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Machine Learning Prediction of Vocational Success Among Young Adults with Intellectual Disabilities: The Roles of Self-Determination, Career Adaptability, and Family Empowerment

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A B S T R A C T

The present study aimed to develop and evaluate an explainable machine learning model for predicting vocational success among young adults with intellectual disabilities based on self-determination, career adaptability, and family empowerment. This cross-sectional predictive study was conducted among 428 young adults with mild to moderate intellectual disabilities recruited from vocational rehabilitation centers, supported employment programs, and transition-to-work services across Canada. Participants completed standardized measures of vocational success, self-determination, career adaptability, and family empowerment. Data preprocessing procedures included standardization, missing-value imputation, and quality screening. Several machine learning algorithms, including Linear Regression, Support Vector Regression, Random Forest, Gradient Boosting, and Extreme Gradient Boosting (XGBoost), were trained and evaluated using a 70:30 training-testing split and five-fold cross-validation. Model performance was assessed using the coefficient of determination (R^2), root mean squared error (RMSE), mean absolute error (MAE), and mean absolute percentage error (MAPE). SHapley Additive exPlanations (SHAP) analysis was employed to identify feature importance and improve interpretability of model predictions. Significant positive associations were observed between vocational success and self-determination ($r = .68$, $p < .001$), career adaptability ($r = .61$, $p < .001$), and family empowerment ($r = .54$, $p < .001$). Among the predictive models tested, XGBoost demonstrated the highest predictive accuracy, accounting for 76% of the variance in vocational success ($R^2 = .76$), with the lowest prediction errors (RMSE = 6.94, MAE = 5.13, MAPE = 6.95%). SHAP analysis revealed that self-determination was the most influential predictor, contributing 41.5% of total model importance, followed by career adaptability (30.4%) and family empowerment (22.7%). Collectively, these three variables accounted for more than 94% of the predictive contribution within the final model. The findings indicate that vocational success among young adults with intellectual disabilities can be predicted with high

accuracy using machine learning techniques. Self-determination emerged as the strongest predictor, followed by career adaptability and family empowerment, highlighting the importance of both personal agency and supportive family environments. The results support the use of explainable artificial intelligence approaches in disability and vocational research and suggest that interventions targeting these psychosocial factors may enhance employment outcomes and long-term vocational success.

Keywords: *intellectual disabilities; vocational success; self-determination; career adaptability; family empowerment; machine learning*

1. Introduction

The successful transition from school to adulthood remains one of the most significant developmental challenges faced by young adults with intellectual disabilities. Although advances in educational inclusion, vocational rehabilitation, and disability rights have expanded opportunities for participation in community life, employment outcomes for individuals with intellectual disabilities continue to lag substantially behind those of the general population. Employment is increasingly recognized not only as a source of income but also as a critical mechanism for promoting autonomy, social inclusion, psychological well-being, personal identity, and quality of life. Meaningful vocational engagement provides opportunities for individuals with intellectual disabilities to develop social relationships, exercise personal choice, acquire new skills, and establish valued social roles within their communities (Gilson et al., 2022; Smith & Parmenter, 2023; Taylor et al., 2022). Research has consistently demonstrated that successful employment experiences contribute positively to psychological health, community participation, and overall life satisfaction among people with disabilities, while unemployment is associated with social isolation, reduced independence, and diminished opportunities for personal growth (Paxinos et al., 2021; Subramanyam et al., 2024; White et al., 2023). Consequently, identifying the factors that promote vocational success among young adults with intellectual disabilities has become an important priority for researchers, practitioners, educators, and policymakers.

The transition from adolescence to adulthood is particularly complex for individuals with intellectual disabilities because it requires navigation of multiple developmental, educational, social, and occupational challenges simultaneously. During this period, young people are expected to make decisions regarding employment, education, independent living, community participation, and long-term life goals. However, many individuals with intellectual disabilities encounter barriers related to limited access to employment opportunities, inadequate transition planning, restricted opportunities for self-determination, and insufficient family or community support (DaWalt et al., 2021; Grigal et al., 2021; Murray et al., 2021). Studies examining postsecondary and employment trajectories have shown that successful adult outcomes are influenced by a combination of individual competencies, environmental supports, educational experiences, and social resources (Cooper et al., 2023; Mazzotti et al., 2020; Tuckett, 2023). Furthermore, employment success among young adults with disabilities cannot be understood solely through the lens of job attainment; rather, it encompasses job retention, workplace adjustment, career development, personal satisfaction, and opportunities for advancement (Alfieri et al., 2025; Smith & Parmenter, 2023). As a result, contemporary research has increasingly focused on identifying the psychosocial factors that contribute to sustainable vocational success rather than merely employment acquisition.

