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THE RELATIONSHIP BETWEEN WORKING MEMORY AND ACADEMIC ACHIEVMENT

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ABSTRACT

This study investigates the relationship between working memory and academic performance among first-year students at the Faculty of Civil Engineering and Architecture, University of Osijek. The primary objective was to examine how different aspects of working memory – such as verbal and numerical information retention, executive functioning, and attention maintenance – relate to students' academic success. A quantitative analysis was conducted using data from an online questionnaire with a five-point Likert scale, applying descriptive analysis, non-parametric tests, and Spearman's correlation coefficient.

The results revealed significant gender differences in executive functioning, with female students reporting greater difficulties compared to their male peers. Furthermore, part-time students demonstrated better coping skills in unexpected situations and showed greater ability to manage paperwork, bills, and similar administrative tasks. Additionally, students who passed more exams in the previous semester showed better organizational skills in managing academic responsibilities. However, no significant correlation was found between working memory and academic achievement in terms of the other analysed factors.

In conclusion, while working memory plays a crucial role in managing academic tasks, its direct impact on academic performance remains uncertain. The study highlights the importance of understanding how executive functioning may differ by gender and the need for further research using objective measurements of working memory capacity. Future studies should expand the sample to include students from various academic disciplines and explore potential interventions for students with working memory deficits, ultimately enhancing educational strategies and support systems.

KEY WORDS

working memory, academic achievement, executive functioning, university students, self-assessment

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INTRODUCTION

Scientists have studied the impact of various factors such as intelligence, motivation, self-efficacy, self-regulation, the use of cognitive and metacognitive strategies, and others on academic achievement [1, 2]. Often, the influence of not just one factor but a combination of several is examined: cognitive (e.g., the impact of intelligence and working memory) and non-cognitive (e.g., academic self-esteem) on academic achievement [3]. Titz and Karbach, in their review paper, conclude that working memory, which enables the storage and manipulation of information in the mind and executive functioning, has a significant impact on academic achievement [4]. They also concluded that cognitive training affecting these two factors positively correlates with academic achievement, not only in children with cognitive and learning difficulties but also in healthy children [4, 5].

It has been shown that working memory capacity significantly influences language and mathematics learning and plays a key role in language comprehension and processing, as well as in the retention and application of mathematical skills [6]. Students at technical faculties often face complex tasks that involve problem-solving encoded in mathematical formulas, complex calculations, and procedures, which they then decode to place the solution in a real-world context [7]. Such tasks require simultaneously holding information in mind and manipulating it, which is a direct function of working memory [8].

Given the importance of working memory in an academic context, particularly in disciplines that require complex problem-solving and information manipulation (such as engineering and architecture), this study aims to explore the relationship between self-assessed working memory capacity and academic achievement among first-year students at the Faculty of Civil Engineering and Architecture in Osijek. By focusing on self-assessed working memory, this research seeks to provide insights into how students perceive their cognitive abilities and how these perceptions correlate with their academic performance.

Based on the reviewed literature, the following hypotheses were formulated:

- **H_1**: There is no statistically significant difference in self-assessed working memory capacity regarding to gender and study type, considering the factors: difficulties in remembering verbal information, difficulties in remembering numerical information, difficulties in executive functions, and difficulties in maintaining attention.
- **H_2**: There is a positive correlation between self-assessed working memory capacity and academic achievement, as measured by the number of passed exams, average grade of exams, and average grade in mathematics on the state exam.

This study explores the role of working memory in an academic context, focusing specifically on students enrolled in civil engineering faculty who routinely engage in complex tasks requiring simultaneous integration of mathematical calculations, spatial reasoning, and verbal processing. Given the specific and demanding nature of these academic programs, examining the role of working memory has clear relevance, as it contributes to identifying students' learning challenges and supports the development of targeted educational interventions. Furthermore, by investigating self-assessed working memory capacity, the present research highlights its relevance within the growing body of literature on metacognition.

The structure of the article is as follows: the second section defines and describes the concept of working memory and the methods of assessing working memory capacity, the third section describes the research methodology. The fourth section presents and analyses the collected data, the fifth section discuss the results in comparison with recent literature. The final section draws conclusions, reflects on the limitations of the study, and suggests future research.

