

DIGITAL COMPETENCES AND PERFORMANCES OF INDUSTRIAL ENGINEERING STUDENTS

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Abstract: The study explores the association between digital competences and academic performances of Industrial Engineering (IE) students at the Faculty of Technical Sciences, University of Novi Sad. Digital Competence Wheel (DCW) is used for measuring IE students' digital competences. For academic performance the class attendance, course completion rate, ECTS credits, High School GPA (HSGPA) and Higher Education (undergraduate) GPA (HEGPA) scores, are used, among others. The findings suggests that, although some DCW scores show the presence of association with certain academic indicators, particularly, features of communication aspect positively correlate with course completion rate, there is a lack of robust evidence in supporting such thesis. Next, although HSGPA correlates with HEGPA, it does not necessarily predict the HEGPA score. Finally, from the exploratory analysis, the evidence suggests that gender may play a role in academic success of IE students given an elevated difference between genders considering both digital competences and academic performances.

Key Words: digital competences, industrial engineering, student academic performance, higher education

1. INTRODUCTION

In the rapidly developing technological landscape, in which Industrial Engineering (IE) finds itself, digital competences/skills are becoming increasingly important. These competences, are vital not only for the professional career [1], but may play a role as an indicator of academic success [2]. Nevertheless, the specific relationship between these competences and academic performance remains unexplored, especially within domain of IE. Thus, this offered us an unique opportunity to investigate if, and how, digital competences affect academic performance of IE students.

Based on the priori research, there is an extensive research assessing the impact of academic performance; however, there is a limited knowledge about the relationship between digital competences and academic performances, specifically IE students. For instance, Sulejmani, Y. et al. [2] discuss how digital competences aid in students' performance. They've pointed out that previous research had conflicting results, where most, however, agree that digital literacy had a positive effect on the academic performance.

On the other hand, a study by Jaya, F. [3] suggests no statistical significance on direct relationship of digital literacy and academic performances, but rather an indirect effect on academic performance through increased active social-emotional involvement. Considering the undergraduate GPA (Grade Point Average) score, a study by Vulperhorst J. et al. [4] suggests that HSGPA (High-School GPA) is significantly correlated with First Year GPA ($r = 0.62$, $p < 0.001$) and Final GPA ($r = 0.72$, $p < 0.001$), even predicting undergraduate first year ($R^2 = 0.46$) and final year ($R^2 = 0.33$) GPA, which was similar to [5]. Another study [6] suggests that a positive association between digital skills and math and reading performance. Finally, a study by Sgibbu, F. [7] show the existence of HSGPA, type of school, credit score and gender, among others, have significant effect ($p < 0.01$) on academic performance.

Based on the search strings (“digital competence wheel” AND “academic performance”), including IE domain, there was no similar articles on the topic. Therefore, based on the prior knowledge this is the first study investigating the potential effect between the DCW and academic performance of IE students.

The rest of the paper is structured as follows. The Methodology section explains survey and data collection, target sample and statistical tests used. The third section reports on the exploratory results and provides a discussion considering the correlation results, effects considering categorical variables and potential relationship in respect to dependent variable of students' academic performance. Finally, the conclusion provides limitations, implications and final remarks of the study.

2. METHODOLOGY

The DCW – Digital Competence Wheel (<https://digital-competence.eu/>) is used as a survey instrument to measure digital competences of Industrial Engineering students (2 semester) at the Faculty of Technical Sciences Novi

Sad and is conducted in February 2022. The DCW instrument was a part of a major EU project called DIGCOMP [8]. The DCW instrument consists of 56 items with 7-point Likert scale ranging from 1 = „To a very small degree“ to 7 = „To a very large extent“. The DCW covers four digital competence aspects, namely Safety, Information, Production, and Communication [9]. The Safety aspect is the ability to use digital technology safely and sustainably in relation to data, identity and work, and to pay attention to legal consequences. The Information aspect is the ability to identify, locate, retrieve, store, organise and analyse digital information and evaluate relevance and purpose. The Communication aspect is the ability to communicate, collaborate, interact with and participate in virtual teams and networks as well as make use of appropriate media, tone and behavior. The Production aspect is the ability to create and edit digital content, solve problems and explore new ways to take advantage of technology. For additional information the reader is referred to [9]. Finally, the 56 items measure sixteen features, four under each aspect, that are provided in the Table 1.

