

Investigating the Association of Artificial Intelligence Tools Acceptance and Digital Self-Efficacy with Academic Anxiety among Medical Students

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Abstract

Purpose

This study aimed to investigate the association of AI (Artificial Intelligence) tool acceptance and digital self-efficacy with academic anxiety among students of Gonabad University of Medical Sciences.

Methods

This cross-sectional study was conducted in 1404. Participants ($n = 237$) were selected using stratified sampling. Data were collected using demographic information questionnaires, the AI technology acceptance questionnaire based on the UTAUT (Unified Theory of Acceptance and Use of Technology) model, the digital self-efficacy questionnaire, and the academic anxiety questionnaire. Data analysis was performed using R software version 4.5.0, and a significance level of less than 0.05 was considered.

Result

Most students had moderate digital literacy (63.3%) and used AI tools for less than one hour daily (56.5%). Lower digital literacy was associated with lower digital self-efficacy ($\beta = -21.13$, $p < 0.001$) and AI tool acceptance ($\beta = -8.04$, $p < 0.001$). Male students reported lower academic anxiety than females ($\beta = -7.90$, $p = 0.001$). GLMtree (Generalized Linear Model Tree) identified gender as the only splitting variable, with a negative association between digital self-efficacy and academic anxiety among males ($\beta = -0.17$, $p = 0.026$) and a positive trend among females ($\beta = 0.16$, $p = 0.053$). The strongest correlation was between digital self-efficacy and AI tool acceptance ($r = 0.50$, $p < 0.001$).

Conclusion

Higher digital literacy was associated with greater AI tool acceptance but not with lower academic anxiety. The association between digital self-efficacy and academic anxiety differed by gender, showing a negative relationship among male students and a positive trend among female students. These findings emphasize the importance of considering gender when evaluating digital competencies and academic anxiety in medical education.

1. Introduction

Artificial intelligence (AI) technologies are increasingly transforming higher education by reshaping learning processes, educational interactions, and access to educational resources. In medical education, AI-based tools, including intelligent tutoring systems, generative AI platforms, and automated decision-support technologies, have been rapidly integrated into students' educational activities. These technologies can enhance learning efficiency, personalize educational experiences, and facilitate access

to information; however, their expanding use has also raised important psychological and behavioral concerns regarding students' adaptation to technology-enhanced learning environments.

One of the most important psychological outcomes associated with rapidly evolving educational environments is academic anxiety. Academic anxiety refers to the cognitive, emotional, and physiological responses associated with academic demands and perceived academic pressures (1, 2). In AI-enhanced learning environments, students may experience academic anxiety because of concerns about the complexity of technology, fears of diminished human capabilities, uncertainty regarding future professional roles, or the pressure associated with continuously adapting to emerging digital systems (3).

Persistent academic anxiety may be associated with poorer academic performance, reduced learning motivation, and compromised mental health among university students, particularly in demanding fields such as medical sciences (4). Technology acceptance theories provide a useful framework for understanding how students interact with emerging technologies. Among these frameworks, the Unified Theory of Acceptance and Use of Technology (UTAUT) has been widely applied to explain users' behavioral intentions and acceptance of digital technologies in the fields of education and healthcare (5, 6). Existing studies have mainly focused on factors associated with the acceptance of artificial intelligence and technology, including perceived usefulness, effort expectancy, and social influence (7, 8).

However, considerably less attention has been given to the potential psychological outcomes associated with AI acceptance, particularly academic anxiety.

In parallel, digital self-efficacy has emerged as an important psychological construct related to individuals' confidence in their ability to effectively use digital technologies. Digital self-efficacy, rooted in social cognitive theory, refers to individuals' beliefs regarding their capability to successfully perform tasks in technology-based environments (9, 10).

Previous studies have shown that higher digital self-efficacy is associated with greater adaptation to educational technologies, increased confidence in digital learning environments, and lower perceived technology-related stress (11, 12).

Therefore, digital self-efficacy may be considered as one of the factors associated with the way students use digital technologies and their emotional responses in educational environments.

Although previous studies have separately examined AI acceptance, digital self-efficacy, and academic anxiety, limited evidence is available regarding the integrated relationships among these constructs within a single conceptual framework. Furthermore, most previous studies have focused on the behavioral outcomes of technology acceptance rather than its psychological outcomes, and the available evidence in medical education settings, particularly in developing countries such as Iran, remains limited (13, 14).

Medical sciences students represent a relevant and unique group for investigating this topic due to their high academic workload, continuous exposure to technological innovations, and high educational expectations; these factors may be associated with their responses to AI-based educational tools.

