

Explainable XGBoost Prediction of Academic Impostor Phenomenon from Perfectionistic Concerns, Fear of Failure, and Self-Doubt

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ABSTRACT

Objective: This study aimed to predict academic impostor phenomenon among Hungarian university students using an explainable XGBoost model based on perfectionistic concerns, fear of failure, and self-doubt.

Methods and Materials: This quantitative, cross-sectional predictive study was conducted among 468 university students enrolled in higher education institutions in Hungary. Data were collected using standardized self-report instruments measuring academic impostor phenomenon, perfectionistic concerns, fear of failure, and self-doubt. After preliminary data screening, descriptive statistics, reliability analysis, and Pearson correlation analysis were performed. The main predictive analysis was conducted using XGBoost regression, with academic impostor phenomenon entered as the continuous outcome variable and perfectionistic concerns, fear of failure, and self-doubt entered as predictors. Model performance was evaluated using root mean square error, mean absolute error, and coefficient of determination. SHAP analysis was applied to interpret the relative contribution of each predictor to the final model.

Findings: The correlation results showed significant positive associations between academic impostor phenomenon and self-doubt, $r = .66$, $p < .001$, perfectionistic concerns, $r = .58$, $p < .001$, and fear of failure, $r = .54$, $p < .001$. The XGBoost model demonstrated the strongest predictive performance compared with the baseline model, multiple linear regression, and random forest regression. The final XGBoost model obtained RMSE = 8.86, MAE = 6.91, and $R^2 = .63$, indicating that the model explained 63% of the variance in academic impostor phenomenon. SHAP-based interpretation showed that self-doubt was the most influential predictor, followed by perfectionistic concerns and fear of failure.

Conclusion: The findings indicate that academic impostor phenomenon can be predicted with considerable accuracy using an explainable XGBoost model. Self-doubt was the strongest predictor, suggesting that persistent uncertainty about

academic competence is central to impostor-related experiences. Perfectionistic concerns and fear of failure also made meaningful predictive contributions, highlighting the importance of maladaptive achievement evaluation in students' psychological vulnerability.

Keywords: *Academic impostor phenomenon; XGBoost; explainable artificial intelligence; SHAP; perfectionistic concerns; fear of failure; self-doubt*

1. Introduction

Academic impostor phenomenon refers to a persistent pattern of doubting one's intellectual competence, discounting personal achievement, and fearing that one's apparent success will eventually be exposed as undeserved or fraudulent. Although individuals experiencing this phenomenon may demonstrate adequate or even excellent academic performance, they often attribute success to luck, excessive effort, timing, external support, or evaluative error rather than to stable ability or legitimate competence. In academic environments, this experience is especially important because students are repeatedly exposed to performance evaluation, comparison with peers, public indicators of success, and implicit expectations of continuous achievement. The impostor phenomenon has therefore become a central construct in contemporary educational and psychological research, particularly in relation to mental health, academic adjustment, professional identity formation, and performance-related distress (Garba et al., 2024; Ménard & Chittle, 2023; Young, 2024). Recent literature has increasingly emphasized that impostor experiences are not merely isolated feelings of insecurity, but may represent a complex cognitive-affective pattern involving self-evaluation, perceived legitimacy, fear of failure, perfectionistic standards, and difficulty integrating external evidence of success into self-concept (Fleischhauer et al., 2021; Walker & Saklofske, 2023).

The relevance of academic impostor phenomenon has been documented across a wide range of educational and professional populations. Research on post-secondary students indicates that impostor feelings are common in higher education and may interfere with academic well-being, persistence, and confidence in one's academic role (Ménard & Chittle, 2023). Among doctoral students, impostor phenomenon has been discussed as a significant issue because doctoral education often includes ambiguous standards, independent work, high intellectual comparison, and uncertain progress markers, all of which may intensify doubts about competence (Wang & Li, 2023). Studies of high-achieving students have also shown that impostor experiences may occur precisely among those who are externally successful, suggesting that achievement alone

does not protect students from internalized feelings of fraudulence (Easley & Guske, 2022; Zülfiqar & Abbasi, 2024). This point is particularly important for academic contexts because students who appear successful may still experience strong psychological distress, hesitate to seek support, or conceal their uncertainty due to fear that disclosure will confirm their perceived inadequacy.

The impostor phenomenon has also been widely examined in health-related educational and professional settings, where academic and professional standards are often intense, evaluative, and identity-relevant. Literature in medicine has linked impostor phenomenon with perfectionism, distress, and psychological vulnerability among medical learners and professionals (Thomas & Bigatti, 2020). Scoping and narrative reviews among medical undergraduates, postgraduate professionals, dentistry students, surgeons, and first-year medical students similarly suggest that impostor experiences are associated with well-being, educational pressure, professional expectations, and the fear of not meeting demanding standards (Boghdady & Ewalds-Kvist, 2025; Chua et al., 2025; Mohammed & Al-Omar, 2025; Wrench et al., 2024). Evidence from surgical populations further indicates that impostor feelings may shape professional confidence and may contribute to self-limiting beliefs even among individuals functioning in highly skilled roles (Joseph et al., 2023). These findings are directly relevant to university students more broadly because they show that impostor experiences can persist across educational stages and professional transitions, particularly in contexts where competence is repeatedly evaluated and where mistakes are perceived as highly consequential.