WORKING MEMORY

Working memory refers to the brain system responsible for temporarily storing and simultaneously manipulating information necessary for complex cognitive tasks such as learning, reasoning, and language comprehension [9]. The concept of working memory evolved from early theories of short-term memory into a widely accepted multi-component model proposed by Baddeley and Hitch [10]. This model, expanded by Baddeley, includes four components: the central executive, which controls attention; the visuospatial sketchpad, which manages visual and spatial information; the phonological loop, responsible for processing verbal information; and the episodic buffer, which integrates multimodal information and connects working memory with long-term memory [10, 11]. Given its clear relevance in explaining cognitive processes crucial for academic achievement, particularly in complex learning environments, Baddeley's model was selected as the theoretical framework for the current study. Working memory plays a critical role in everyday tasks, such as following directions, understanding spoken or written information, and performing mathematical calculations [12]. Its limited capacity directly impacts academic performance; exceeding this capacity negatively affects learning outcomes, particularly in areas involving complex information processing such as language comprehension and mathematics [13, 14].

Research has established that both short-term memory and working memory play a crucial role in reading comprehension and mathematical skill acquisition in children and adults with learning difficulties. However, working memory appears to be of greater significance for individuals without such difficulties [12]. Despite its significance, studies indicate that many teachers have insufficient knowledge of working memory and effective strategies to support children with working memory deficits [15].

A variety of instruments have been developed for the assessment of working memory. A clear distinction must be made between psychometric tests, which assess working memory through tasks resembling real-life situations, and self-report questionnaires, where individuals evaluate statements related to their memory and executive functioning in daily activities [16]. One widely used working memory questionnaire, developed by Vallat-Azouvi et al., assesses three key factors: short-term memory, attention, and executive functioning [17]. This questionnaire was adapted and translated into Croatian by Dodaj and Sesar and was utilized in the present study [16].

METHODOLOGY

RESEARCH OBJECTIVE

This study aims to examine first-year students' self-assessed working memory at the Faculty of Civil Engineering and Architecture, University of Osijek. Furthermore, it seeks to investigate the relationship between students' working memory and their academic performance, as well as to determine whether statistically significant differences exist based on demographic characteristics such as gender and type of study.

SAMPLE

The sample was convenience-based ($N = 143$) and consisted of first-year undergraduate professional students (both full-time and part-time) and undergraduate university students majoring in civil engineering at the Faculty of Civil Engineering and Architecture in Osijek. All collected questionnaires ($N = 143$) were fully completed, with no missing data. The total eligible population was approximately 200 students (180 full-time and 20 part-time enrolees), resulting in a response rate of 71,5%. While the faculty also offers an architecture program, students from that program were not included in the survey. The sample included 44,1% male and 55,9% female students. This population was selected due to the lack of existing research on self-assessed working memory within Croatian technical faculties, despite the cognitively demanding nature of such academic programs. As such, the study aims to provide a contribution to understanding working memory in a local academic context. At the national level in Croatia, 95,8% of full-time students enrol in higher education before age 21, while the proportion is somewhat lower (78,0%) among part-time students, though still constituting a significant majority [18]. Thus, while exact age data were not collected as it was not a study variable, the sample represents a relatively homogeneous age group.

DATA COLLECTION PROCEDURE

The questionnaire was administered and completed online via the Moodle system. In April 2024, the author of this article visited all the specified student groups and provided them with a link to the questionnaire during class. Participation was voluntary and anonymous, and the questionnaire remained available for two weeks.

MEASURMENT INSTRUMENT

The measurement instrument used in this study was a questionnaire consisting of two main sections. The first section collected demographic data, while the second assessed students' self-perceived working memory. This section employed an adapted version of the Working Memory Questionnaire by Vallat-Azouvi et al, specifically the Croatian-translated and validated version by Dodaj and Sesar [16, 17]. The questionnaire was developed based on Baddeley's working memory model [11]. The original questionnaire comprises 30 items divided into three subscales: short-term memory, attention, and executive functioning [17]. The short-term memory subscale measures the ability to retain verbal or numerical information in short-term memory. The attention subscale assesses distractibility, mental slowness, fatigue, and the ability to process dual tasks. The executive functioning subscale evaluates decision-making, planning, and cognitive flexibility [16]. Responses were recorded on a 5-point Likert scale, ranging from 1 ("not at all") to 5 ("extremely").

However, in the Croatian version of the questionnaire, Dodaj and Sesar identified four factors through factor analysis [16]:

1) difficulties in remembering verbal information
2) difficulties in remembering numerical information
3) difficulties in executive functions
4) difficulties in maintaining attention.