Accordingly, the present study aimed to examine the associations of AI tool acceptance and digital self-efficacy with academic anxiety among medical sciences students. This study also investigated whether demographic characteristics were involved in the patterns of relationships among the studied variables. To identify linear relationships as well as potential nonlinear relationships among the study variables, generalized linear model trees (GLM Tree) were used as an exploratory analytical approach capable of identifying subgroup-specific patterns within the data (14). This approach has previously been applied in similar studies to identify complex and subgroup-specific relationships in biomedical and behavioral research (13, 15).

Understanding these relationships may help policymakers and educational planners design targeted interventions to enhance students' digital readiness, support the effective integration of AI, and reduce technology-related academic stress in medical education environments.

2. Materials and Methods

2.1. Study Design and Participants

This cross-sectional study was conducted in 2025 among students from all academic disciplines and educational levels at Gonabad University of Medical Sciences. Based on the statistics provided by the university's Vice-Chancellery for Education, the study population consisted of 1,982 students from four faculties: Medicine ($n = 876$), Paramedical Sciences ($n = 312$), Nursing ($n = 507$), and Public Health ($n = 287$). Considering an expected correlation coefficient of 0.21, which was reported in a previous study (16).

The significance level of 0.05, an appropriate statistical power, and the required sample size were estimated using R software version 4.5.0 and the "pwr.r.test" function. The minimum required sample size was calculated as 233 participants. Considering a 10% potential attrition rate, the target sample size was determined to be 250 participants. Proportionate stratified sampling was used to determine the number of participants from each of the four faculties: Medicine, Paramedical Sciences, Nursing, and Public Health.

Sample allocation to each faculty was performed based on proportionate stratified sampling according to the size of each stratum in the study population. Accordingly, the allocated sample sizes were as follows: Medicine ($n = 98$), Nursing ($n = 57$), Paramedical Sciences ($n = 50$), and Public Health ($n = 32$).

Within each stratum, participants were selected from the official list of students provided by the university's Vice-Chancellery for Education using systematic sampling. After determining the sampling interval, individuals were selected systematically from the list. Efforts were also made to ensure

proportional representation of different academic disciplines, genders, and educational levels within each faculty to provide appropriate representation of educational subgroups. It should be noted that despite the proportionate allocation of samples during the study design phase, minor differences occurred between the final sample distribution and the initially calculated values due to some students' unwillingness to participate and non-response. However, the final analysis was conducted based on the available eligible sample.

The inclusion criteria were being enrolled at Gonabad University of Medical Sciences in 2025 and willingness to participate in the study. The exclusion criteria included incomplete or inconsistent responses to the questionnaires.

Ultimately, data from 237 participants were analyzed, representing a participation rate of 94.8%. This study was approved by the Student Research Ethics Committee of Gonabad University of Medical Sciences under ethics code IR.GMU.REC.1404.062.

2.2. Data Collection Instruments

Data were collected using four questionnaires, including a researcher-developed demographic questionnaire, the Artificial Intelligence Technology Acceptance Questionnaire, the Digital Self-Efficacy Scale, and the Academic Anxiety Questionnaire. The artificial intelligence tools examined in this study included generative artificial intelligence systems, AI-based medical software, and educational platforms such as ChatGPT and Gemini. Before data collection, the study objectives were explained to the participants, and informed consent was obtained. The demographic questionnaire included variables such as age, gender, educational level and field of study, average daily duration of artificial intelligence tool use, self-reported digital literacy level, and grade point average. All standardized questionnaires were scored based on the sum of item scores, and none of the questionnaires included reverse-scored items.

The Artificial Intelligence Technology Acceptance Questionnaire was developed based on the Unified Theory of Acceptance and Use of Technology (UTAUT) model proposed by Venkatesh et al. (2003). The questionnaire consists of 21 items across six subscales: "performance expectancy," "effort expectancy," "social influence," "facilitating conditions," "behavioral intention to use," and "actual use." Each item was scored using a five-point Likert scale (1 to 5), with the total score ranging from 21 to 105. Higher scores indicate greater acceptance of artificial intelligence technology. A total score of ≤ 42 indicated low acceptance, 43–72 indicated moderate acceptance, and ≥ 73 indicated high acceptance. The adapted version used in this study was redesigned based on the Iranian cultural context, and its face validity was confirmed by experts. The reliability of this instrument was reported with an overall Cronbach's alpha coefficient of 0.80. In addition, validity and reliability indices included a CVI (Content Validity Index) greater than 0.79, a CVR (Content Validity Ratio) greater than 0.62, and test–retest reliability ranging from 0.37 to 0.4 (17, 18).