One of the most consistently discussed psychological correlates of impostor phenomenon is perfectionism. Perfectionism is a multidimensional construct that includes both adaptive striving and maladaptive concerns; however, the impostor literature has repeatedly highlighted the importance of perfectionistic concerns, such as excessive concern over mistakes, doubts about actions, fear of negative evaluation, and harsh self-criticism. The distinction between striving for excellence and pursuing perfection is crucial in academic research because excellence may support motivation and growth, whereas rigid perfectionistic

standards may foster chronic dissatisfaction and vulnerability to impostor feelings (Gaudreau et al., 2023). Theoretical and empirical work has shown that perfectionism can become problematic when students interpret anything less than flawless performance as evidence of inadequacy or failure (Flett & Hewitt, 2022). In this sense, perfectionistic concerns may serve as a psychological bridge between achievement contexts and impostor phenomenon: students may succeed academically, yet still feel fraudulent because their internal standards remain unattainable and their accomplishments are evaluated against unrealistic expectations.

Prior studies have provided substantial evidence for the association between perfectionism and impostor phenomenon. Pannhausen and colleagues described the relation between multidimensional perfectionism and impostor phenomenon under the theme of “never good enough,” emphasizing how perfectionistic tendencies may sustain feelings of inadequacy even when objective performance is acceptable (Pannhausen et al., 2020). Among Russian college students, perfectionism was examined alongside impostor phenomenon, self-esteem, and personality traits, further supporting the view that impostor experiences are embedded in a broader network of self-evaluative dispositions (Sheveleva et al., 2023). Studies among nursing educators, emerging adults, dental hygiene students, women medical students, and professionals in child life training have similarly demonstrated that perfectionism and impostor phenomenon often co-occur in educational and professional development contexts (AbuDujain et al., 2025; Alderton et al., 2024; Koshy et al., 2022; Nashwa Ahmed Hussein Abdel, 2022; Tenhulzen et al., 2023). These findings suggest that students high in perfectionistic concerns may be especially likely to interpret academic achievement as insufficient, temporary, or externally caused, thereby strengthening impostor-related self-doubt.

Fear of failure is another theoretically central predictor of academic impostor phenomenon. In achievement settings, fear of failure involves the anticipation that poor performance will lead to shame, loss of worth, disappointment of others, damaged future opportunities, or negative social judgment. Students who are highly afraid of failure may become hypervigilant to evaluation, avoid situations that could expose uncertainty, and interpret ordinary academic challenges as signs of incompetence. The association between fear of failure and impostor phenomenon has been directly examined in emerging adults, indicating that fear of failure may be an important emotional

mechanism through which achievement pressure becomes linked to fraudulent self-perception (Koshy et al., 2022). Qualitative work with student physiotherapists has also highlighted the lived experience of perfectionism and the desire for relief from the “hatred of failure,” illustrating how academic identity can become organized around avoiding mistakes rather than developing competence (McKay et al., 2023). In high-achieving students, test anxiety has been examined as a mediator in the association between impostor phenomenon and perfectionism, further suggesting that evaluation-related fear may intensify impostor experiences in academic contexts (Zülfiqar & Abbasi, 2024).

Self-doubt is a closely related but distinct psychological construct that may be especially important in predicting academic impostor phenomenon. While perfectionistic concerns describe maladaptive standards and fear of failure reflects threat-based responses to possible underperformance, self-doubt captures chronic uncertainty about one’s abilities, decisions, and legitimacy. The impostor phenomenon is fundamentally characterized by difficulty internalizing success; therefore, self-doubt may function as a direct cognitive basis for impostor experiences. A student who persistently questions whether they are truly competent may reinterpret grades, praise, or academic progress as unstable evidence and may remain vulnerable to feelings of fraudulence even after repeated success. Recent psychometric work on the assessment of impostor phenomenon supports the view that impostor experiences involve identifiable dimensions of self-appraisal and perceived fraudulence (Walker & Saklofske, 2023). Moreover, studies examining the nomological network of impostor phenomenon show that it is connected with broader personality and self-evaluative factors, reinforcing the need to examine self-doubt as a central predictor rather than as a secondary symptom (Fleischhauer et al., 2021; Kananifar & Garcia, 2026).

The importance of social and contextual factors should also be acknowledged. Academic impostor phenomenon does not develop in a vacuum; it is shaped by institutional expectations, cultural norms, gendered experiences, professional hierarchies, and social comparison processes. Context-dependent social comparison has been experimentally linked to impostor phenomenon, suggesting that students may experience stronger impostor feelings when they compare themselves with highly competent or selectively presented peers (Snyder et al., 2024). Research on women leaders in higher education, Ecuadorian women in the labour market, and managers in Polish enterprises

further indicates that impostor phenomenon may be intensified by social role expectations, status transitions, and identity-related pressures (Gilbert, 2024; Kanatova, 2023; Kowalczyk-Kroenke, 2024). In Korean daycare directors and intensive care unit nurses, impostor phenomenon has also been studied in relation to professional identity, pride, perfectionistic self-presentation, and role-based expectations, showing that impostor feelings may appear when individuals perceive a discrepancy between external responsibility and internal confidence (Choi & Lee, 2025; Jang et al., 2025). These studies collectively support the view that academic impostor phenomenon should be understood as both an individual psychological experience and a context-sensitive pattern shaped by evaluative environments.

