Total points	Risk level (I - V)
	Man	*Female*	*Mass (M)*	*Position (S)*	*Conditions (A)*	*Intensity (I)*	*Accuracy (P)*	*Organizational conditions (O)*	*Movement (K)*		
SGR-A	M	-	1	2	1	8	-	-	-	32	III
SGR-A	-	F	2	2	1	8	-	-	-	40	III
SGR-B	M	-	1.5	4	2	4	2	-	-	38	III
SGR-B	-	F	1.5	4	2	2	2	-	-	24.7	II
SGR-C	M	-	-	2	1	1	2	0	1	22	II
SGR-C	-	F	-	2	1	1	2	0	1	22	II

It was found that for SGR–A, lifting and moving, which in this case is an electric saw and a petrol chainsaw, both men with 32 points and women with 40 points are exposed to occupational risk group III, which means that the work has a significantly increased physical load, and overload is possible for individuals with normal physical fitness. For SGR–B, pushing and rolling assorted firewood, small logs, etc., men are exposed to the III risk group with 38 points, indicating that the weight of the material to be moved is significantly increased and overload is possible for people with normal physical fitness. In turn, women are exposed to risk group II with 24.7 points, which indicates that physical overload is possible for people older than 40 or younger than 21 years of age, as well as for people suffering from diseases. SGR-C, monotonous manual activities (picking branches), both women and men with 22 points are exposed to risk group II, which indicates that the load is increased and overload is possible for people with reduced working capacity (people younger than 21 or older than 40, as well as those who are not physically fit and people who are sick.

To find out how favourable the psychological microclimate is during the "power tool" practice, a survey



was conducted where the answers were provided by 2nd year full-time and 3rd year part-time students. For more detailed results, the respondents were divided into age groups, where 1st group (18 – 20 years); 2nd group (21 – 24 years); 3rd group (25 – 30 years); 4th group (31 – 35 years) and 5th group (36 – 41 years).

The survey results Fig. 1 show that the highest number of responses were submitted by students in the first age group (58.33%), but the least responses were submitted by students in the fifth age group (6.12%). It is also observed that group 1 and group 4 evaluated the first week of practice with a lower score, but the second week of practice with a higher score, which indicates that students were more dissatisfied with something in the first week of professional practice. For group 2, group 3 and group 5, it is observed that the score was higher in the first week, but lower in the second week.

Fig. 1. Summary of the psychological microclimate among students.

As indicated by the results summarized in the questionnaire, during the internship, 42% of students felt free and without unnecessary stress under the supervision of instructors, however, 58% of respondents indicated that their stress level was indeed increased.

TABLE 2 PROCESSING THE RESULTS OF THE PSYCHOLOGICAL MICROCLIMATE TEST WITH AN ONLINE INTERACTIVE CALCULATOR

Study program (practicum time)	**Respondents, number**	**Respondents, number**	**Amplitude, A**	**Median, M_e**	**Mode, M_o**	**Mean**
Start of full-time student internship	29	1277	16	44	40	44.3
End of full-time student internship	27	1239	10	46	40	45.9
Full-time student internship in February-March	29	1129	18	38	40	38.9
Part-time student internship begins	12	846	11	43	42; 43	44.5
End of part-time student internship	22	928	16	42	37; 42	42.2
Part-time student student internship in February-March	19	802	11	42	42	42.2

In the results submitted by the students of the full-time study program, Table 2 shows that in the first week of practice, the arithmetic mean or the sum of the average values of the data set is 40.3 points, and in the second week of practice, 45.9, which, according to the values of the point scale, indicates that the psychological microclimate supports a healthy work environment. The results obtained in February - March show that the students' opinion about the psychological microclimate has changed slightly and the average sum of the values is 38.9, which indicates that there were probably disagreements in the work team that had to be resolved.

In the NASA – TLX survey, respondents assessed how low or high the workload is during professional practice. The survey assessed six workload subgroups (mental workload, physical and temporal workload, effort, performance and frustration), the assessment of these factors is based on the work duties performed by students. The aggregated results of full-time and part-time study program students show Fig. 2 that the average workload assessment during professional practice is 57.30 points, which confirms that the workload is increased during professional practice.