Table 1. Digital Competence Wheel' aspects and underlying features covered

Information		Communication		Production		Safety	
Acronym	Feature	Acronym	Feature	Acronym	Feature	Acronym	Feature
STOR	Storage	ACTPA	Active Participation	PROSHA	Production & Sharing	LAW	Law
SEAR	Search	COLL	Collaboration	DIGEXP	Digital Exploration	IDMAN	Identity Management
CRITEV	Critical Evaluation	SOCAWE	Social Awareness	AUTO	Automation	DATAP	Data Protection
SELF-SERV	Self-service	MEDCHO	Media Choice	CONF	Configuration	HEALT	Health

In addition, the follow-up assessment is conducted on the same sample of IE students' in third year (7 semestar) to synthesise information using the following variables: Average Secondary-Education Grade Point Average (HSGPA), accomplished European Credit Transfer and Accumulation System (ECTS), Exams (courses) finished (EFIN), Exams (courses) not finished (ENFIN), Average number of times before passing the course (ANOT), presence (attendance) on classes (PRESE), and Average Higher-Education GPA (HEGPA). The Serbian secondary education consist of three types: gymnasiums, professional and craft schools. The sample consists of 16 professional (15 technical and 1 economic) and 12 gymnasium. Thus, the sample consists of technical and non-technical group. Finally, there are two categorical variables gender (*Gender*) and Secondary Education High-School Type (*SEC_EDU*).

Considering that this is a preliminary, exploratory analysis, several test statistics have been conducted. Namely, for measuring the independence between variables, an independent samples *t*-test statistic is used. The categorical variables consists of *Gender*, *V-R* (Valid and Reliable) score, and *SEC_EDU* (Secondary Education). The *Gender* is male and female, the *V-R* is valid and invalid, and *SEC_EDU* is technical and non-technical high-school. The *V-R* is measure of time to complete the test. Namely, from the DCW self-assessment test, conclusion is drawn that at least 10 minutes of time is required to finish the test. Therefore, students who filled out the survey below 10 minutes are labelled as invalid. Before conducting test-statistics, a Shapiro-Wilk (SW) test for testing the normality assumption is used. In case normality assumption is broken, a non-parametric counter part (e.g., Mann-Whitney *U* test) is used instead. Also, Brown-Forsythe is used for testing the assumption of equality (homogeneity) of variances. The Pearson's correlation is used to test the correlation between variables, where also, if the normality assumption is broken a non-parametric alternative is used (e.g., Spearman's correlation).

3. RESULTS AND DISCUSSION

The realisation of the survey included the sample of 43 IE students out of 82 enrolled in the IE programe, resulting in 52.4% response rate. In the follow-up testing, 15 students dropped from the survey, with 28 students providing their performance results. Testing the assumptions, the results show that *EFIN* and *ENFIN* (SW = 0.014, $p < 0.01$), *ECTS* (SW = 0.08, $p < 0.01$), and *PRESE* (SW = 0.883, $p < 0.01$) violate normality. The Brown-Forsythe test did not detect variance heterogeneity of included variables. The descriptive results show 58% Male to Female, while 70% proportion of DCW are considered valid (*time* > 10 min). The descriptives of all variables included ($k = 34$) are not provided due to paper length limitations.

Considering the *Gender*, the obtained significance (with reduced $\alpha < 0.1$) show: *STOR* (Figure 1a), *COLL* (Figure 1b), *MEDCHO* (Figure 1c), and *LAW* (Figure 1d) items. Considering *SEC_EDU*, the *t*-test score of *DIGEXP* item suggests statistically significant value (Figure 1e). The results of *V-R* suggest there is a significant difference in *ANOT* variable (Figure 1f). Notice that VS-MPR (Vovk-Sellke Maximum p-level Ratio) score as a measure of diagnosticity of reported *p* values [10], [11] is used. Given the results, the overall VS-MPR score is relatively small considering alternative(s) H_1 . For instance, even the borderline score of *STOR* item ($p = 0.05$) in case of *Gender*, the likelihood of finding small *p* values is only 2.46 times higher than finding larger ones. Although there is a difference in the obtained sample, there is not enough evidence for supporting the statistical significance with higher confidence.

Investigating the correlation between DCW score and IE students' performances, only the Communication features, *ACTPA* and *SOCAWE*, correlate positively with *EFIN* (and negatively with *ENFIN*). Specifically, the *ACTPA* and *EFIN* ($r = 0.381$, $p = 0.045$) and *SOCAWE* and *EFIN* ($r = 0.378$, $p = 0.047$) suggest significance. However, since normality assumptions are violated, the Spearman's rank test is used. Thus, assessing monotonic relationship, as a non-parametric alternative, failed to reject the null ($p = 0.122$), suggesting a lack of evidence in terms of the existence of correlation between DCW scores and IE students' performances.