The mental health implications of impostor phenomenon provide an additional reason for studying its predictors in university students. Impostor experiences have been associated with psychological distress, reduced well-being, anxiety-related processes, stress, and vulnerability in demanding educational and professional settings (Barari et al., 2024; Garba et al., 2024). Research among undergraduate nursing and medical students has examined the association between resilience and impostor syndrome, indicating that personal resources may be relevant in buffering impostor-related difficulties (Khalil et al., 2024). Interventional research has also begun to address impostor phenomenon directly; for example, a brief self-compassion intervention for college students with impostor phenomenon points to the possibility that maladaptive self-evaluation can be modified through psychological support (Liu et al., 2023). At the same time, the recurrence of impostor phenomenon across educational and professional groups suggests that more precise predictive models are needed to identify students most at risk and to clarify which psychological variables are most influential.

Despite the growing body of research, several limitations remain in the existing literature. Much of the evidence has relied on correlational designs, group comparisons, or linear statistical models, which are valuable but may not fully capture the nonlinear and interaction-based nature of academic impostor phenomenon. The relationships among perfectionistic concerns, fear of failure, and self-doubt are likely complex: for some students, self-doubt may be the strongest direct predictor; for others, fear of failure may amplify the effect of perfectionistic concerns; and for others, the combination of all three may produce especially high impostor vulnerability. Calls for more nuanced research are

consistent with recent work emphasizing the multidimensionality of impostor phenomenon, its links with personality and mental health, and the need for better conceptual and measurement clarity (Kananifar & Garcia, 2026; Walker & Saklofske, 2023; Young, 2024). Therefore, predictive modeling approaches can contribute to the literature by estimating academic impostor phenomenon at the individual level and by identifying the relative importance of theoretically relevant predictors.

Explainable machine learning is particularly suitable for this purpose because it can combine predictive accuracy with interpretability. XGBoost, as a gradient-boosting decision-tree method, is capable of modeling nonlinear associations and interactions among psychological predictors, while explainability methods such as SHAP values can show how each predictor contributes to model output. In the context of academic impostor phenomenon, this approach is valuable because it avoids treating prediction as a purely technical task and instead connects statistical performance with psychological meaning. A model that predicts impostor phenomenon from perfectionistic concerns, fear of failure, and self-doubt can clarify whether these variables operate with similar predictive strength or whether one variable is especially influential in shaping students' impostor-related experiences. This is especially relevant for university populations, where early identification of psychological risk patterns can support prevention, counseling, academic advising, and psychoeducational interventions.

The present study builds on previous research by examining academic impostor phenomenon among university students through an explainable XGBoost prediction framework. By focusing on perfectionistic concerns, fear of failure, and self-doubt, the study integrates three constructs that are theoretically and empirically central to impostor experiences in achievement contexts. Prior literature has established that impostor phenomenon is associated with perfectionism, mental health difficulties, social comparison, professional identity strain, and educational stress across diverse populations (Alderton et al., 2024; Chua et al., 2025; Jayne et al., 2025; Thomas & Bigatti, 2020). However, less is known about how these predictors jointly contribute to individual-level prediction in a model designed to be both accurate and interpretable. Addressing this gap may help move the field beyond documenting associations toward identifying the most influential psychological markers of academic impostor phenomenon and understanding their predictive contribution in a transparent way.

The aim of this study was to predict academic impostor phenomenon among Hungarian university students using an explainable XGBoost model based on perfectionistic concerns, fear of failure, and self-doubt.

2. Methods and Materials

2.1. Study Design and Participants

This study was designed as a quantitative, cross-sectional, predictive study aimed at examining the extent to which academic impostor phenomenon can be predicted from perfectionistic concerns, fear of failure, and self-doubt using an explainable XGBoost machine learning approach. The statistical population consisted of university students enrolled in public and private higher education institutions in Hungary during the academic year. Participants were recruited from universities located in Budapest, Debrecen, Szeged, Pécs, and Győr through online academic networks, university mailing lists, and student communication platforms. The final analytic sample consisted of 468 Hungarian university students who met the inclusion criteria and completed all main study measures. Inclusion criteria were being at least 18 years old, being currently enrolled in an undergraduate or postgraduate university program in Hungary, having sufficient proficiency in the language of the questionnaire, and providing informed consent before participation. Students who submitted incomplete responses, gave patterned or careless answers, or completed the questionnaire in an unrealistically short time were excluded before the final analysis. The sample included students from different fields of study, including social sciences, humanities, health sciences, engineering, economics, and natural sciences, in order to increase the heterogeneity of academic experiences represented in the dataset. Participation was voluntary and anonymous, and respondents were informed that they could withdraw from the study at any stage without penalty.

2.2. Measures

Academic impostor phenomenon was assessed using the Clance Impostor Phenomenon Scale, which is one of the most widely used self-report instruments for measuring impostor-related thoughts and feelings in achievement contexts. The scale evaluates persistent doubts about competence, fear of being exposed as intellectually inadequate, difficulty internalizing academic success, and the tendency to attribute achievements to luck, effort, timing,

or external evaluation rather than genuine ability. Items are rated on a Likert-type response format, with higher total scores indicating stronger impostor phenomenon. In the present study, the total score of this scale was used as the outcome variable in the predictive model because the main objective was to estimate individual differences in academic impostor phenomenon rather than to classify students into categorical groups. The scale was selected because its content directly corresponds to the academic experience of feeling fraudulent despite objective evidence of competence, which is central to the present research question.