During professional practice, it was observed that physical risks the work environment significantly affect the quality of work performance, as the practice takes place in August, the hottest summer month (+27º, +28º). This increased stress and fatigue for students, which was compounded by the noise and vibration caused by the saw. Being surrounded by noise causes fatigue as well as nervousness. During the "power tool" practice, it is mandatory to wear ear protection, because the noise caused by a gasoline chainsaw reaches 106 decibels (dB), while an electric saw reaches 95 decibels (dB), which means that the noise can be harmful to hearing. Such noise creates difficulties in communicating with teammates, and can also cause changes or disturbances in hearing. Similarly, the vibration caused by the saw increases the stress level, making the student more nervous. Increased vibration can cause a loss of strength. Similar studies have shown that high cognitive load can increase stress, emotional and mental fatigue, reducing students' ability to acquire knowledge as cognitive overload increases [12], therefore it is important to consider options for reducing the load, as it significantly affects outcomes [13].

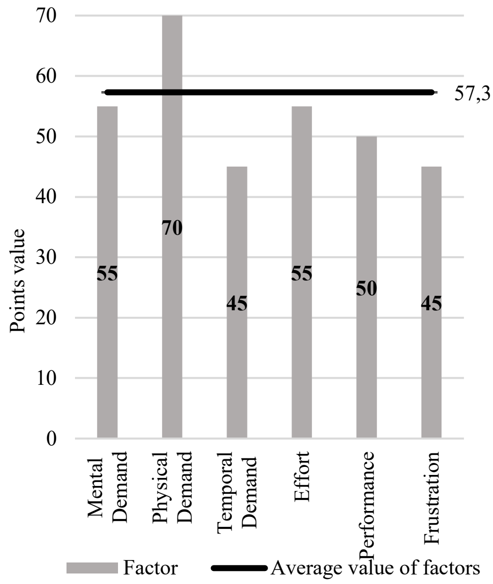


Fig. 2. Assessment of the total workload provided by students.

To assess how cognitive aspects affect students' work capacity and stress, and what improvements should be introduced into the "Power Tools" practice, the study involved 15 experts. from three different sectors: 5 medical experts, 5 occupational safety experts, and 5 forest industry experts. The criteria for selecting experts encompassed education, work experience and experience in their sector (experts' work experience from 5 to 25 years; all experts had higher education). The interview consists of 10 open questions and a point rating which determines the relevance of the question.

Key expert insights:

- Before the internship, students' theoretical knowledge should be tested to determine their level of preparation for the job, while during the internship, a smaller number of students per instructor is needed to allow for longer individual training per student,
- Participating in internships with serious previous injuries can contribute to discomfort, pain, and stress, so a doctor should be consulted before participating in internships where students may be exposed to increased stress,
- Due to physical unpreparedness, students often face ergonomic overload – due to a lack of experience and knowledge of proper ergonomics - which manifests itself in physical fatigue. Instructors need to pay more attention and correct non-ergonomic actions and movements,
- Before the start of the internship, it is necessary to repeat or undergo first aid or emergency medical care courses, because working with a saw in the forest, a person is exposed to various risk factors,
- Where the employee is exposed to increased workload, it is recommended to perform relaxation exercises every day after work,
- Students of the Forestry Engineering program need to acquire in-depth knowledge of working with a saw (petrol chainsaw, electric saw), because as future direct supervisors, they must be familiar with correct work techniques and occupational safety in logging, forest maintenance, etc.,
- Occupational safety regulations must not be ignored; instructors must respond to and point out mistakes made by students in order to encourage them to recognize and analyse their mistakes,
- Students do not sufficiently respect work safety, which is the result of a lack of work experience, lack of knowledge, youthful maximalism, as well as working in a dangerous work environment, which increases the stress level, causing a person to become careless and insecure.

In order to evaluate the importance rankings of the competence components, the data are summarized in Table 3. The obtained results were subjected to statistical data processing, where non-parametric statistics were determined: mode Mo, median Me and amplitude A.