The Digital Self-Efficacy Questionnaire (Ulfert-Blank & Schmidt, 2022) consists of 25 items across five subscales: "communication and collaboration," "information and data literacy," "digital content creation,"

“problem solving,” and “security.” The items were scored using a six-point Likert scale (1 to 6), with total scores ranging from 25 to 150; higher scores indicate greater digital self-efficacy. Total scores of 56 or lower were considered indicative of low digital self-efficacy, scores of 57 to 102 represented moderate digital self-efficacy, and scores of 103 or higher indicated high digital self-efficacy. The Persian version of this questionnaire was used in the present study. The reliability of this instrument has been reported in previous studies, with Cronbach’s alpha coefficients greater than 0.70 and test–retest reliability values greater than 0.70. In addition, its face and content validity have been confirmed, with CVI values greater than 0.79 and CVR values greater than 0.62 reported. Construct validity and composite reliability have also been confirmed in previous studies (19, 20).

Academic anxiety was assessed using the 19-item questionnaire developed by Casali N and colleagues (2022). This questionnaire consists of four subscales: “academic anxiety,” “cognitive anxiety,” “test anxiety,” and “motivational anxiety.” Each item was scored using a five-point Likert scale (1 to 5), with total scores ranging from 19 to 95; higher scores indicate greater anxiety. Total scores of 38 or lower were considered indicative of low anxiety, scores of 39 to 76 represented moderate anxiety, and scores of 77 or higher indicated high anxiety. The available Persian version of this questionnaire was also used without any changes to its structure. The reliability of this instrument has been reported in previous studies, with Cronbach’s alpha coefficients ranging from 0.88 to 0.95. In addition, test–retest reliability has been reported in the range of 0.65 to 0.96, and validity indices including CVI values greater than 0.79 and CVR values greater than 0.62 have been reported (21, 22).

All questionnaires were completed in person, and ethical principles, including confidentiality of information and voluntary participation of participants, were fully observed.

2.3. Statistical Analysis

Descriptive statistics, including means, standard deviations, frequencies, and percentages, were used to summarize demographic characteristics and main study variables. The associations between demographic variables and the main study factors (Digital Self-Efficacy, AI Tools Acceptance, and Academic Anxiety) were examined using univariate linear regression analyses. Pearson's correlation coefficients were computed to explore the relationships between the main factors and their subcomponents. To identify demographic subgroups with differential patterns of association, a generalized linear model tree (GLMtree) approach was employed, in which generalized linear models were fitted at the terminal nodes (outcome variable ~ predictor variable | demographic variables). Candidate trees were evaluated using BIC (Bayesian Information Criterion), AIC (Akaike Information Criterion), and Gini index criteria, and (14) only statistically significant models were reported. All statistical analyses were conducted using R software version 4.5.0, utilizing the "ggplot2" and "partykit" packages, with a 95% confidence level.

3. Results

Table 1 presents the demographic characteristics and descriptive statistics of the main study variables. The participants had a mean age of 21.92 years (Standard Deviation = 1.95), with a relatively balanced gender distribution (51.9% male, 48.1% female). Regarding academic background, the majority were undergraduate students (53.6%), followed by medical students (37.6%), while postgraduate students comprised only 8.9% of the sample. In terms of faculty affiliation, Medicine had the highest representation (41.4%), followed by Nursing (24.1%), Paramedicine (21.1%), and Health (13.5%). Most students reported using AI tools for less than one hour per day (56.5%), with only 7.2% using them for more than 3 hours daily. Regarding digital literacy, the majority of participants were at a moderate level (63.3%), while only 14.3% reported high digital literacy. Furthermore, most students had a grade point average between 14 and 17 (62.4%), with 32.5% having a GPA (grade point average) above 17, and only 5.1% having a GPA below 14.

Table 1
Description of demographic characteristics, digital self-efficacy, AI tool acceptance, and academic anxiety

Variables	Mean $\pm$ Sd
Age (18–29 year)	21.92 $\pm$ 1.95
	Frequency (%)
Sex	
Male	123(51.9)
Female	114(48.1)
Faculty	
Medicine	98(41.4)
Paramedicine	50(21.1)
Health	32(13.5)
Nursing	57(24.1)
Education level	
Undergraduate student	127(53.6)
Postgraduate student(Master's)	21(8.9)
Medical(M.D)	89(37.6)
AI-tool usage (hour/day)	
Less than 1 hour/day	134(56.5)
1–3 hours/day	86(36.3)
More than 3 hours/day	17(7.2)
Digital literacy	
Low	53(22.4)
Medium	150(63.3)
High	34(14.3)
Last grade point average (GPA)	
Less than 14	12(5.1)
14–17	148(62.4)
Sd = (Standard Deviation)	

Variables	Mean $\pm$ Sd
More than 17	77(32.5)
Sd = (Standard Deviation)	

Figure 1 presents the distribution of levels and mean scores for the three study variables: digital self-efficacy, acceptance of AI tools, and academic anxiety (Fig. 1). The majority of participants demonstrated high levels of digital self-efficacy (69.2%, $n = 164$), with a mean score of 112.93 ($SD = 18.84$). Conversely, acceptance of AI tools was predominantly distributed within the medium-level category, with 94.9% ($n = 225$) of participants classified at this level and a mean score of 79.92 ($SD = 12.41$). Academic anxiety was distributed across the low (58.2%, $n = 138$) and medium (41.8%, $n = 99$) levels, with a mean total score of 54.11 ($SD = 16.10$). The bar plots in Fig. 1 further illustrate the mean scores across the different variable groups.