Perfectionistic concerns were measured using items representing the maladaptive evaluative dimension of perfectionism. This dimension reflects excessive concern over mistakes, doubts about the quality of one's actions, perceived pressure to meet unrealistically high standards, and a tendency to interpret academic shortcomings as signs of personal failure. In academic settings, perfectionistic concerns are particularly relevant because students with high levels of this trait often evaluate their performance harshly, experience persistent dissatisfaction even after success, and become vulnerable to impostor feelings when they believe that only flawless performance can confirm their competence. Respondents rated each item on a Likert-type scale, and higher scores indicated stronger perfectionistic concerns. The total score was entered into the machine learning model as one of the main predictor variables.

Fear of failure was assessed using a standardized self-report measure designed to evaluate the emotional, cognitive, and motivational consequences of perceived failure. The instrument measures the extent to which individuals associate failure with shame, loss of self-worth, uncertain future opportunities, disappointing important others, or negative evaluation by peers and instructors. In the context of academic impostor phenomenon, fear of failure is theoretically important because students who perceive failure as highly threatening may become more likely to conceal uncertainty, discount success, avoid academic risks, and interpret ordinary academic challenges as evidence of inadequacy. Items were scored on a Likert-type response format, with higher scores reflecting greater fear of failure. The total fear of failure score was used as a predictor in the XGBoost model.

Self-doubt was measured using a self-report scale assessing chronic uncertainty about one's abilities, decisions, judgments, and academic competence. This construct captures a generalized tendency to question the adequacy of one's performance and to remain uncertain

about personal capability even in the presence of positive feedback or successful outcomes. In the present study, self-doubt was considered a central predictor because academic impostor phenomenon is strongly characterized by difficulty accepting competence and persistent internal questioning of whether success is deserved. Participants responded to items on a Likert-type scale, and higher total scores represented greater self-doubt. Before analysis, all questionnaire scores were checked for range accuracy, internal consistency, missing values, and distributional characteristics. Total scores were computed only when participants provided valid responses according to the scoring rules of each instrument.

2.3. Data analysis

Data analysis was conducted in several stages. First, the dataset was screened for missing values, duplicate entries, out-of-range responses, careless response patterns, and extreme completion times. Cases with substantial missing data or invalid response patterns were removed from the dataset before model training. Descriptive statistics, including mean, standard deviation, minimum, maximum, skewness, and kurtosis, were calculated for academic impostor phenomenon, perfectionistic concerns, fear of failure, and self-doubt. Internal consistency reliability was examined for each multi-item scale using Cronbach's alpha and composite reliability indices. Pearson correlation coefficients were also calculated to examine the preliminary linear associations among the study variables; however, these analyses were used only as preliminary descriptive evidence and not as the main predictive approach.

The main predictive analysis was performed using Extreme Gradient Boosting, commonly known as XGBoost. XGBoost was selected because it is a powerful tree-based ensemble learning algorithm that can model nonlinear relationships, detect interaction effects among predictors, handle complex psychological data structures, and provide high predictive accuracy even when the number of predictors is relatively limited. In this study, academic impostor phenomenon was defined as the continuous target variable, while perfectionistic concerns, fear of failure, and self-doubt were entered as the main predictor variables. Prior to model estimation, the dataset was randomly divided into training and testing subsets, with 80% of the data used for model training and hyperparameter optimization and 20% reserved for final model evaluation. The training data were used in a cross-validation framework to reduce overfitting and to identify the most appropriate model configuration.

Hyperparameters such as learning rate, maximum tree depth, number of estimators, subsampling ratio, column sampling ratio, minimum child weight, gamma, and regularization parameters were tuned to improve model performance while maintaining generalizability.

Model performance was evaluated using standard regression metrics, including root mean square error, mean absolute error, and coefficient of determination. These indices were selected because they provide complementary information about prediction accuracy: root mean square error reflects the magnitude of prediction errors with greater sensitivity to larger errors, mean absolute error shows the average absolute difference between observed and predicted impostor phenomenon scores, and coefficient of determination indicates the proportion of variance in academic impostor phenomenon explained by the model. To provide a comparative statistical reference, the predictive performance of the XGBoost model was also examined against simpler baseline models, including multiple linear regression. This comparison made it possible to determine whether the nonlinear machine learning model offered additional predictive value beyond a conventional linear approach.

To increase interpretability and address the explainable artificial intelligence objective of the study, SHAP values were calculated after final model estimation. SHAP analysis was used to determine the relative contribution of perfectionistic concerns, fear of failure, and self-doubt to the prediction of academic impostor phenomenon. Global SHAP importance values were examined to identify which predictor had the strongest overall influence on model output, while SHAP dependence patterns were inspected to understand how changes in each predictor were associated with predicted impostor phenomenon scores. This explainability procedure allowed the XGBoost model to be interpreted not only in terms of predictive accuracy but also in terms of psychological meaning. All analyses were conducted using statistical and machine learning software appropriate for psychological data analysis, and the final interpretation of the model combined predictive performance metrics with explainable feature-importance evidence.

3. Findings and Results

The final analysis was conducted on data from 468 university students enrolled in higher education institutions in Hungary. The participants' ages ranged from 18 to 35

years, with a mean age of 22.64 years and a standard deviation of 3.41. In terms of gender distribution, 282 participants were female, representing 60.3% of the sample, 176 participants were male, representing 37.6%, and 10 participants, representing 2.1%, identified as non-binary or preferred not to report their gender. Regarding educational level, 321 students, equal to 68.6% of the sample, were enrolled in undergraduate programs, 119 students, equal to 25.4%, were enrolled in master's programs, and 28 students, equal to 6.0%, were doctoral students. The participants were

recruited from universities in several major academic centers in Hungary, including Budapest, Debrecen, Szeged, Pécs, and Győr. With respect to academic field, the sample included students from social sciences and humanities, health sciences, engineering and natural sciences, economics and business, and other interdisciplinary fields. This distribution indicated that the sample represented a heterogeneous group of Hungarian university students with diverse educational backgrounds and academic experiences.