TABLE 3 RELATIVE IMPORTANCE OF COMPONENTS

Experts	**Competency components**					**Total**
	Medicine	***Ergonomics***	***Work safety***	***Civil protection***	***Forestry***	
A	1	3	2	5	4	15
B	2	3	1	4	5	15
C	3	4	1	5	2	15
D	3	4	1	2	5	15
E	1	4	2	5	3	15
F	4	2	1	5	3	15

Experts	Competency components					Total
	Medicine	*Ergonomics*	*Work safety*	*Civil protection*	*Forestry*	
G	4	2	1	5	3	15
H	4	3	1	5	2	15
I	2	3	1	5	4	15
J	4	2	1	5	3	15
K	3	2	4	1	5	15
L	1	4	2	5	3	15
M	1	2	3	4	5	15
N	1	3	2	5	4	15
O	3	1	2	5	4	15
Sum of ranks, L_i	37	42	25	65	55	225
Sum of ranks, rank	2	3	1	5	4	-
Median, M_e	3	3	1	5	4	-
Moda, M_o	1	3;2	1	5	3	-
Amplitude, A	3	3	3	4	3	-

The consensus of the importance ranking of the components of the expert survey results was calculated using the Kendall correlation coefficient W and its significance level (1).

$$W = \frac{12 \times S}{m^2 n\,(n^2-1)} = \frac{12 \times 1014}{15^2 \times 5\,(5^2-1)} = \frac{12168}{27000} = 0.45 \qquad (1)$$

Kendall's concordance coefficient W = 0.45, its significance level is $p < 0.05$. The survey components are ranked: medicine – 1, ergonomics – 2, occupational safety – 3, civil protection – 4, forestry – 5. By comparing the sums of the Li ratings, it was found that Table 4.

TABLE 4 CONSENSUS OF EXPERTSURVEY IMPORTANCE RATING

Experts	Competency components					Total
	Medicine	*Ergonomics*	*Work safety*	*Civil protection*	*Forestry*	
A	1	3	2	5	4	15
B	2	3	1	4	5	15
C	3	4	1	5	2	15
D	3	4	1	2	5	15
E	1	4	2	5	3	15
F	4	2	1	5	3	15
G	4	2	1	5	3	15
H	4	3	1	5	2	15
I	2	3	1	5	4	15
J	4	2	1	5	3	15
K	3	2	4	1	5	15
L	1	4	2	5	3	15
M	1	2	3	4	5	15
N	1	3	2	5	4	15
O	3	1	2	5	4	15
m=15	n=5					
Sum of ranks, L_i	37	42	25	66	55	225

Experts	**Competency components**					**Total**
	Medicine	***Ergonomics***	***Work safety***	***Civil protection***	***Forestry***	
L_i ranks	2	3	1	5	4	-
d_i	22	27	10	51	40	150
d_i^2	484	729	100	2601	1600	5514

The level of significance of medicine and ergonomics is in good agreement, i.e. no significant differences were found ($p = 0.56$). The level of importance of medical and occupational safety is weakly correlated, i.e. no significant differences were found ($p = 0.13$). Very significant differences were found for medical and civil protection assessments ($p < 0.00$). Significant differences were found for medical and forestry assessments ($p < 0.05$). Significant differences were found for ergonomics and occupational safety assessments ($p < 0.04$). Significant differences were found for ergonomics and civil protection assessments ($p < 0.02$). The level of importance of ergonomics and forestry is moderate, or no significant differences are observed ($p = 0.19$). Between occupational safety and civil protection assessments, it was found that there are extremely significant differences ($p < 0.00$). Between occupational safety and forestry assessments, it was found that there are extremely significant differences ($p < 0.00$). The level of importance of civil protection and forestry is moderate coincidence, or no significant differences are observed ($p =0.30$).

CONCLUSIONS

The results of the study show that during professional practice, students have an increased workload, as well as a significantly increased physical load, where overload is possible for individuals with normal physical fitness. Fatigue and reduced working capacity appear at the end of the practice, especially when it was necessary to make decisions about action in emergency situations. Instructors should offer students stress-relieving exercises that would be used daily to relieve muscle strain. Internships should be held in the autumn-spring period, reducing psycho-emotional risk factors, which are otherwise exacerbated by heat, sweating, overheating, insects, etc.. In adverse weather conditions, one should leave the work environment in a timely manner, without endangering oneself and others.