The univariate linear regression analysis (Fig. 2) revealed that digital literacy was the strongest and most consistent predictor across outcomes. Participants with low and medium digital literacy exhibited significantly lower Digital Self-Efficacy ($\beta = -21.13$, $p < 0.001$; $\beta = -14.01$, $p < 0.001$) and lower AI Acceptance ($\beta = -8.04$, $p < 0.001$ for low literacy). Lower GPA (< 14) was also significantly associated with reduced Digital Self-Efficacy ($\beta = -18.22$, $p < 0.001$). Regarding Academic Anxiety, male students reported significantly lower anxiety than females ($\beta = -7.90$, $p = 0.001$), while Master's students ($\beta = -12.38$, $p = 0.001$) and those from the Health faculty ($\beta = -6.79$, $p = 0.049$) showed significantly lower anxiety compared to their counterparts. Marginally significant trends ($p < 0.10$) were observed for Master's education with AI Acceptance ($\beta = -5.07$, $p = 0.089$), medium digital literacy with AI Acceptance ($\beta = -4.30$, $p = 0.062$), and lower GPA with AI Acceptance ($\beta = -6.52$, $p = 0.086$), suggesting potential associations needing further exploration. Age, faculty type (Medicine and Paramedics), and AI usage patterns showed no significant associations with any outcome.

Pearson's correlation coefficients showed that the strongest relationship was observed between acceptance of artificial intelligence tools and digital self-efficacy ($r = 0.50$), with most dimensions of AI acceptance being aligned with self-efficacy. Motivational anxiety was positively correlated with digital content creation ($r = 0.13$), whereas cognitive anxiety ($r = -0.22$) and overall academic anxiety ($r = -0.14$) showed negative correlations with information and data literacy. Effort expectancy ($r = 0.14$), behavioral intention to use ($r = 0.13$), and overall acceptance of artificial intelligence tools ($r = 0.16$) also demonstrated weak positive relationships with overall academic anxiety (Fig. 3).

Figure 4 presents the results of the GLMtree model. The GLMtree model identifies demographic subgroups in which the relationship between digital self-efficacy and academic anxiety varies. Gender emerged as the sole splitting variable ($p < 0.001$), indicating distinct association patterns across gender groups. Among male students, a significant negative relationship was observed ($\beta = -0.17$, $SE = 0.07$, $p = 0.026$), indicating that higher levels of digital self-efficacy are associated with lower academic anxiety. In contrast, among female students, the relationship was positive ($\beta = 0.16$, $SE = 0.08$, $p = 0.053$).

4. Discussion

This study examined the associations of artificial intelligence tool acceptance and digital self-efficacy with academic anxiety among medical sciences students based on the UTAUT model. Most students had a moderate level of digital literacy and used artificial intelligence tools for less than one hour per day. Female students reported higher levels of academic anxiety than male students. Digital literacy was positively associated with digital self-efficacy and acceptance of artificial intelligence tools. The relationship between digital self-efficacy and academic anxiety differed by gender; a negative relationship was observed among males, whereas a positive pattern was observed among females.

These results are consistent with the findings of Wang et al. and Mansoor et al., who also reported moderate levels of digital literacy and AI-related skills among university students (23, 24). This difference may be related to variations in university and faculty policies, as well as students' attitudes. Female students showed higher levels of academic anxiety than males. This finding is consistent with the studies by Russo and Huang, which reported higher levels of anxiety among women in relation to the use and learning of artificial intelligence tools (25, 26). This gender difference in academic anxiety may reflect differences in exposure, opportunities, and perceptions of advanced technologies. Gender-sensitive educational programs regarding the use of AI may help reduce academic anxiety and the digital gender gap.

The findings showed that digital literacy was positively associated with both digital self-efficacy and AI tool acceptance. Similarly, Hornberger et al. demonstrated in a multinational study that students with higher AI literacy had greater confidence in learning and using AI (27).

This association may be related to the fact that students with higher digital literacy have more previous positive experiences. These students may better manage digital risks and perceive AI as more controllable and acceptable. In contrast, students with lower digital literacy may have greater concerns about data privacy, which may be associated with lower self-efficacy and willingness to use AI.