Among the variables associated with positive vocational outcomes, self-determination has emerged as one of the most influential constructs in disability research. Self-determination refers to an individual's ability to act as the primary causal agent in his or her life through autonomous decision-making, goal setting, self-regulation, and self-advocacy. Theoretical and empirical work has consistently highlighted self-determination as a fundamental prerequisite for successful adult functioning among individuals with intellectual and developmental disabilities (Mumbardó-Adam et al., 2020; Sánchez et al., 2020). Individuals who possess stronger self-determination skills are more likely to participate actively in educational planning, employment decision-making, community activities, and independent living arrangements. Research has shown that opportunities to exercise choice and autonomy significantly enhance self-determination, which in turn contributes to improved life outcomes (Salt & Jahoda, 2020; Sánchez et al., 2020). Investigations involving students and young adults with disabilities have demonstrated that self-determination predicts academic achievement, postsecondary

E-ISSN: 3060-6713

participation, career engagement, and quality of life (Choi & Sung, 2025; Newman et al., 2022; Tomaszewski et al., 2020). Additional evidence indicates that self-determination remains a critical factor across the lifespan, influencing outcomes among both younger and older adults with intellectual disabilities (Álvarez-Aguado et al., 2024; Álvarez-Aguado et al., 2021). Recent validation studies have further strengthened the evidence base by demonstrating robust associations between self-determination and multiple indicators of successful adult functioning, including employment and community participation (Moreira et al., 2026). Moreover, growing attention has been devoted to developing culturally responsive and psychometrically sound measures of self-determination to facilitate research and intervention across diverse populations (Castro-Durán et al., 2024). Collectively, these findings suggest that self-determination represents a central mechanism through which individuals with intellectual disabilities can navigate vocational challenges and achieve meaningful employment outcomes.

Another factor that may substantially influence vocational success is career adaptability. Derived from career construction theory, career adaptability refers to the psychosocial resources that enable individuals to cope effectively with vocational transitions, occupational challenges, and changing work environments. Career adaptability encompasses dimensions such as concern for the future, personal control, curiosity regarding opportunities, and confidence in one's ability to overcome obstacles. For young adults with intellectual disabilities, career adaptability may be particularly important because employment pathways often involve frequent transitions, uncertainty, and the need to respond flexibly to changing workplace demands. Research has shown that employability skills, career planning competencies, and adaptive vocational behaviors contribute significantly to successful employment outcomes among individuals with intellectual disabilities (Krishnan & Meena, 2023). Similarly, studies examining self-advocacy and work adjustment have highlighted the importance of adaptive personal resources in facilitating workplace integration and long-term employment success (Kavitha, 2023). Investigations involving transition-age individuals with disabilities have further demonstrated that career engagement is influenced by psychological factors such as motivation, self-efficacy, and fulfillment of basic psychological needs (Choi & Sung, 2025). Evidence from studies of employment experiences among autistic and disabled young adults also suggests that adaptability plays a critical role in navigating workplace expectations, maintaining employment, and pursuing career advancement opportunities (Kraemer et al., 2024; Ye & Jiqing, 2025). Consequently, career adaptability may serve as a key predictor of vocational success among young adults with intellectual disabilities.

The role of family support has also received substantial attention within disability and transition research. Families often function as primary sources of emotional support, advocacy, resource coordination, and vocational guidance throughout the transition to adulthood. Family empowerment refers to the extent to which families perceive themselves as capable of influencing decisions, accessing services, advocating for their family members, and supporting developmental outcomes. Empowered families are more likely to facilitate access to educational opportunities, vocational training programs, community resources, and employment supports. Research indicates that family expectations and involvement significantly influence transition outcomes for young adults with disabilities (DaWalt et al., 2021; Voermans et al., 2023). Informal support networks frequently play critical roles in helping individuals with intellectual disabilities secure employment, adapt to workplace environments, and maintain long-term occupational engagement (Voermans et al., 2023). Furthermore, empowerment-oriented approaches have been associated with enhanced resilience, self-confidence, and community participation among individuals with disabilities (Martínez, 2025). Studies examining personal development and decision-making have similarly emphasized the importance of supportive environments in fostering autonomy and life planning among individuals with intellectual disabilities (García-Candel et al., 2023). These findings suggest that family empowerment may represent an important contextual factor influencing vocational success.