To assess the reliability of the questionnaire, the Dodaj and Sesar calculated Cronbach's alpha coefficient, which was 0,93 for the entire questionnaire, with values for individual factors ranging from 0,75 to 0,83 [16]. This questionnaire was selected because it had already been translated into Croatian and validated.

RESULTS

The data were processed using SPSS 26 (Statistical Package for Social Sciences) and analyzed quantitatively. Descriptive statistics were applied. Due to the lack of normal distribution for all variables, as assessed by the Shapiro–Wilk test (e.g., Q06_graduation percentage: $W = 0,898$, $p < 0,001$; working memory scale items: W ranging from 0,797 to 0,909, all $p < 0,001$), non-parametric statistical tests were employed. Specifically, Mann-Whitney U, Kruskal-Wallis, and Spearman's correlation tests were used as robust alternatives to parametric procedures. The chosen significance level was $\alpha = 0,05$. To assess the reliability of the questionnaire, Cronbach's alpha coefficient was calculated, yielding a value of 0,913 for the entire questionnaire. Additionally, Cronbach's alpha coefficients were computed separately for each of the four identified factors, Table 1.

Table 1. Cronbach's alpha coefficients by factors.

No.	Factor	Number of items in the factor	Cronbach's alpha
1.	Difficulties in remembering verbal information	8	0,808
2.	Difficulties in remembering numerical information	6	0,576
3.	Difficulties in executive functions	7	0,767
4.	Difficulties in maintaining attention	9	0,794

DEMOGRAPHIC CHARACTERISTICS OF STUDENTS

The questionnaire was completed by $N = 143$ first-year students at the Faculty of Civil Engineering and Architecture in Osijek. Table 2 presents the demographic characteristics of the respondents, categorized by gender and type of study. It is noticeable that there were about 10% more female respondents. The ratio of full-time to part-time students who participated in the survey was 3,33, which closely mirrors their actual enrolment ratio of 3,3. The ratio of students enrolled in the university undergraduate program to those in the professional undergraduate program (full-time) who completed the questionnaire was 1,57, while the actual enrolment ratio is 2. This slightly lower response rate from university program students can be attributed to the fact that the researcher, being a lecturer in the professional program, was able to remind those students more frequently to complete the questionnaire.

Table 2. Demographic characteristics of students.

Characteristic	frequency	Percentage, %
Gender		
Female	80	55,9
Male	63	44,1
Type of study		
University	78	54,5
Professional full-time	50	35
Professional part-time	15	10,5

DESCRIPTIVE STATISTICS

The questionnaire consisted of 30 items measured on a 5-point Likert scale (ranging from 1 – 'not at all' to 5 – 'extremely'). Table 3 presents all 30 items along with their corresponding mean values. It can be observed that for all items, the minimum value was 1 and the maximum value was 5 (except for Q18, where the maximum value was 4), indicating that at least one respondent selected each value for every item. It is important to note that higher mean values indicate a greater perceived difficulty. Interestingly, items Q16 and Q1 had the highest mean values (3,66 and 3,20, respectively), both of which are related to fatigue. This suggests that, among all the individual difficulties, fatigue had the most significant impact on the respondents.

For further analysis, factor analysis identified four factors [16]:

F_1: Difficulties in remembering verbal information,
F_2: Difficulties in remembering numerical information,
F_3: Difficulties in executive functions, and
F_4: Difficulties in maintaining attention.

Table 1 presents the Cronbach's alpha coefficients for each factor, as obtained in this study. In their questionnaire, Dodaj and Sesar calculated the result for each factor as the sum of the individual item scores [16]. However, in this study, the author opted to analyse the average values for each subscale (factor) rather than the sum of scores. This approach was selected because the factors consisted of a different number of items, and in order to facilitate comparisons across all four factors, the results needed to be standardized to a common measure. It is important

Table 3. Descriptive statistics of items (continued on p.346).