From the perspective of the UTAUT model, higher digital literacy may be associated with greater perceived usefulness and ease of use of AI tools, thereby facilitating greater acceptance.

In the present study, a moderate correlation was observed between AI tool acceptance and digital self-efficacy, whereas the association of these variables with academic anxiety was weak. This finding suggests that academic anxiety is likely related to broader factors such as educational pressures, academic expectations, and psychological factors. In addition, Deng et al. showed that technical competencies and self-efficacy had only weak associations with coping and test anxiety, indicating that skills alone may not fully explain differences in anxiety levels (28).

Our findings showed that the pattern of the association between digital self-efficacy and academic anxiety differed between the two genders; a negative regression coefficient was observed in men, whereas a positive regression coefficient was observed in women. This finding is consistent with

previous studies suggesting that self-efficacy in academic and technological domains is generally associated with lower levels of stress and better adaptation. Male students often report higher levels of confidence in using advanced technologies, which may be accompanied by lower levels of academic anxiety (29, 30).

The observed pattern among female students may reflect more complex interactions between digital self-efficacy, individual expectations, and academic pressures (31, 32). This study had several limitations. First, its cross-sectional design limits the ability to draw causal inferences between AI acceptance, digital self-efficacy, and academic anxiety. Second, focusing on a single university limits the generalizability of the findings. In addition, the use of self-reported questionnaires may introduce response bias, and unmeasured confounding factors may have affected the observed associations.

Based on the findings of this study, several practical implications can be derived. First, given the positive association of digital literacy with digital self-efficacy and AI acceptance, conducting educational workshops to enhance students' digital literacy may be beneficial. Second, considering that higher levels of academic anxiety were observed among female students than among male students, and that the association between digital self-efficacy and academic anxiety showed a positive pattern among women, educational programs should adopt a gender-sensitive approach and consider the specific needs of female students.

From a theoretical perspective, the present findings indicate that the UTAUT model may be useful for explaining technology acceptance; however, other psychological and contextual factors should also be considered to better understand academic anxiety. Third, given that most students used AI tools for less than one hour per day, universities may promote more effective use of these tools by providing practical training.

5. Conclusion

Students who used AI tools for less than one hour per day generally had moderate levels of digital literacy and academic anxiety. Female students reported higher academic anxiety compared with their male counterparts.

In this population, a positive association was observed between digital literacy and both digital self-efficacy and AI tool acceptance. However, no consistent overall association was observed between academic anxiety and AI tool acceptance or digital self-efficacy. The association between digital self-efficacy and academic anxiety differed according to gender, showing a negative relationship among male students and a positive pattern among female students.

Overall, the findings suggest that the association between digital self-efficacy and academic anxiety varies according to gender, while AI tool acceptance showed no consistent association with academic anxiety. These findings also indicate that contextual and psychosocial factors may play an important role in understanding academic anxiety. Targeted educational workshops may be useful for enhancing

digital literacy and improving the use of AI tools. These findings highlight the importance of considering gender-sensitive and comprehensive mental health support alongside initiatives to strengthen digital competence.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Gonabad University of Medical Sciences (Approval No. IR.GMU.REC.1404.062). Written informed consent was obtained from all participants before enrollment after providing information about the study objectives. All methods were carried out in accordance with relevant guidelines and regulations and the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

All authors contributed to the study conception and design. P. M, M. E, M. N, and H. B performed material preparation, data collection, analysis, writing, review, and editing. All authors read and approved the final manuscript.

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Data Availability

Anonymized data supporting this study are available for academic use upon reasonable request from the corresponding author. The corresponding author confirms that this manuscript accurately and transparently reports the study, with no important aspects omitted and any deviations from the planned study explained.