A growing body of research has highlighted the interconnected nature of personal, familial, educational, and environmental influences on employment outcomes. Employment success is increasingly conceptualized as the product of dynamic interactions between individual capabilities and contextual supports rather than the result of isolated personal characteristics. For example, opportunities for self-determination are often shaped by family involvement, educational practices, and community resources (Mumbardó-Adam et al., 2020; Sánchez et al., 2020). Similarly, vocational participation may be influenced by access to assistive technologies, workplace accommodations, mental health supports, and lifelong

E-ISSN: 3060-6713

learning opportunities (Kļaviņa et al., 2024; Liljeholm et al., 2020; Tuckett, 2023). Research examining community participation and rehabilitation interventions has demonstrated that supportive environments can substantially improve social inclusion, employment engagement, and quality of life among individuals with disabilities (Alfieri et al., 2025; Giummarra et al., 2022). Furthermore, investigations involving adaptive functioning and developmental outcomes suggest that successful transitions to adulthood require coordinated support across multiple domains of functioning (Matthews et al., 2021; Murray et al., 2021). These findings underscore the need for comprehensive models that account for both personal and contextual influences on vocational success.

Despite increasing recognition of the factors associated with employment outcomes, much of the existing literature has relied on traditional statistical approaches that may not adequately capture the complexity of relationships among vocational predictors. Human behavior, vocational development, and disability-related outcomes are often characterized by nonlinear interactions, multidimensional influences, and heterogeneous patterns that may be difficult to detect using conventional analytical methods. Machine learning techniques offer powerful alternatives by enabling the identification of complex relationships, predictive patterns, and variable interactions within large datasets. These approaches have gained increasing prominence in health, psychology, education, and rehabilitation research because of their ability to improve predictive accuracy while uncovering nuanced patterns that may otherwise remain hidden (Moreira et al., 2026; Subramanyam et al., 2024). Applying machine learning methods to vocational research may therefore provide valuable insights into the relative contributions of self-determination, career adaptability, and family empowerment while simultaneously enhancing the prediction of vocational success among young adults with intellectual disabilities.

Given the continuing challenges associated with employment participation among individuals with intellectual disabilities and the growing importance of evidence-based transition planning, further research is needed to identify the factors that most strongly contribute to vocational success. Understanding how self-determination, career adaptability, and family empowerment interact to influence employment outcomes may inform the development of targeted interventions, family support programs, vocational rehabilitation services, and transition planning initiatives designed to improve adult outcomes for this population.

The aim of the present study was to employ machine learning techniques to predict vocational success among young adults with intellectual disabilities based on self-determination, career adaptability, and family empowerment.

2. Methods and Materials

2.1. Study Design and Participants

This study employed a cross-sectional predictive research design utilizing machine learning techniques to examine the extent to which self-determination, career adaptability, and family empowerment predict vocational success among young adults with intellectual disabilities. The study was conducted across multiple vocational rehabilitation centers, community employment agencies, and transition-to-work programs in the provinces of Ontario, British Columbia, and Alberta, Canada, between March and September 2025. The target population consisted of young adults diagnosed with mild to moderate intellectual disabilities who were actively engaged in supported employment programs, vocational training initiatives, or competitive employment settings. Eligibility criteria included being between 18 and 30 years of age, possessing a documented diagnosis of intellectual disability according to clinical and educational records, having sufficient communication abilities to complete self-report questionnaires with or without assistance, and providing informed consent either independently or through legal guardians when required. Participants with severe psychiatric disorders, significant sensory impairments that prevented participation, or incomplete questionnaire responses were excluded from the final analysis.

A total of 428 participants were recruited using a stratified cluster sampling approach. Vocational rehabilitation centers and employment support organizations were first identified across the selected provinces, and eligible participants were subsequently invited to participate. The final sample consisted of 428 young adults with intellectual disabilities, including both males and females from diverse socioeconomic and cultural backgrounds. The sample size was determined based on recommendations for machine learning studies requiring sufficient observations for model training, validation, and testing procedures while maintaining adequate statistical power and predictive stability.

E-ISSN: 3060-6713

2.2. Measures

Vocational success was assessed using the Vocational Index for Adults with Disabilities developed by Moore and colleagues (2015). This instrument evaluates employment-related outcomes across several domains, including job retention, work performance, workplace independence, job satisfaction, employer evaluations, and employment stability. The scale consists of 24 items rated on a five-point Likert scale ranging from strongly disagree to strongly agree. Higher scores indicate greater vocational success and workplace integration. Previous research has demonstrated satisfactory psychometric properties for the instrument, including strong internal consistency coefficients exceeding .85 and evidence of construct validity among adults with developmental and intellectual disabilities. Reliability and validity have also been supported across vocational rehabilitation and supported employment contexts.

Self-determination was measured using the Arc's Self-Determination Scale developed by Wehmeyer and Kelchner (1995). This widely used instrument assesses personal autonomy, self-regulation, psychological empowerment, and self-realization among individuals with disabilities. The questionnaire contains 72 items organized into four major dimensions and has been extensively employed in transition planning and disability research. Participants respond to items using structured formats appropriate for individuals with intellectual disabilities. Higher scores reflect stronger self-determination capacities. Numerous studies have confirmed the scale's reliability, with Cronbach's alpha coefficients typically ranging from .80 to .92, while construct validity, criterion validity, and cross-cultural applicability have been consistently reported.