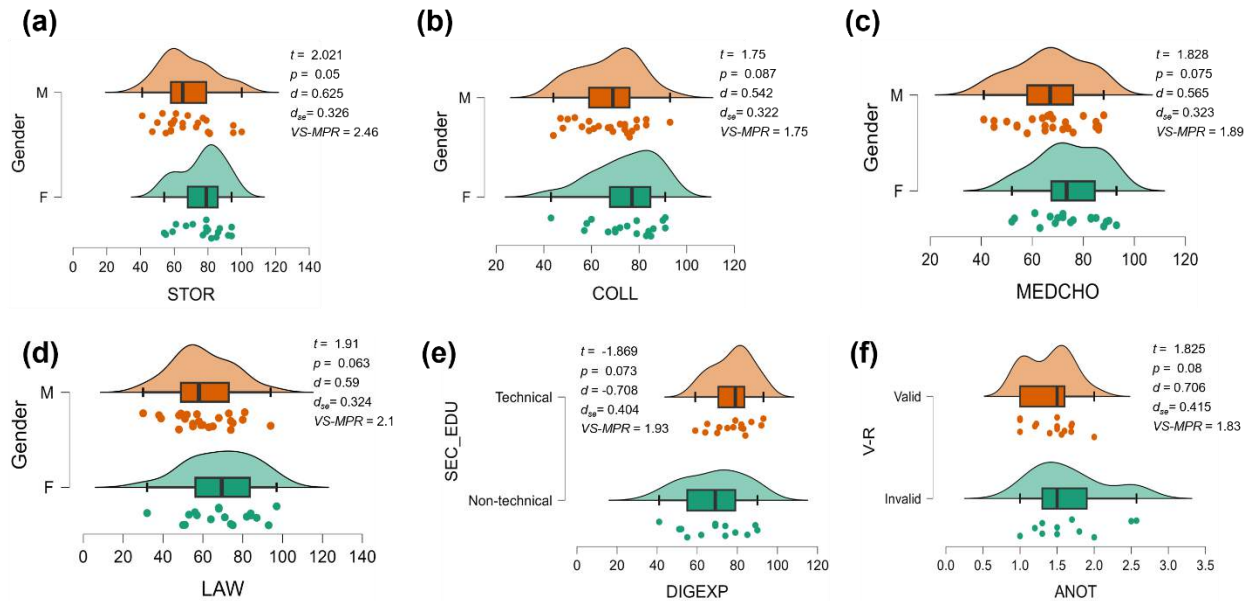


Figure 1. Reporting significant results of t-test considering Gender (a) STOR; (b) COLL; (c) MEDCHO; and (d) LAW; considering SEC_EDU (e) DIGEXP; and V-R split (f) ANOT; with reduced α level to 0.1.

Considering High-School GPA (HSGPA), there is a positive correlation with HEGPA (Figure 2a,b), ECTS (Figure 2a,b), EFIN (Figure 2a,b), and a negative correlation with ANOT (Figure 2a,b). Although the high-school HSGPA correlates with HEGPA, it does not predict the GPA score of IE students. In fact, the effect between HEGPA as a dependent variable, include only two predictors: EFIN ($t = 4.075$; $p < 0.001$) and ANOT ($t = -2.833$; $p = 0.009$), which is determined by the Stepwise Regression (stepping $p < 0.05$ for entry and $p > 0.1$ for removal). The results suggests $R^2 = 61.38$ ($R^2_{adj} = 58.3$) with $p < 0.001$, where coefficients are given as $HEGPA = 5.91 + 0.1601 EFIN - 0.738 ANOT$. Thus, the strength of the relationship between predictors and undergraduate GPA, i.e., HEGPA, score cannot be solely proven by linear regression, although the effect of the relationship exists.