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Figures

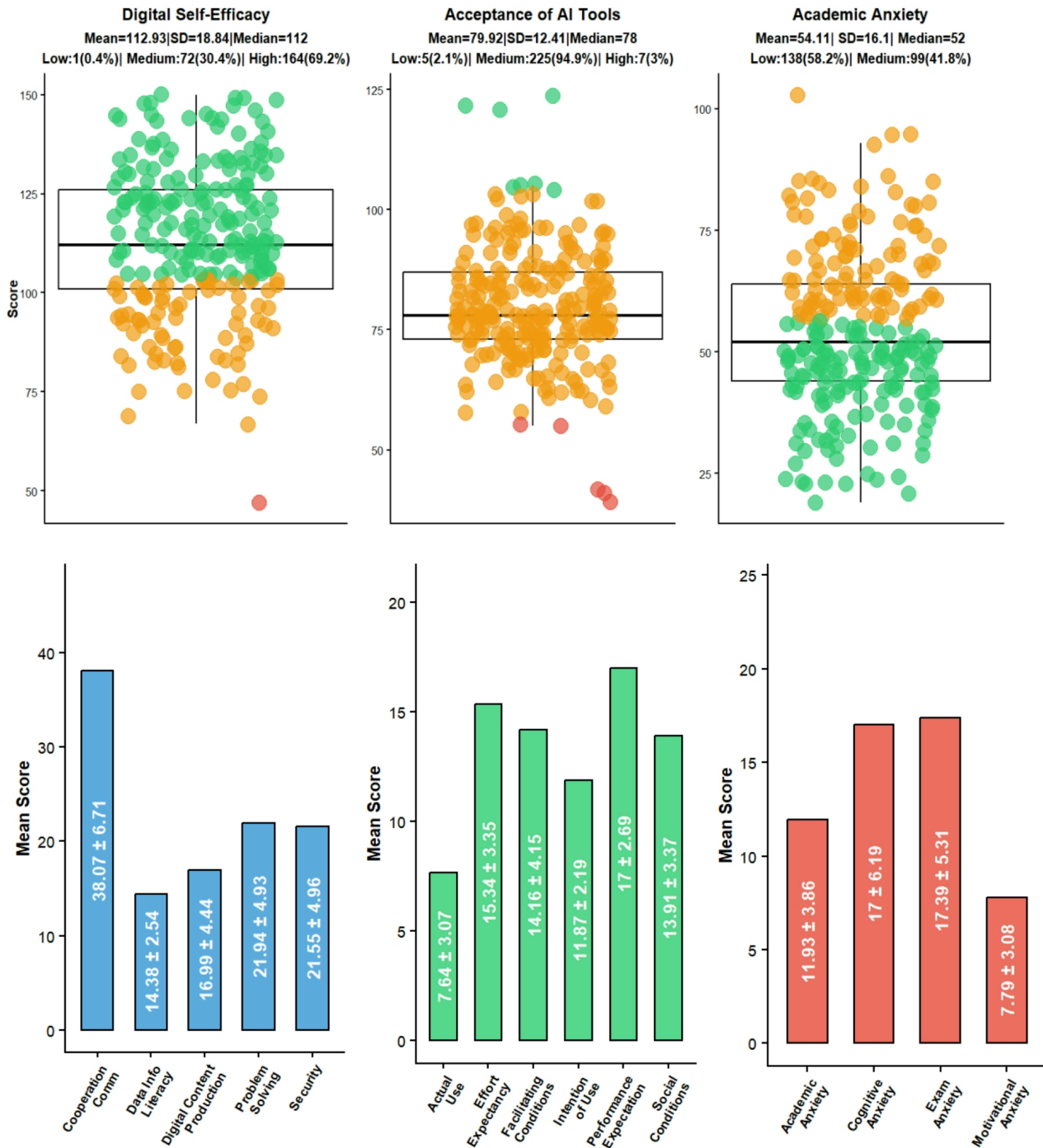


Figure 1

Distribution of Levels and Mean Scores for Academic Anxiety, AI Tool Acceptance, and Digital Self-Efficacy