Further research on the assessment of the logging work environment is particularly relevant, because today's students become the next generation of direct supervisors, who must know correct work techniques and occupational safety practices in logging, forest care, etc.

REFERENCES

[1] International Ergonomics Association. What is ergonomics? [Online]. Avaiable: https://iea.cc/about/what-is-ergonomics/ [Accessed: Sep. 10, 2024].

[2] L. Bulotaite, D. Šoryte, S. Vičaite, R. Šidagyte, S. Lakiša, I. Vanadziņš, L. Kozlova, M. Eglīte, L. Hopsu, A. Salmi, and J. Lerssi – Uskelin, "Workplace health promotion in health care setting in Finland, Latvia, and Lithuania",Medicina, vol. 53, no. 5, p. 348 +, December 2017. [Online]. Available: https://doi.org/10.1016/j.medici.2017.10.002. [Accessed Feb. 23, 2024],

[3] U. Karlsons and R. Putans, "Cognitive workload for administrative workers", presented at 82nd International Scientific Conference on University of Latvia, Riga, Latvia, 2024.

[4] V. Kalakoski, S. Selinheimo, T. Valtonen, J.Turunen, S. Käpykangas, H. Ylisassi, P. Toivio, H. Järnefelt, H. Hannonen, and T. Paajanen, "Effects of a cognitive ergonomics workplace intervention (CogErg) on cognitive strain and well-being: A cluster-randomized controlled trial. A study protocol ", BMC Psychology, vol. 8, no 1, p.1 +. Available: https://doi.org/10.1186/s40359-019-0349-1 [Accessed Feb. 23, 2024].

[5] I. Potočnik and A. Poje, "Forestry Ergonomics and Occupational Safety in High Ranking Scientific Journals from 2005–2016." Croatian journal of forest engineering, 38(2):291-310, 2017. Available: [Abstract]. Available: Scopus https://www-scopus-com. [Accessed Feb. 23, 2024].

[6] M. Bačić, M. Matija Landekić, Z. Pandur, M. Šušnjar, M. Šporčić, H. Nevečereland, K. Lepoglavec, "Forestry Ergonomics Publications in the Last Decade". A Review. Forests 15(4):616, 2024. Available: [Abstract]. Available: Scopus https://www-scopus-com. [Accessed Jan. 23, 2024] DOI: 10.3390/f15040616.

[7] C. D. Spielberger and E. C. Reheiser. Measuring Occupational Stress: The Job Stress, 2nd ed. CRC Press, pages 19, eBook ISBN9781003072430, 1995.

[8] D. Sharek, "A useable, online NASA-TLX tool", Sage Journals, vol.55,issue1, Sep. 2011. [Online]. Available: https://journals.sagepub.com/doi/abs/10.1177/1071181311551286, [Accessed Sep. 30, 2023] https://doi.org/10.1177/1071181311551286.

[9] L. Paura and I. Arhipova, "Nonparametric methods: SPSS computer program".Jelgava: LLKC, p. 148, 2002.

[10] K. J. Preacher, "Calculation for the Chi – Square Test" [Online]. Available: https://quantpsy.org/chisq/chisq.htm

[11] V.Kaļķis, Methods for assessing workplace risks.. Riga, Latvian Education Foundation, 2008.

[12] A. Houichi and D. Sarnou, "Cognitive Load Theory and its Relation to Instructional Design: Perspectives of Some Algerian University Teachers of English ". Arab World English Journal, 11 (4) 110-127, 2020. [Abstract]. Available: Scopus https://www-scopus-com [Accessed Jan., 2025], DOI: https://dx.doi.org/10.24093/awej/vol11no4.8

[13] S. Koudsia and M. Kirchner, "Reducing Cognitive Overload for Students in Higher Education: A Course Design Case Study. Journal of Higher Education Theory and Practice Vol. 24(10) 2024. [Online]. Available: https://articlegateway.com/index.php/JHETP/article/view/7382. [Accessed Dec. 13, 2024], https://doi.org/10.33423/jhetp.v24i10.7382