Career adaptability was assessed using the Career Adapt-Abilities Scale developed by Savickas and Porfeli (2012). The instrument comprises 24 items distributed across four dimensions, including concern, control, curiosity, and confidence. Responses are recorded on a five-point Likert scale ranging from not strong to strongest. The scale measures individuals' psychosocial resources for coping with career transitions, occupational challenges, and employment-related decision-making processes. Previous investigations have reported excellent internal consistency estimates exceeding .90 for the total scale and satisfactory validity across diverse populations, including individuals with disabilities and those participating in vocational training programs.

Family empowerment was measured using the Family Empowerment Scale developed by Koren, DeChillo, and Friesen (1992). This instrument evaluates parents' and family members' perceptions of competence, advocacy, service navigation abilities, and involvement in supporting individuals with disabilities. The scale consists of 34 items rated on a five-point Likert scale. Higher scores indicate greater family empowerment and stronger engagement in supporting vocational and developmental outcomes. Previous studies have demonstrated robust psychometric characteristics, including internal consistency coefficients ranging from .84 to .92 and substantial evidence for convergent and discriminant validity. The instrument has been extensively utilized in disability, special education, and family support research.

Demographic information was collected using a researcher-developed questionnaire that included age, gender, educational attainment, type of employment setting, duration of employment experience, living arrangements, family socioeconomic status, and level of support received within vocational programs. These variables were used to describe the sample and were considered as potential covariates during exploratory analyses.

2.3. Data Analysis

Data analysis was conducted using Python version 3.12 and R version 4.4. Prior to model development, data were screened for missing values, outliers, and distributional irregularities. Missing data rates were below 5% and were handled using multiple imputation procedures. Continuous variables were standardized using z-score normalization to ensure comparability across predictors. Descriptive statistics, including means, standard deviations, skewness, and kurtosis values, were calculated for all study variables. Pearson correlation coefficients were also computed to examine preliminary associations among vocational success, self-determination, career adaptability, and family empowerment.

The machine learning analysis employed the Extreme Gradient Boosting (XGBoost) algorithm due to its superior performance in handling complex nonlinear relationships and interactions among psychosocial predictors. The dataset was randomly divided into training (70%) and testing (30%) subsets. Hyperparameter optimization was performed using five-fold cross-validation combined with grid-search procedures to identify optimal model configurations. Model performance was evaluated using multiple predictive

E-ISSN: 3060-6713

metrics, including the coefficient of determination (R^2), mean absolute error (MAE), root mean squared error (RMSE), and mean absolute percentage error (MAPE). To enhance interpretability and identify the relative contribution of each predictor, SHapley Additive exPlanations (SHAP) analysis was conducted. SHAP values provided both global and local explanations of model predictions, allowing detailed examination of the influence of self-determination, career adaptability, and family empowerment on vocational success outcomes. Feature importance rankings were generated based on mean absolute SHAP values, and partial dependence analyses were conducted to visualize nonlinear associations between predictors and vocational success. Statistical significance for preliminary analyses was evaluated at the .05 level, while predictive accuracy and model explainability served as the primary criteria for evaluating the effectiveness of the machine learning model.

3. Findings and Results

A total of 428 young adults with intellectual disabilities participated in the study. The mean age of the participants was 24.31 years (SD = 3.42), with ages ranging from 18 to 30 years. Among the participants, 238 (55.6%) were male and 190 (44.4%) were female. Regarding educational attainment, 127 participants (29.7%) had completed secondary education, 198 (46.3%) had completed vocational training programs, and 103 (24.1%) had attended post-secondary transition programs. In terms of employment status, 172 participants (40.2%) were engaged in supported employment, 146 (34.1%) worked in competitive employment settings, and 110 (25.7%) were enrolled in vocational preparation programs. The average duration of employment experience was 2.87 years (SD = 1.54). Demographic analyses indicated that the sample represented a diverse range of vocational backgrounds and family circumstances, providing an appropriate basis for evaluating predictors of vocational success.

Table 1

Descriptive Statistics and Correlations Among Study Variables

Variable	Mean	SD	1	2	3	4
1. Vocational Success	84.67	14.21	—			
2. Self-Determination	217.84	28.45	.68**	—		
3. Career Adaptability	87.36	13.17	.61**	.58**	—	
4. Family Empowerment	119.52	16.84	.54**	.49**	.46**	—

Table 1 presents the descriptive statistics and bivariate correlations among the study variables. Participants reported moderate to high levels of vocational success, self-determination, career adaptability, and family empowerment. Examination of the correlation matrix revealed statistically significant positive associations among all variables. Vocational success demonstrated the strongest correlation with self-determination ($r = .68$, $p < .001$), followed by career adaptability ($r = .61$, $p < .001$) and family empowerment ($r = .54$, $p < .001$). The positive intercorrelations among the predictor variables ranged from .46 to .58, suggesting that although related, the constructs represented distinct dimensions of psychosocial functioning. The absence of excessively high correlations indicated that multicollinearity was unlikely to pose a substantial threat to subsequent machine learning analyses. These findings provided preliminary evidence that higher levels of self-determination, career adaptability, and family empowerment are associated with greater vocational success among young adults with intellectual disabilities.