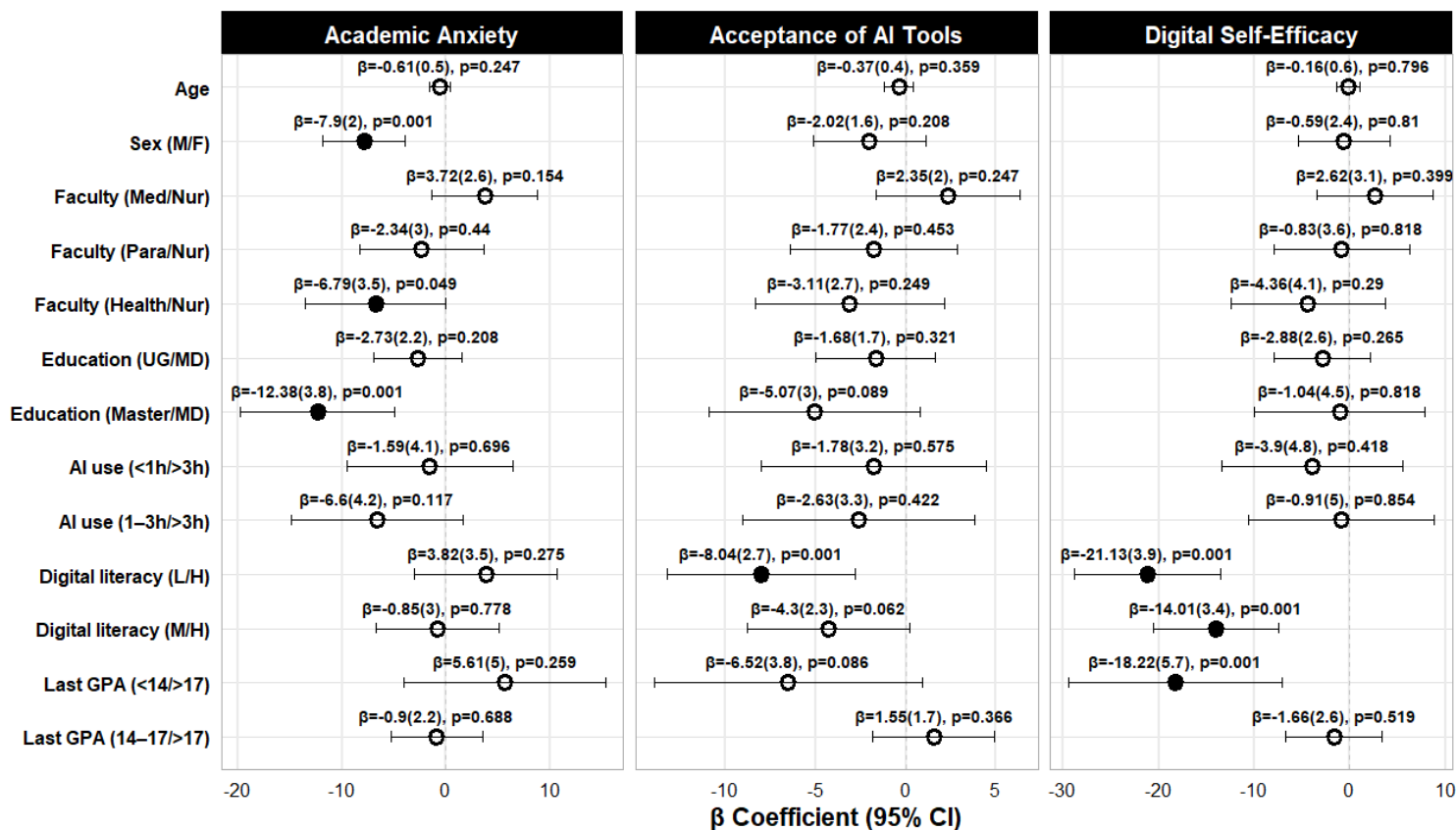


Figure 2

Univariate Linear Regression of Demographic Variables, Digital Self-Efficacy, AI Tool Acceptance, and Academic Anxiety