Table 1

Descriptive statistics, reliability coefficients, and correlations among the main study variables

Variable	M	SD	Min	Max	Skewness	Kurtosis	α	1	2	3	4
1. Academic impostor phenomenon	63.42	14.76	28.00	96.00	0.18	-0.61	0.91	1			
2. Perfectionistic concerns	37.85	9.21	14.00	58.00	0.24	-0.48	0.88	.58***	1		
3. Fear of failure	68.34	16.09	29.00	113.00	0.31	-0.39	0.90	.54***	.49***	1	
4. Self-doubt	36.92	8.74	12.00	56.00	0.27	-0.44	0.89	.66***	.52***	.47***	1

As shown in Table 1, the mean score of academic impostor phenomenon was 63.42, indicating that, on average, students reported a moderate to relatively high level of impostor-related academic experiences. The distribution indices showed that all main variables had acceptable skewness and kurtosis values, suggesting that the variables did not demonstrate problematic departures from normality at the descriptive level. The internal consistency coefficients were also satisfactory for all instruments, with Cronbach's alpha values ranging from 0.88 to 0.91. These values indicated that the measures used in the study had strong reliability in the present sample. The correlation matrix showed that academic impostor phenomenon had significant positive associations with all three predictor variables. The strongest correlation was observed between academic impostor phenomenon and self-doubt, $r = .66$, $p < .001$,

indicating that students with higher levels of chronic uncertainty about their abilities and academic competence tended to report stronger impostor feelings. Academic impostor phenomenon was also positively associated with perfectionistic concerns, $r = .58$, $p < .001$, and fear of failure, $r = .54$, $p < .001$. These findings suggest that students who were more concerned about mistakes, more fearful of academic failure, and more doubtful about their own competence were more likely to experience difficulty internalizing success and to perceive themselves as academically inadequate despite evidence of achievement. The correlations among the predictor variables were also significant but not so high as to suggest redundancy, supporting their simultaneous inclusion in the predictive model.

Table 2

Predictive performance of baseline and machine learning models for academic impostor phenomenon

Model	RMSE	MAE	R ²	Cross-validated RMSE, M $\pm$ SD
Mean-only baseline model	14.63	11.92	-0.01	14.81 $\pm$ 0.77
Multiple linear regression	10.61	8.29	0.48	10.94 $\pm$ 0.66
Random forest regression	9.72	7.63	0.56	9.98 $\pm$ 0.58
XGBoost regression	8.86	6.91	0.63	9.12 $\pm$ 0.54

Table 2 presents the predictive performance of the baseline model, multiple linear regression, random forest regression, and XGBoost regression in estimating academic impostor phenomenon. The mean-only baseline model showed the weakest performance, with an RMSE of 14.63, MAE of 11.92, and an R^2 value close to zero, indicating that prediction based only on the average impostor phenomenon score did not provide meaningful individual-level estimation. Multiple linear regression improved prediction substantially, explaining 48% of the variance in academic impostor phenomenon. This finding shows that perfectionistic concerns, fear of failure, and self-doubt had strong linear predictive value. However, the tree-based machine learning models performed better than the linear model. Random forest regression achieved an RMSE of

9.72, MAE of 7.63, and R^2 of 0.56, indicating improved prediction through the modeling of nonlinear and interaction-based patterns. The best performance was obtained by the XGBoost regression model, which produced the lowest prediction errors and the highest explained variance, with an RMSE of 8.86, MAE of 6.91, and R^2 of 0.63. The cross-validation results further supported the stability of the XGBoost model, as it had the lowest mean cross-validated RMSE and a relatively small standard deviation across folds. These findings indicate that the explainable XGBoost model provided the most accurate prediction of academic impostor phenomenon and offered a meaningful improvement over both the baseline and conventional linear regression models.

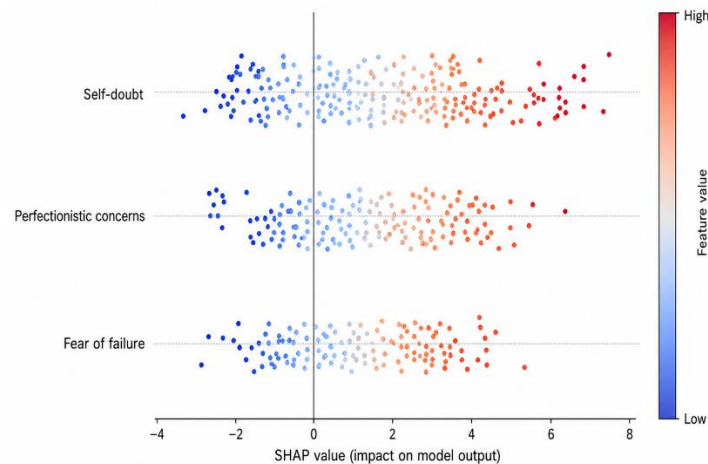
Table 3

Feature importance and SHAP-based contribution of predictors in the final XGBoost model