Table 2

Predictive Performance of Machine Learning Models

Model	R^2	RMSE	MAE	MAPE (%)
Linear Regression	.48	10.82	8.31	11.42
Random Forest	.67	8.17	6.12	8.46
Support Vector Regression	.63	8.74	6.48	8.97
Gradient Boosting	.71	7.62	5.74	7.88
XGBoost	.76	6.94	5.13	6.95

E-ISSN: 3060-6713

Table 2 summarizes the predictive performance of the machine learning algorithms tested in the study. Comparison of model performance indices demonstrated that the XGBoost algorithm achieved the highest predictive accuracy, explaining 76% of the variance in vocational success scores within the testing dataset. The model produced the lowest prediction errors, with an RMSE of 6.94, MAE of 5.13, and MAPE of 6.95%. Gradient Boosting emerged as the second most accurate model, followed by Random Forest and Support Vector Regression. Traditional linear regression showed the weakest predictive performance, accounting for only 48% of the variance in vocational success. The superior performance of XGBoost suggests that the relationships among vocational success, self-determination, career adaptability, and family empowerment involve nonlinear patterns and complex interactions that are more effectively captured by advanced machine learning approaches than by conventional statistical models. These results support the suitability of explainable machine learning methods for identifying vocational success determinants among individuals with intellectual disabilities.