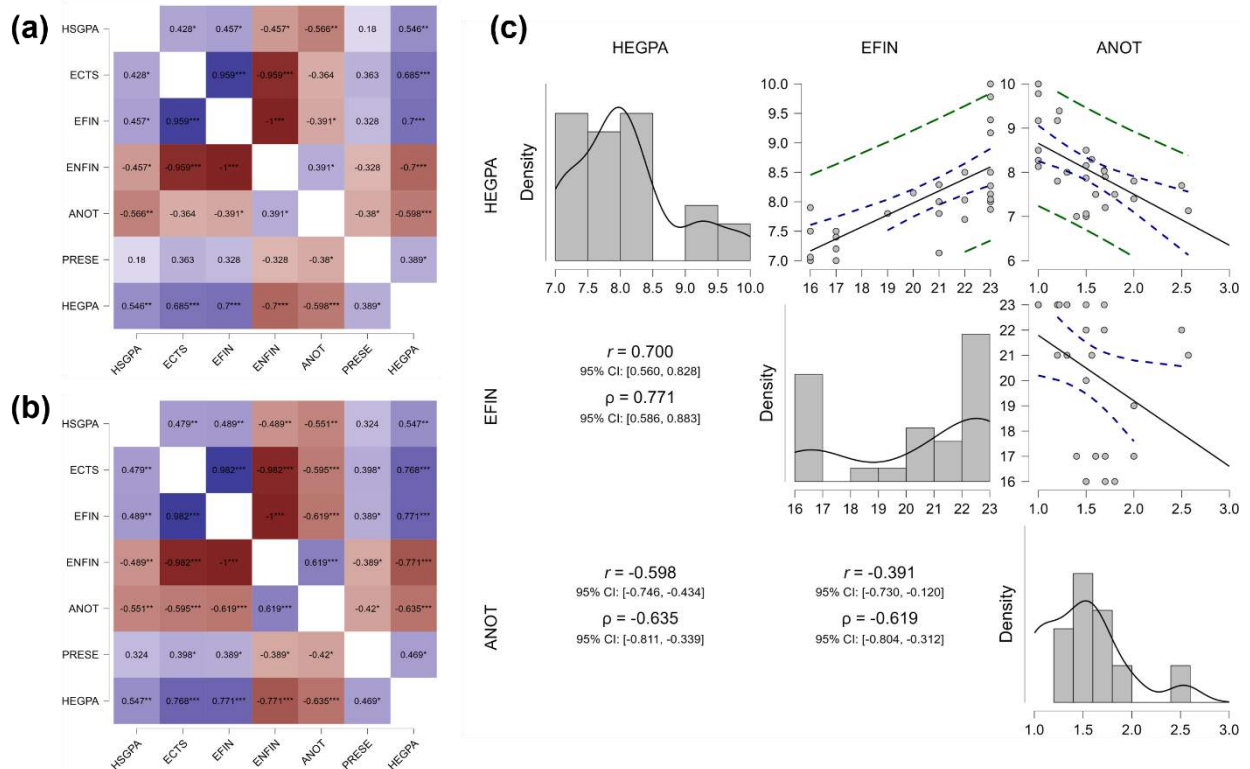


Figure 2. The results of (a) Pearson's r heatmap; (b) Spearmans' ρ heatmap; and (c) correlation plot analysis. The results in heatmaps include reported significance (*0.05; **0.01; ***0.001). The correlation plot reports 1000 bootstrapped confidence intervals (blue dotted line) and prediction intervals (green dotted lines).

4. CONCLUSIONS

This study investigated the potential impact of digital competences on the academic performance of Industrial Engineering students at the Faculty of Technical Sciences, University of Novi Sad. Our findings reveal a nuanced relationship between digital skills and academic outcomes. Notably, certain communication features demonstrate a positive correlation with academic performances, specifically course completion rates. Nevertheless, the influence of high-school GPA (*HSGPA*) score on undergraduate GPA (*HEGPA*) was not definitive, suggesting that competences interact with undergraduate IE students' performance in complex ways, which was not fully captured in this study.

Moreover, there are several limitations in the study. Firstly, the sample size and diversity was limited to a specific cohort of IE students at the Faculty of Technical Sciences Novi Sad, which may not adequately represent the general population of IE students. Secondly, conducted within a single institution also constraints the generalisability to other educational contexts, and/or regions. Thirdly, the study's cross-sectional nature limits our ability to draw inferences over time, considering the relationship between digital competences and academic performance. Finally, the reliance on self-reported measures via DCW survey imposes significant bias on the study outcome.

The implications of the study, considering the positive correlation between certain aspects of digital competences and course completion rates, suggests that integrating digital literacy into IE curricula may enhance or act as a moderator for educational outcomes. Next, educational policy-makers may consider the impact of digital competences on academic performance, consequently moving beyond traditional metrics, such as *HSGPA* for student assessments. Finally, the future research may require longitudinal studies, with broader and more diverse sample populations to deepen the understanding how digital literacy, i.e., competences and skills, impact academic success.

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