Predictor	Gain-based importance (%)	Mean absolute SHAP value	Direction of association	Interpretive contribution
Self-doubt	39.6	6.21	Positive	Strongest predictor of higher academic impostor phenomenon
Perfectionistic concerns	33.8	5.42	Positive	Substantial predictor, especially at moderate to high levels
Fear of failure	26.6	4.37	Positive	Meaningful predictor, with stronger effects among students reporting high failure-related threat

Table 3 shows the relative contribution of the predictor variables in the final XGBoost model based on gain-based importance and SHAP values. Self-doubt emerged as the most important predictor of academic impostor phenomenon, accounting for 39.6% of the gain-based importance and showing the highest mean absolute SHAP value. This indicates that self-doubt had the strongest overall influence on the model's predictions. Students with higher self-doubt scores were more likely to receive higher predicted scores for academic impostor phenomenon, suggesting that chronic uncertainty about personal competence is a central psychological marker of impostor-related academic experiences. Perfectionistic concerns were the second most important predictor, accounting for 33.8% of the model's gain-based importance. This finding shows

that students who were highly concerned about mistakes, overly critical of their performance, and doubtful about the adequacy of their academic work were more likely to be predicted as having stronger impostor feelings. Fear of failure also made a meaningful contribution to the model, accounting for 26.6% of the gain-based importance. Although its relative contribution was lower than that of self-doubt and perfectionistic concerns, fear of failure remained an important predictor, particularly among students who perceived academic failure as threatening to their self-worth, future success, or social evaluation. Overall, the feature-importance results demonstrated that the XGBoost model did not rely on a single psychological variable but integrated all three predictors to estimate academic impostor phenomenon.

Figure 1*SHAP summary plot for the XGBoost prediction of academic impostor phenomenon*

The SHAP summary plot showed that higher values of self-doubt, perfectionistic concerns, and fear of failure consistently pushed the model output toward higher predicted levels of academic impostor phenomenon. The visual pattern of the SHAP values indicated that self-doubt had the widest range of contribution scores, meaning that this predictor was responsible for the largest individual differences in predicted impostor phenomenon. Students with high self-doubt tended to receive substantially higher predicted impostor scores, whereas students with low self-doubt tended to receive lower predicted scores. Perfectionistic concerns also showed a clear positive pattern, with higher scores contributing to elevated predicted impostor phenomenon, especially among students whose responses reflected strong concern over mistakes and persistent dissatisfaction with academic performance. Fear of failure demonstrated a positive but slightly more variable contribution pattern, suggesting that its predictive effect was particularly pronounced when fear of failure was combined with high self-doubt or high perfectionistic concerns. The SHAP interpretation therefore confirmed that the final XGBoost model was psychologically coherent: the model predicted higher academic impostor phenomenon when students simultaneously reported uncertainty about their competence, maladaptive perfectionistic evaluation, and heightened fear of academic failure. These findings support the explanatory value of the machine learning model and indicate that the prediction was not only statistically accurate but also theoretically meaningful.

Overall, the findings showed that academic impostor phenomenon among Hungarian university students could be predicted with considerable accuracy from perfectionistic

concerns, fear of failure, and self-doubt. The descriptive and correlational results demonstrated that all three predictors were positively associated with academic impostor phenomenon, while the machine learning results showed that XGBoost provided the strongest predictive performance compared with baseline, linear, and random forest models. The explainability analysis further revealed that self-doubt was the most influential predictor, followed by perfectionistic concerns and fear of failure. These findings suggest that academic impostor phenomenon is most strongly linked to students' internal uncertainty about their own abilities, but it is also shaped by maladaptive perfectionistic evaluation and fear-based interpretations of academic failure.

4. Discussion

The present study aimed to predict academic impostor phenomenon among Hungarian university students using an explainable XGBoost model based on perfectionistic concerns, fear of failure, and self-doubt. The findings showed that all three predictors were positively and significantly associated with academic impostor phenomenon, indicating that students who reported higher levels of perfectionistic concerns, stronger fear of failure, and greater self-doubt also tended to report higher impostor-related academic experiences. The predictive findings further demonstrated that the XGBoost model outperformed the mean-only baseline model, multiple linear regression, and random forest regression, explaining 63% of the variance in academic impostor phenomenon. The explainability analysis showed that self-doubt was the most influential predictor, followed by perfectionistic concerns

and fear of failure. Therefore, the findings suggest that academic impostor phenomenon is not only associated with maladaptive self-evaluation but can also be predicted with considerable accuracy when these psychological variables are analyzed through a nonlinear and interpretable machine learning framework.

The positive association between self-doubt and academic impostor phenomenon was the strongest finding of the study and is theoretically consistent with the central definition of impostor phenomenon. Academic impostor experiences involve difficulty internalizing success, persistent questioning of competence, and the belief that achievements do not reflect genuine ability. Therefore, self-doubt may be considered a core cognitive mechanism through which students reinterpret success as accidental, fragile, or undeserved. This result aligns with psychometric and conceptual work emphasizing that impostor phenomenon is embedded in patterns of perceived fraudulence, unstable self-appraisal, and difficulty integrating objective success into one's academic identity (Fleischhauer et al., 2021; Walker & Saklofske, 2023). It is also consistent with research showing that impostor phenomenon is related to personality, self-evaluative vulnerability, and mental health among students, suggesting that persistent doubt about personal ability can function as a central pathway to psychological distress in academic contexts (Garba et al., 2024; Kananifar & Garcia, 2026). In the present model, the high SHAP contribution of self-doubt indicates that this variable did not merely correlate with impostor phenomenon but carried the strongest predictive weight in estimating individual differences in students' impostor scores.