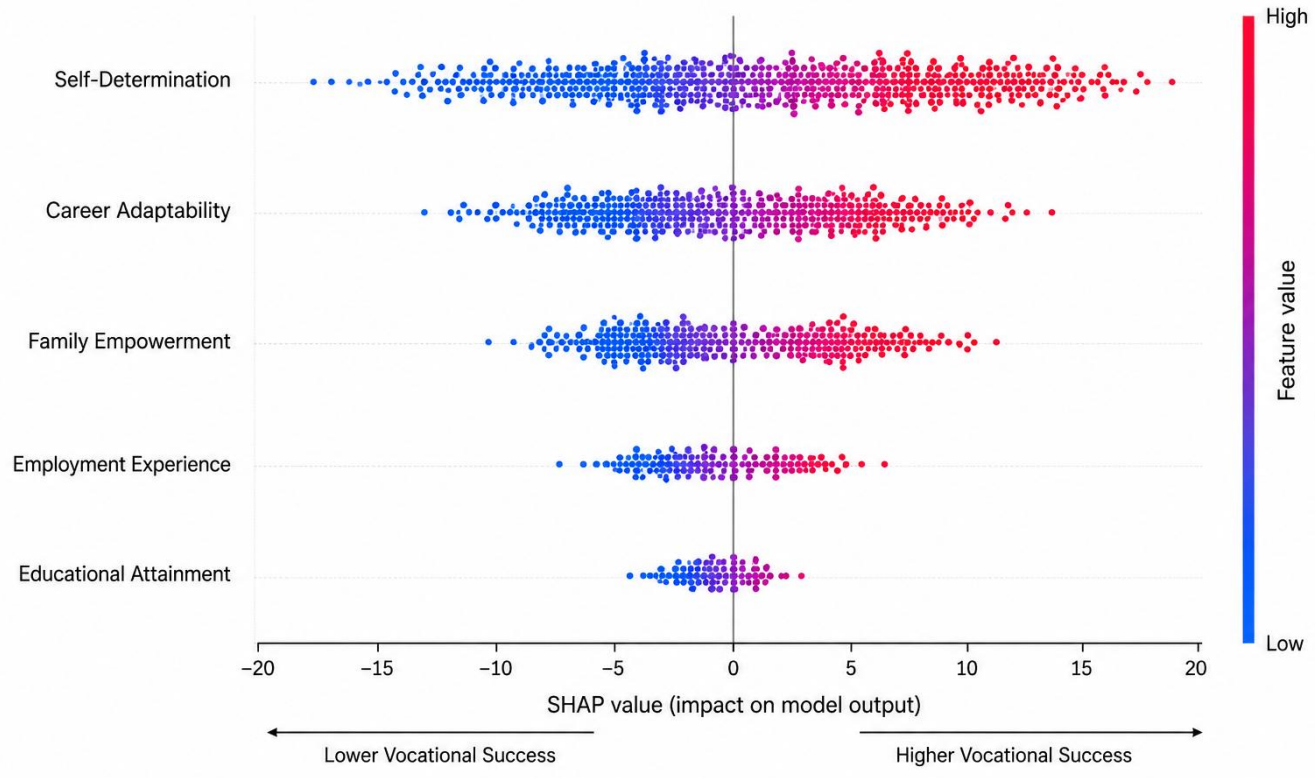
Table 3

SHAP Feature Importance Rankings for Predicting Vocational Success

Predictor	Mean Absolute SHAP Value	Relative Importance (%)	Rank
Self-Determination	9.84	41.5	1
Career Adaptability	7.21	30.4	2
Family Empowerment	5.38	22.7	3
Employment Experience	1.12	4.7	4
Educational Attainment	0.17	0.7	5

Figure 1

SHAP Summary Plot Illustrating the Relative Contributions of Self-Determination, Career Adaptability, and Family Empowerment to Vocational Success Predictions



E-ISSN: 3060-6713

Table 3 presents the SHAP-based feature importance analysis derived from the optimal XGBoost model. Self-determination emerged as the most influential predictor of vocational success, accounting for 41.5% of total model importance. Career adaptability represented the second most important factor, contributing 30.4% to overall prediction accuracy. Family empowerment ranked third, accounting for 22.7% of model importance. Together, these three psychosocial variables explained more than 94% of the total predictive contribution identified by the machine learning model. In contrast, demographic characteristics such as employment experience and educational attainment contributed relatively little additional explanatory value. The SHAP analysis therefore suggests that personal agency, adaptive career-related resources, and supportive family environments constitute the primary determinants of vocational success among young adults with intellectual disabilities. Furthermore, local SHAP examinations indicated that higher levels of self-determination and career adaptability consistently increased predicted vocational success scores, while lower levels of these characteristics substantially reduced the probability of positive vocational outcomes.

Figure 1 illustrates the SHAP summary plot generated from the final XGBoost model. The figure demonstrates that self-determination exhibited the widest distribution of SHAP values, indicating the strongest influence on model predictions across participants. Individuals with high self-determination scores generally showed positive SHAP values associated with increased vocational success, whereas low self-determination scores contributed negatively to predictions. Career adaptability displayed a similar pattern, although with a somewhat smaller range of SHAP values. Family empowerment also exerted a meaningful positive influence on vocational success, particularly among participants who reported strong family involvement and support in vocational decision-making processes. The figure additionally revealed several nonlinear effects, including threshold patterns whereby increases in self-determination and career adaptability beyond moderate levels produced disproportionately larger gains in predicted vocational success. Overall, the SHAP visualization confirms the central role of psychosocial and family-related resources in shaping vocational outcomes and provides interpretable evidence regarding the mechanisms through which these factors contribute to successful employment and workplace adaptation among young adults with intellectual disabilities.

4. Discussion

The present study employed an explainable machine learning approach to investigate the predictive contributions of self-determination, career adaptability, and family empowerment to vocational success among young adults with intellectual disabilities. The findings demonstrated that all three psychosocial variables were positively associated with vocational success, with self-determination emerging as the strongest predictor, followed by career adaptability and family empowerment. Furthermore, the XGBoost model achieved high predictive performance, explaining 76% of the variance in vocational success outcomes, while SHAP analyses revealed that the three focal predictors collectively accounted for the overwhelming majority of the model's explanatory power. These findings provide important evidence regarding the factors that contribute to successful employment outcomes among young adults with intellectual disabilities and highlight the value of machine learning methodologies for understanding complex vocational phenomena.

One of the most important findings of the study was the identification of self-determination as the strongest predictor of vocational success. Participants who demonstrated greater autonomy, self-regulation, decision-making capacity, and psychological empowerment were substantially more likely to achieve favorable employment outcomes. This finding is highly consistent with contemporary theories of disability and transition planning, which emphasize self-determination as a central mechanism through which individuals exert control over their educational, occupational, and personal trajectories. Previous studies have repeatedly demonstrated that self-determination is associated with successful adult outcomes among individuals with intellectual and developmental disabilities. For example, criterion validation research found robust relationships between self-determination and positive life outcomes across multiple domains of functioning (Moreira et al., 2026). Similarly, investigations of adults with intellectual disabilities reported that higher levels of self-determination were associated with greater independence, enhanced community participation, and improved quality of life (Álvarez-Aguado et al., 2024; Álvarez-Aguado et al., 2021). The present findings extend this body of evidence by demonstrating that self-determination is not only associated with vocational success but represents the single most influential predictor within a machine learning framework.