Question	Min.	Max.	Mean	Std. Dev.
Q1 You tend to get tired quickly during the day.	1	5	3,20	1,127
Q2 You find it challenging to make decisions, such as planning a vacation.	1	5	2,27	1,139
Q3 You struggle to remember a sequence of numbers, like phone numbers.	1	5	2,17	1,171
Q4 You need to put extra effort into maintaining concentration during conversations involving several people.	1	5	1,99	1,144
Q5 You have trouble recalling the name of someone who just introduced themselves.	1	5	2,85	1,463
Q6 You often end up spending more money than you intended while shopping.	1	5	2,94	1,304
Q7 You have difficulty remembering what you have read.	1	5	2,59	1,096
Q8 You have difficulty continuing your current activity if you have been interrupted, for example, by a loud noise (e.g., a door slamming, a car siren).	1	5	2,22	1,207
Q9 You find it difficult to perform an activity in chronological order (e.g., cooking, sewing, home repairs).	1	5	1,57	0,860
Q10 You are bothered by other people's conversations while you are talking to someone.	1	5	2,17	1,169
Q11 You need to read a sentence multiple times to understand it.	1	5	2,65	1,176
Q12 You have difficulty organizing your time according to scheduled appointments and daily activities.	1	5	2,43	1,225
Q13 You find it difficult to perform two or more tasks simultaneously (e.g., doing household chores while listening to the radio; cooking while listening to the radio).	1	5	1,43	0,860
Q14 You find it difficult to change your strategy (method) of work if you notice that you are making a mistake while performing an activity.	1	5	2,01	1,048
Q15 You have difficulty understanding what you have read.	1	5	2,16	1,105
Q16 You feel that fatigue significantly reduces your concentration.	1	5	3,66	1,192
Q17 When you pay for something in cash, you find it difficult to assess whether you have been given the correct change.	1	5	1,42	0,867
Q18 You find it difficult to follow all the instructions in a manual (e.g., for assembling furniture, installing a new electronic device).	1	4	1,41	0,643
Q19 You have difficulty performing activities while there is background noise (e.g., radio, TV).	1	5	1,92	1,154
Q20 An unexpected event can significantly disrupt your plans or the activity you are currently engaged in.	1	5	3,01	1,166
Q21 You have difficulty understanding a text if a character is referred to differently throughout the text.	1	5	2,09	1,054
Q22 You feel uncomfortable when talking to unfamiliar person.	1	5	2,32	1,254
Q23 You hesitate for a long time when making purchases, even for usual items.	1	5	2,28	1,207
Q24 You feel slowed down when performing usual activities?	1	5	2,03	1,156

Table 3. Descriptive statistics of items (continuation from p.345).

Question	Min.	Max.	Mean	Std. Dev.
Q25 You need to check a written phone number multiple times when dialing it if you don't know it by heart.	1	5	2,52	1,162
Q26 You have difficulty with paperwork, paying bills, and similar tasks.	1	5	1,69	1,037
Q27 You find it difficult to remember what someone said or asked of you if they speak too quickly.	1	5	2,09	1,150
Q28 You get tired quickly during activities that require a higher level of concentration (e.g., reading).	1	5	2,45	1,243
Q29 After shopping, you are surprised by the number of unnecessary items you have purchased.	1	5	2,07	1,214
Q30 You have difficulty engaging in a conversation with several people at once.	1	5	1,77	1,005

to note that all subsequent statistical analyses were conducted using both definitions of the factors, and the results were consistent in both cases. It should be noted that all subsequent statistical analyses were performed on factors defined in both ways, and the results were found to be identical in both cases.

From Table 4, it can be observed that the highest average score (2,66) was achieved by Factor F_3, indicating that students report the most difficulties with executive functions. The next set of difficulties, which cause mild to moderate problems, are those related to verbal information memory. Interestingly, difficulties with remembering numerical information were the least problematic for the respondents (with an average score of 1,92). This can be explained by the sample choice, as all the respondents were students of a technical faculty.

Table 4. Descriptive statistics of factors.

Factor	Min.	Max.	Mean	Std. Dev.
F_1	1,13	4,63	2,400	0,784
F_2	1,00	4,17	1,916	0,586
F_3	1,29	4,71	2,657	0,772
F_4	1,00	4,89	2,010	0,660

THE INFLUENCE OF STUDENTS' PERSONAL CHARACTERISTICS ON THE RESULTS

Working memory results regarding gender

In addition to the descriptive analysis presented, nonparametric tests were also used in the data analysis. The selected significance level was $\alpha = 0,05$, meaning that null hypotheses regarding the equality of the observed samples were rejected when the p-value was less than 0,05.

The nonparametric Mann-Whitney test indicated a statistically significant difference in certain items regarding gender, Table 5. Given that four out of these five items belong to subscale F_3, it was expected that a statistically significant difference by gender would also be observed in Factor F_3, Table 6. No statistically significant differences regarding gender were found in the other factors.