The importance of perfectionistic concerns in the model also supports a substantial body of previous research linking perfectionism and impostor phenomenon. The results showed that perfectionistic concerns had a strong positive correlation with academic impostor phenomenon and emerged as the second most important predictor in the XGBoost model. This means that students who were excessively concerned about mistakes, doubtful about the adequacy of their academic work, and inclined to evaluate themselves harshly were more likely to experience impostor feelings. This finding is consistent with the view that maladaptive perfectionism creates a psychological condition in which achievements are rarely experienced as sufficient. Students may perform successfully but continue to feel inadequate because their internal standard is not excellence but flawlessness. This interpretation is supported by studies

showing strong links between multidimensional perfectionism and impostor phenomenon in students and professional samples (AbuDujain et al., 2025; Pannhausen et al., 2020; Sheveleva et al., 2023). It is also aligned with theoretical distinctions between the pursuit of excellence and the pursuit of perfection, because the former may promote healthy achievement, whereas the latter may increase distress, fear of mistakes, and the inability to experience competence as legitimate (Flett & Hewitt, 2022; Gaudreau et al., 2023).

The finding regarding perfectionistic concerns is also consistent with research in health, education, and professional development contexts. Previous studies have shown that perfectionism and impostor phenomenon co-occur among nursing educators, dental hygiene students, medical students, and professionals in highly evaluative training environments (Alderton et al., 2024; Chua et al., 2025; Nashwa Ahmed Hussein Abdel, 2022; Thomas & Bigatti, 2020). Similar patterns have been reported among dentistry students and professionals, first-year medical students, surgeons, and child life trainees, where demanding standards and performance visibility may intensify both perfectionistic self-monitoring and impostor feelings (Boghdady & Ewalds-Kvist, 2025; Mohammed & Al-Omar, 2025; Tenhulzen et al., 2023; Wrench et al., 2024). The present findings extend this line of evidence to a Hungarian university student sample and show that perfectionistic concerns are not only associated with impostor phenomenon but also contribute substantially to its prediction in an explainable machine learning model. This is important because perfectionistic concerns may represent a modifiable target for university counseling, psychoeducation, and academic support programs.

Fear of failure also made a meaningful contribution to the prediction of academic impostor phenomenon. Although its relative importance was lower than that of self-doubt and perfectionistic concerns, fear of failure remained a significant predictor and contributed positively to model output. This finding suggests that students who interpret academic failure as threatening to their self-worth, future opportunities, or social acceptance are more vulnerable to impostor experiences. Fear of failure may intensify impostor phenomenon because it increases vigilance toward mistakes and encourages students to interpret ordinary academic setbacks as evidence that they do not belong. This interpretation is aligned with previous research among emerging adults showing associations among impostor phenomenon, perfectionism, and fear of failure (Koshy et al.,

2022). It is also consistent with qualitative evidence describing the lived experience of student perfectionists who experience failure as emotionally aversive and identity-threatening (McKay et al., 2023). Moreover, the present finding parallels research indicating that test anxiety may mediate the association between perfectionism and impostor phenomenon among high-achieving students, suggesting that fear-based academic evaluation processes may be central in maintaining impostor-related distress (Zülfiqar & Abbasi, 2024).

The superiority of the XGBoost model over linear regression is another important finding. Multiple linear regression explained a substantial proportion of variance, which confirms that the three predictors have strong direct associations with academic impostor phenomenon. However, the XGBoost model showed better predictive performance, with lower RMSE and MAE and a higher coefficient of determination. This suggests that the association between the predictors and academic impostor phenomenon may not be fully linear. Instead, impostor phenomenon may be shaped by nonlinear thresholds and interaction patterns. For example, moderate self-doubt may not be highly problematic when perfectionistic concerns are low, but high self-doubt combined with strong fear of failure and elevated perfectionistic concerns may produce a more intense impostor profile. This pattern is consistent with recent conceptualizations of impostor phenomenon as a multidimensional and context-sensitive construct rather than a simple unitary trait (Ménard & Chittle, 2023; Young, 2024). It also supports the value of using advanced predictive models in psychological research when the goal is to estimate individual-level vulnerability rather than merely test isolated linear associations.

The SHAP analysis added interpretive value by showing how each predictor contributed to the model's predictions. This is particularly important because machine learning models can be criticized when they provide accuracy without psychological transparency. In this study, the explainability analysis showed a coherent pattern: higher self-doubt, higher perfectionistic concerns, and higher fear of failure pushed predictions toward higher academic impostor phenomenon. This pattern is consistent with social and educational studies showing that impostor phenomenon is shaped by self-evaluation, comparison, and the perceived demands of role performance. For example, experimental evidence on context-dependent social comparison suggests that impostor experiences may be intensified when individuals compare themselves with highly competent peers or selectively

idealized standards (Snyder et al., 2024). Research on women leaders in higher education, Ecuadorian women in the labour market, Polish managers, daycare directors, and ICU nurses similarly indicates that impostor phenomenon may be amplified in contexts where individuals perceive a gap between external responsibility and internal confidence (Choi & Lee, 2025; Gilbert, 2024; Jang et al., 2025; Kanatova, 2023; Kowalczyk-Kroenke, 2024). The present results suggest that, in university students, this perceived gap may be especially predictable from internal self-doubt and maladaptive performance standards.