E-ISSN: 3060-6713

The strong influence of self-determination may be explained by the fact that successful employment requires individuals to make decisions, solve problems, communicate preferences, advocate for accommodations, manage workplace challenges, and pursue career-related goals. Individuals with higher levels of self-determination are likely to engage more actively in vocational planning and workplace adaptation processes. Research has shown that opportunities to exercise choice and autonomy serve as critical foundations for the development of self-determination among individuals with intellectual disabilities (Sánchez et al., 2020). Furthermore, self-determination has been linked to postsecondary enrollment, educational engagement, and successful transitions to adulthood (Newman et al., 2022; Tomaszewski et al., 2020). Studies examining everyday autonomy and adult identity have similarly demonstrated that self-directed behavior contributes significantly to successful adult functioning (Salt & Jahoda, 2020). The current findings therefore reinforce the argument that interventions designed to enhance autonomy, self-advocacy, and decision-making skills may produce meaningful improvements in vocational outcomes.

The second major finding was the significant contribution of career adaptability to vocational success. Although somewhat less influential than self-determination, career adaptability emerged as a powerful predictor within the machine learning model and accounted for a substantial proportion of explanatory variance. This finding suggests that individuals who possess greater confidence in managing vocational transitions, exploring opportunities, and responding to workplace challenges are more likely to achieve successful employment outcomes. Career adaptability may be particularly important for young adults with intellectual disabilities because employment pathways often involve changing job requirements, evolving workplace expectations, and the need for continuous learning and adjustment. Consistent with the present findings, previous studies have demonstrated that employability skills and adaptive vocational competencies contribute significantly to workplace success among adults with intellectual disabilities (Krishnan & Meena, 2023). Research examining self-advocacy in employment settings has likewise emphasized the importance of adaptive capacities in facilitating workplace adjustment and job retention (Kavitha, 2023).

The role of career adaptability is also supported by studies investigating career engagement among transition-age individuals with disabilities. Choi and Sung reported that psychological resources and satisfaction of basic psychological needs significantly influence vocational engagement and participation (Choi & Sung, 2025). Similarly, research involving young autistic adults demonstrated that successful employment experiences depend heavily on an individual's ability to navigate changing vocational environments and respond effectively to workplace demands (Kraemer et al., 2024). Career adaptability likely functions as a bridge between personal strengths and environmental opportunities, enabling individuals to translate aspirations into concrete vocational achievements. The SHAP analyses in the present study revealed nonlinear effects, suggesting that increases in adaptability beyond moderate levels may generate disproportionately greater gains in vocational success. This finding highlights the potential value of interventions focused on career exploration, vocational confidence, and transition readiness.

Another important result was the significant predictive role of family empowerment. Although family empowerment ranked third in importance, it nevertheless accounted for nearly one-quarter of the overall predictive contribution identified by the model. This finding underscores the enduring influence of family systems on the vocational development of young adults with intellectual disabilities. Families frequently serve as primary advocates, support providers, and facilitators of access to educational and vocational resources. Empowered families may be better equipped to navigate service systems, advocate for employment opportunities, encourage vocational aspirations, and provide emotional support during challenging transitions. These findings align closely with previous research demonstrating the importance of family involvement in shaping adult outcomes for individuals with intellectual disabilities (DaWalt et al., 2021). Studies examining informal support networks have similarly shown that family members play essential roles in facilitating employment acquisition and maintenance (Voermans et al., 2023).

The importance of family empowerment may also be understood within broader ecological frameworks of disability. According to these perspectives, vocational outcomes emerge through interactions between individuals and their environments rather than through personal characteristics alone. Research examining personal development and decision-making among individuals with intellectual disabilities has highlighted the importance of supportive social contexts for fostering autonomy and life

E-ISSN: 3060-6713

planning (García-Candel et al., 2023). Likewise, studies focusing on empowerment and resilience have demonstrated that supportive family environments promote confidence, self-efficacy, and community participation (Martínez, 2025). The present findings suggest that family empowerment not only provides practical support but may also create opportunities for the development of self-determination and career adaptability, thereby indirectly contributing to vocational success.

The correlation analyses further demonstrated that self-determination, career adaptability, family empowerment, and vocational success were all positively related. These findings support integrative models proposing that personal and contextual variables operate synergistically rather than independently. Previous research has emphasized the interconnected nature of self-determination and contextual opportunities, suggesting that autonomy develops most effectively when supported by families, educators, and communities (Mumbardó-Adam et al., 2020; Sánchez et al., 2020). Similarly, transition research has highlighted the importance of coordinated support systems in promoting successful adult outcomes (Mazzotti et al., 2020; Murray et al., 2021). The current findings therefore contribute to an emerging consensus that vocational success is best understood as a multidimensional phenomenon influenced by both individual competencies and environmental supports.