Table 5. Mann-Whitney test results for selected items regarding gender.

Question	Q1	Q6	Q16	Q22	Q29
Mann-Whitney U	1588,00	1587,50	1840,50	1859,50	1871,50
p-value (2-tailed)	< 0,001	< 0,001	0,004	0,005	0,005

Table 6. Mann-Whitney test results for all four factors regarding gender.

Factor	F_1	F_2	F_3	F_4
Mann-Whitney U	2369,50	2385,00	1564,50	2472,50
p - value (2-tailed)	0,540	0,581	< 0,001	0,846

Furthermore, we aimed to determine which gender scored higher on the items where a statistically significant difference was observed. By analysing the mean rank values for the selected items and Factor F_3 regarding gender (Table 7), we observed that female students achieved higher values in all examined items (Q1, Q6, Q16, Q22, and Q29) as well as in Factor F_3.

Table 7. Mean rank values regarding gender.

Item	**Gender**	***N***	**Mean rank value**	**Rank sum**
Q1	female	80	83,65	6 692,00
	male	63	57,21	3 604,00
Q6	female	80	83,66	6 692,50
	male	63	57,20	3 603,50
Q16	female	80	80,49	6 439,50
	male	63	61,21	3 856,50
Q22	female	80	80,26	6 420,50
	male	63	61,52	3 875,50
Q29	female	80	80,11	6 408,50
	male	63	61,71	3 887,50
F_3	female	80	83,94	6 715,50
	male	63	56,83	3 580,50

Working memory results regarding the type of study

This study examined whether statistically significant differences existed across all items and factors based on the type of program (university or professional) and the mode of study (full-time or part-time). No statistically significant differences were identified across the examined factors. However, significant differences emerged in two specific items, Q20 and Q26, as presented in Table 8. Table 9, which displays the mean rank values, indicates that part-time students reported the least difficulty with these items. Specifically, they experienced fewer challenges related to paperwork, bill payments, and similar administrative tasks and were less likely to have their plans disrupted by unexpected events. These findings suggest a statistically significant difference between full-time and part-time students in their perceived difficulty with administrative tasks (Q20) and their ability to adapt to unforeseen circumstances (Q26). Notably, part-time students reported fewer difficulties, suggesting a greater capacity to manage these challenges effectively.

Table 8. Results of the Kruskal–Wallis test for items Q20 and Q26 regarding the type of study.

Item	**Kruskal–Wallis H**	***df***	**p-value**
Q20	6,588	2	0,037
Q26	6,875	2	0,032

THE INFLUENCE OF WORKING MEMORY ON ACADEMIC ACHIEVMENT

Additionally, we explored the association between academic achievement and working memory, specifically focusing on its constituent factors. To investigate this, we first assessed the number of exams passed from the first semester. Using the non-parametric Kruskal-Wallis test, a statistically significant difference was observed in only one of the 30 items (Q12). Additionally, no significant differences were found in any of the four factors, Table 10. From Table 11, it is evident that students who passed the fewest exams reported the most significant

Table 9. Mean rank value for items Q20 and Q26 regarding the type of study.

Item	Type of study	*N*	Mean rank value
Q20	University	78	73,34
	Professional full-time	50	77,30
	Professional part-time	15	47,37
Q26	University	78	78,86
	Professional full-time	50	66,06
	Professional part-time	15	56,13

difficulties in time management related to their academic obligations. The mean rank for students who passed only one of the six exams was 130,5, progressively decreasing to 62,39 for those who passed all six exams. As depicted in Figure 3, these results can be approximated by a quadratic function $y = 3{,}75 \cdot x^2 - 39{,}29 \cdot x + 164{,}03$. These findings suggest that students with lower academic performance, as indicated by the number of exams passed, are likely to experience greater challenges in managing their time effectively. This may imply that working memory, along with its associated factors, such as time management, plays a role in academic success. However, the lack of significant differences in most items and factors suggests that the relationship between working memory and academic achievement is multifaceted, possibly influenced by additional variables not considered in this study. Further research is needed to explore these dynamics in greater depth.

Table 10. Results of the Kruskal–Wallis test for item Q12 regarding the number of exams passed.

	Q12
Kruskal-Wallis H	13,624
df	5
p-value	0,018

Table 11. Mean rank value for item Q12 regarding the number of exams passed.