The findings are also consistent with the broader literature on impostor phenomenon and mental health. Students who experience impostor phenomenon may appear academically capable but still experience psychological strain, diminished well-being, and vulnerability to anxiety or stress. Prior work has framed impostor syndrome as a threat to mental health and has emphasized its association with distress across educational and occupational contexts (Barari et al., 2024; Garba et al., 2024). Studies in medical, nursing, and surgical contexts similarly show that impostor phenomenon may have implications for well-being, self-confidence, and professional development (Chua et al., 2025; Joseph et al., 2023; Khalil et al., 2024). The current findings contribute to this literature by identifying a predictive profile in which self-doubt, perfectionistic concerns, and fear of failure jointly signal higher risk for academic impostor phenomenon. This profile may help explain why students with high achievement can nevertheless experience insecurity, emotional exhaustion, avoidance of academic opportunities, or difficulty accepting positive feedback.

The findings also have implications for intervention. If self-doubt is the strongest predictor of academic impostor phenomenon, then interventions should not focus only on performance skills or academic achievement. Instead, they should address the student's interpretation of competence, success, and mistakes. Interventions that promote self-compassion, flexible self-evaluation, and more balanced responses to achievement may be particularly useful. This interpretation is supported by evidence that brief self-compassion intervention can be beneficial for college students with impostor phenomenon (Liu et al., 2023). At the same time, the strong role of perfectionistic concerns indicates that students may benefit from learning to distinguish healthy striving from rigid perfectionism. Research on calling, perfectionism, and impostor phenomenon suggests that even meaningful academic or

career goals may become psychologically burdensome when they are linked to fraudulent self-perception or perfectionistic self-evaluation (Jayne et al., 2025). Similarly, research among advanced placement and high-achieving students indicates that high performance does not eliminate impostor vulnerability, reinforcing the need for preventive support even among academically successful students (Easley & Guske, 2022; Zülfiqar & Abbasi, 2024).

5. Conclusion

Overall, the present findings advance the literature by showing that academic impostor phenomenon among Hungarian university students can be predicted accurately and interpretably from perfectionistic concerns, fear of failure, and self-doubt. The study supports previous evidence that impostor phenomenon is closely related to perfectionism, self-evaluative uncertainty, fear-based academic motivation, and mental health vulnerability (Koshy et al., 2022; Ménard & Chittle, 2023; Pannhausen et al., 2020; Thomas & Bigatti, 2020). However, the use of explainable XGBoost adds a methodological contribution by demonstrating that the combined predictive structure of these variables can be modeled with greater accuracy than conventional linear analysis. The results suggest that self-doubt is the most central predictor, but perfectionistic concerns and fear of failure also provide meaningful explanatory value. Thus, academic impostor phenomenon should be understood as a psychologically complex pattern in which students' uncertainty about competence, rigid standards, and threat-based interpretation of failure jointly shape the perception that academic success is undeserved.

6. Limitations & Suggestions

The present study had several limitations. First, the cross-sectional design prevents causal inference, meaning that although perfectionistic concerns, fear of failure, and self-doubt predicted academic impostor phenomenon, the directionality of these relationships cannot be definitively established. Second, the study relied on self-report questionnaires, which may be influenced by social desirability, response bias, or participants' temporary emotional states. Third, although the sample included students from several Hungarian universities and academic fields, it may not fully represent all higher education students in Hungary, particularly students from smaller institutions, nontraditional programs, or underrepresented demographic groups. Fourth, the model included three psychologically

relevant predictors, but academic impostor phenomenon may also be influenced by other variables such as academic climate, family expectations, personality traits, social comparison, cultural norms, prior academic failure, and perceived belonging. Finally, although XGBoost provided strong predictive performance, the findings should be interpreted as sample-based estimates that require external validation in independent datasets before being generalized broadly.

Future research should examine the predictive model longitudinally to clarify whether perfectionistic concerns, fear of failure, and self-doubt precede increases in academic impostor phenomenon over time or whether impostor experiences intensify these psychological vulnerabilities. Future studies should also test the model in more diverse student populations, including international students, doctoral students, first-generation university students, and students from different cultural and institutional contexts. In addition, researchers should include broader contextual variables such as academic belonging, perceived institutional support, competitive classroom climate, supervisor feedback, peer comparison, and family achievement expectations. Further research may also compare several machine learning algorithms and apply external validation to determine whether the predictive superiority of XGBoost remains stable across samples. Finally, mixed-method designs could provide deeper insight into how students subjectively experience self-doubt, perfectionistic pressure, and fear of failure in relation to impostor feelings.

From a practical perspective, the findings suggest that universities should treat academic impostor phenomenon as a meaningful psychological and educational issue rather than as a normal or harmless form of student insecurity. Counseling centers, academic advisors, and student support services should screen for self-doubt, maladaptive perfectionistic concerns, and fear of failure, especially among students who appear outwardly successful but report internal uncertainty about their competence. Preventive workshops should help students reinterpret mistakes as part of learning, develop more flexible standards of achievement, reduce harsh self-criticism, and internalize success more accurately. Instructors can also contribute by normalizing academic difficulty, providing constructive feedback, reducing excessive comparison, and creating classroom climates in which uncertainty and help-seeking are not interpreted as signs of inadequacy. At the institutional level, student well-being programs should include targeted

psychoeducation on impostor phenomenon and should emphasize that competence develops through feedback, effort, revision, and realistic self-evaluation.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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All authors equally contributed in this article.

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