A particularly noteworthy aspect of the present study concerns the performance of the machine learning model itself. The XGBoost algorithm substantially outperformed traditional linear regression and other predictive models, indicating that vocational success is influenced by complex and nonlinear relationships among predictors. This finding is theoretically meaningful because employment outcomes among individuals with intellectual disabilities are rarely determined by a single factor. Instead, vocational success likely reflects interactions among psychological resources, family supports, educational experiences, social opportunities, health-related factors, and environmental conditions. Previous studies examining transition outcomes, employment experiences, and quality of life have consistently reported substantial heterogeneity among individuals with disabilities (Gilson et al., 2022; Smith & Parmenter, 2023; Taylor et al., 2022). Machine learning methods are uniquely suited to capturing such complexity and may therefore represent valuable tools for future disability and vocational research.

The findings also have broader implications for understanding adult outcomes among individuals with intellectual disabilities. Research has increasingly emphasized the importance of meaningful participation, purpose, and social inclusion as components of successful adulthood (Gilson et al., 2022; White et al., 2023). Employment provides opportunities not only for economic independence but also for identity formation, social integration, and personal growth. Studies have shown that access to competitive employment contributes positively to economic, psychological, and physical well-being among individuals with intellectual and developmental disabilities (Taylor et al., 2022). Furthermore, educational opportunities, community participation initiatives, assistive technologies, and vocational interventions have all been identified as mechanisms for improving adult outcomes (Alfieri et al., 2025; Giummarra et al., 2022; Grigal et al., 2021; Kļaviņa et al., 2024). The present study contributes to this literature by identifying the psychosocial variables most strongly associated with vocational success and demonstrating their relative importance within a predictive framework.

The findings additionally support developmental perspectives emphasizing the importance of lifelong learning, participation, and empowerment. Studies have highlighted the challenges that young adults with disabilities face during the transition to adulthood and the necessity of creating opportunities for skill development and career engagement (Cooper et al., 2023; Tuckett, 2023). Research examining employment experiences among individuals with disabilities has repeatedly shown that successful vocational outcomes require more than technical job skills alone; they also depend on confidence, adaptability, support systems, and opportunities for self-directed action (Kraemer et al., 2024; Ye & Ji-qing, 2025). The present findings reinforce these conclusions and suggest that interventions addressing both individual and family-level factors may be especially effective in promoting vocational achievement.

5. Conclusion

The study's findings should also be interpreted in light of broader evidence linking participation, mental health, and well-being. Employment and community engagement have been associated with improved psychological functioning and greater quality of life among individuals with disabilities (Liljeholm et al., 2020; White et al., 2023). Conversely, limited opportunities for participation may contribute to

E-ISSN: 3060-6713

poorer psychosocial outcomes (Paxinos et al., 2021). By identifying self-determination, career adaptability, and family empowerment as key predictors of vocational success, the present study highlights modifiable targets that may simultaneously enhance employment outcomes and broader indicators of well-being.

The present study has several limitations that should be considered when interpreting the findings. First, the cross-sectional design limits the ability to establish causal relationships among the variables. Second, the reliance on self-report measures may have introduced response bias and shared method variance. Third, participants were recruited from Canadian vocational and transition programs, which may limit the generalizability of findings to other cultural, educational, and service contexts. Fourth, although the machine learning model demonstrated strong predictive performance, additional factors such as workplace characteristics, employer attitudes, mental health status, social skills, and community resources were not included in the model. Finally, the study focused primarily on young adults with mild to moderate intellectual disabilities, and the findings may not fully apply to individuals with more significant support needs.

Future research should employ longitudinal designs to examine how self-determination, career adaptability, and family empowerment influence vocational outcomes over time. Researchers should also investigate potential mediating and moderating mechanisms linking these variables to employment success. Additional studies could incorporate workplace-level variables, employer perspectives, technological supports, and broader environmental factors to develop more comprehensive predictive models. Comparative studies across countries and service systems would further enhance understanding of cultural influences on vocational development. Finally, future investigations should continue to explore advanced machine learning approaches and explainable artificial intelligence methods to improve prediction accuracy and intervention targeting.

The findings suggest several practical implications for educators, rehabilitation professionals, policymakers, and families. Transition programs should prioritize the development of self-determination skills through opportunities for choice-making, self-advocacy training, goal setting, and independent decision-making. Vocational interventions should include components designed to strengthen career adaptability, such as career exploration, problem-solving training, workplace readiness instruction, and confidence-building activities. Family-centered services should empower parents and caregivers by providing education, advocacy training, and access to resources that support vocational development. Employment programs should adopt holistic approaches that address both individual competencies and environmental supports. By targeting self-determination, career adaptability, and family empowerment simultaneously, service providers may be better positioned to promote sustainable vocational success and improve long-term quality of life among young adults with intellectual disabilities.

Authors' Contributions

Authors equally contributed to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

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

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