Item	Number of exams passed	*N*	Mean rank value
Q12	1	2	130,50
	2	9	96,11
	3	39	81,78
	4	37	67,20
	5	34	62,40
	6	22	62,39

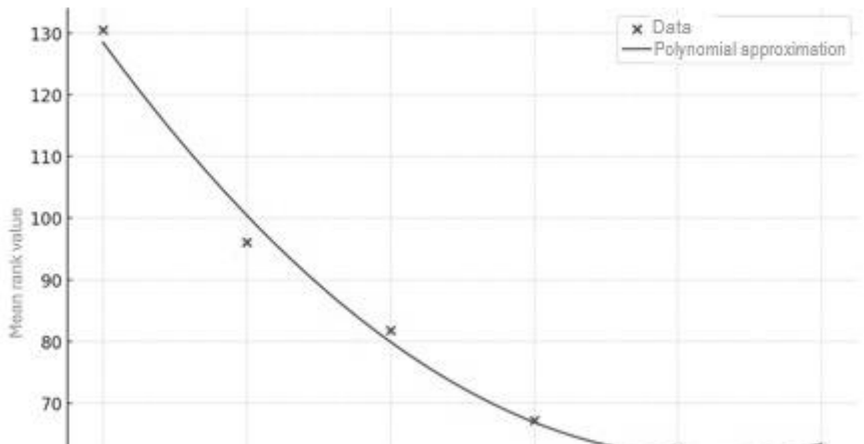

Figure 3. Polynomial approximation of the mean rank values.

Additionally, an analysis was conducted across all variables and factors regarding to the average grades of completed courses, the level of the mathematics matura exam taken (higher level A or basic level B), and the scores achieved on the mathematics matura exam. The matura exam is a standardized final examination taken by students at the end of high school in several countries, including Croatia. It is important to note that the scores obtained on the mathematics matura exam, regardless of whether they were taken at the higher-level A or the basic level B, were standardized to a common scale. This was achieved by multiplying the scores from level A by a coefficient of 1,6, as outlined in the State matura brochure [19]. For the analysis of the matura level, the Mann-Whitney U test was employed, while Spearman's correlation coefficients were calculated for the other two analyses. However, no significant associations were found between the types of academic achievement examined and working memory.

DISCUSSION

The aim of this study was to examine the relationship between self-assessed working memory and academic achievement among first-year students at a technical faculty. The results partially confirmed the hypotheses, revealing statistically significant gender differences in self-perceived executive functions as well as differences between full-time and part-time students in their ability to manage unexpected situations and administrative tasks. A relationship was also demonstrated between the number of passed exams and self-assessed time management skills. Despite these findings, no consistent or broad correlation was found between working memory and other indicators of academic achievement, such as average course grades or state matura exam results. Several possible interpretations and contextual factors may explain these findings.

These results align with certain findings in the existing literature while differing from others. For instance, Alloway et al. found that working memory in children was a better predictor of academic achievement than intelligence, whereas Giofrè et al. demonstrated only an indirect relationship between the two [3, 20]. Peng et al. also confirmed the complex and variable association between working memory and mathematics performance, influenced by sample characteristics and the specific domain of working memory assessed [8]. A similar absence of significant correlation between working memory and academic achievement was reported in a study involving final-year medical students [21]. Importantly, many of these studies relied on objective measures of working memory, while the present research used a self-assessment approach.

The use of self-assessment to measure working memory presents both advantages and limitations. Self-report measures can effectively capture students' subjective experiences and perceptions of their cognitive functioning, which is valuable for identifying areas where students feel they need support. However, literature consistently points to the limitations of self-report assessments, such as susceptibility to response bias, social desirability, and limited accuracy compared to objective measures like standardized memory tasks [22]. Future research incorporating objective measurements could provide complementary data to confirm and further clarify the relationship between working memory and academic performance.

The findings indicate that female students perceive themselves as having significantly greater difficulties in executive functioning compared to their male counterparts. These results do not align with those reported by Dodaj and Sesar, whose analysis showed that male students scored significantly higher across all four factors [16]. However, our findings are more consistent with those of the original English-language questionnaire, which did not identify any statistically significant gender differences in any factor [17]. It is important to emphasize that these results should not be interpreted as evidence that female students objectively perform worse in executive functioning than their male counterparts. Prior research has shown that men tend to express greater self-confidence than women in their performance on self-assessment questionnaires, regardless of actual ability, and that this pattern is consistent across age groups [23]. This could partially explain the observed gender difference in self-reported executive functioning.