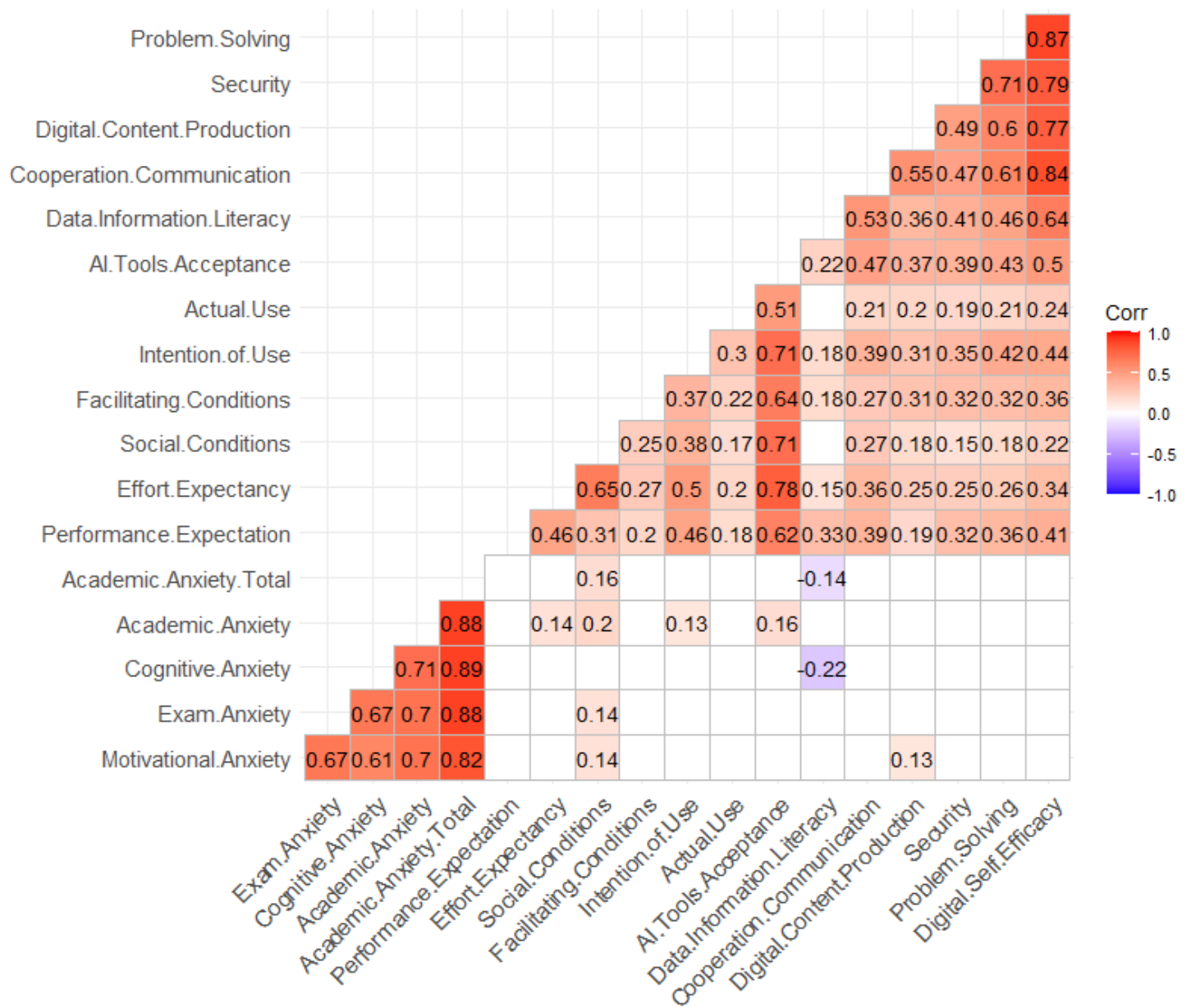


Figure 3

Correlation Matrix of AI Tools Acceptance, Digital Self-Efficacy, and Academic Anxiety Components

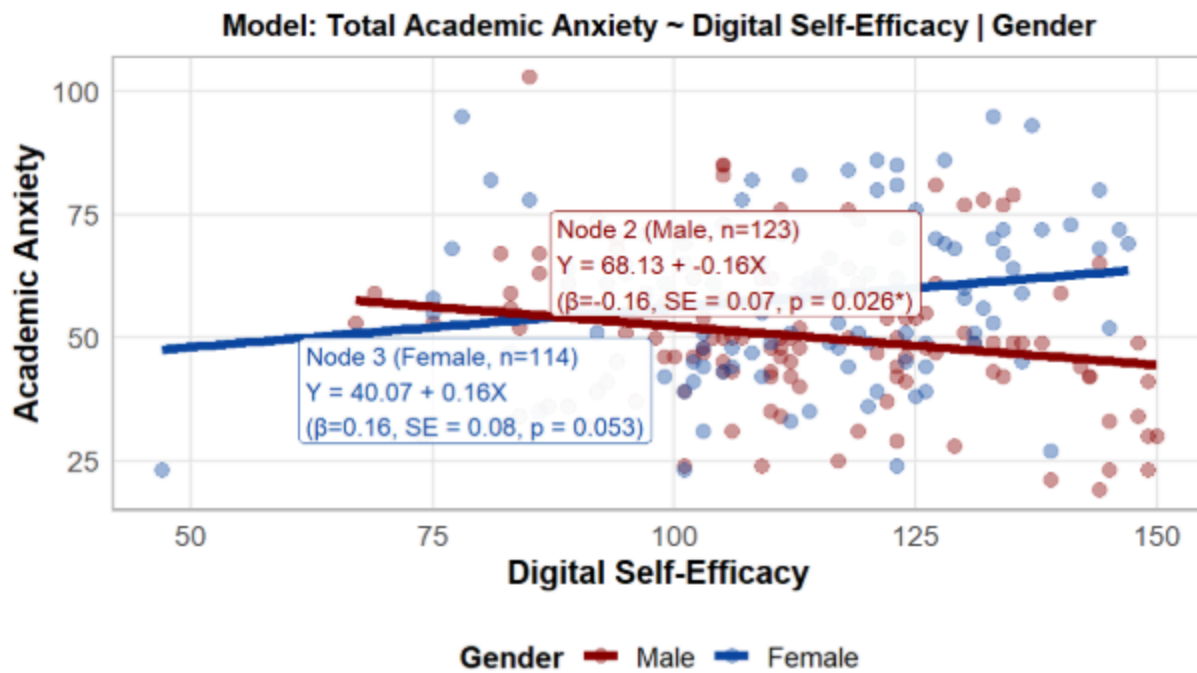


Figure 4

Relationship of Digital Self-Efficacy and AI Tool Acceptance with Academic Anxiety by Demographics (GLMtree)