Additionally, the observed difference between full-time and part-time students in managing administrative tasks and unexpected events may reflect life experience. Part-time study programs are typically designed for individuals who pursue education alongside employment or other responsibilities [24]. Consequently, students in these programs are often older, employed, and in some cases, have family obligations, which may contribute to their greater familiarity with administrative tasks and their ability to navigate unpredictable situations. Moreover, research on self-regulation and organizational skills has demonstrated that students balancing education with external commitments, such as work or family responsibilities, tend to develop stronger planning and problem-solving strategies [25]. These skills likely enable them to perceive fewer difficulties and to manage unexpected challenges more effectively. Additionally, previous studies have shown that older students and those with work experience tend to exhibit superior time management skills [26]. This further suggests that part-time students possess specific competencies that enhance their resilience in dealing with such challenges.

The lack of significant correlations between working memory and academic achievement might also stem from several factors. Although the questionnaire used is validated and utilized in previous studies, it may not have been sufficiently sensitive or fully appropriate for detecting this connection within this relatively homogeneous sample, composed exclusively of technical faculty students. Such homogeneity may have resulted in restricted variability in working memory and academic performance scores, a known factor that can reduce observable correlations in statistical analyses [27]. Furthermore, academic achievement is influenced by numerous factors: motivation, prior knowledge, learning strategies, emotional regulation, and environmental support which may have confounded or overshadowed the role of working memory in this study.

Although international studies have explored similar constructs, there is a lack of such research in the Croatian academic context. By using a validated Croatian version of a self-assessment tool, this study fills a gap in the local literature and establishes a foundation for further research that could compare students across disciplines and national contexts. Future studies might benefit from including both subjective and objective measures of working memory, diversifying the sample.

In sum, while the findings do not offer a straightforward confirmation of working memory as a predictor of academic success, they highlight key gender-based perceptions and raise important methodological considerations regarding self-assessment.

CONCLUSION

At the end of the last century, the understanding of the types of memory stored in the human brain changed, offering new models of human memory. The working memory model was introduced as a link between short-term and long-term memory. It has been established that reduced capacities in short-term and working memory are responsible for learning difficulties, especially those related to reading comprehension and mathematical skills.

This article analysed the results of a self-assessment questionnaire administered to first-year technical faculty students regarding their working memory, which was examined through four factors. The factors measured difficulties in remembering verbal and numerical information, executive functioning, and sustained attention.

The hypothesized expectations were partially rejected in both cases, and a more detailed explanation follows. From the results, it was observed that female students reported more difficulties in executive functioning compared to their male peers, with a significance level of 0,05. Furthermore, part-time students showed significantly fewer difficulties in managing unexpected events and completing administrative tasks.

In analysing the relationship between working memory and academic achievement, various criteria of academic success were defined and examined: the level of the mathematics matura exam taken, the percentage of correct answers on the mathematics matura exam, the average grades of completed courses (with a maximum of six courses possible to pass in the first semester), and the number of exams passed in the first semester. Only the latter criterion showed a significant difference, indicating that students who passed more exams exhibited fewer difficulties in organizing their time according to all their obligations compared to those who passed fewer exams. Analyses with respect to the other criteria did not show a significant correlation between working memory and academic achievement.

One of the possible limitations of this study is the use of self-assessment of working memory instead of objective measurement of its capacity. Therefore, it is not possible to conclusively determine whether the observed gender differences are attributable to actual disparities in executive functions or whether they arise from subjective perceptions, which have been previously shown to vary by gender. However, the use of self-assessment provides valuable subjective insights into students' perceived cognitive abilities, complementing objective measures. Another limitation is the convenience sample, which means that the results cannot be generalized to the broader population, but rather only to groups with similar characteristics. Nevertheless, these results provide valuable insight into working memory and lay the groundwork for future research.

The unique contribution of this study lies in its focus on a sample of Croatian technical students, an area previously unexplored in the literature. Future research could address these limitations by incorporating objective measures of working memory and expanding the sample to include students from a range of academic disciplines, to explore whether differences exist based on the field of study. Moreover, this article could serve as a catalyst for further research into the role of working memory across all educational levels, as well as for the development of a more systematic approach to identifying and supporting children and young people with deficits in working memory capacity. In this way, it may contribute to the development of more effective interventions and support for this population.

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