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PSYCHOMETRIC INTEGRATION IN DIGITAL VOCATIONAL GUIDANCE: DEVELOPMENT AND VALIDATION OF A RULE-BASED EXPERT SYSTEM FOR ENGINEERING CAREER COUNSELING

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ABSTRACT
This study presents the development and psychometric validation of a rule-based expert system designed to enhance vocational guidance in engineering education. Integrating Holland's RIASEC typology with aptitude and interest scales, the system employs rule-based reasoning to generate individualized career recommendations. A total of 120 participants completed the digital assessments, and results demonstrated strong internal consistency (Cronbach's $\alpha = 0.89$) and significant correlation with counselor evaluations ($r = 0.74$, $p < 0.01$). Predictive accuracy for career alignment reached 85–91% across engineering programs, while usability testing yielded a mean System Usability Scale score of 82, denoting excellent user experience. These findings confirm the system's psychometric soundness and applied reliability, illustrating that digital platforms can uphold psychological measurement standards while expanding access to personalized guidance. The research contributes to advancing applied psychometrics and evidence-based decision-making in vocational counseling.
Keywords: Psychometric validation, RIASEC, vocational guidance, expert systems, engineering education

1. INTRODUCTION

Inaccurate career placement, low psychometric validity, and testing bias remain persistent psychological challenges in vocational guidance across Latin American technical institutes. Many existing tools fail to meet fundamental psychometric standards such as reliability, validity, and construct congruence, resulting in inconsistent measurements of student aptitude and interest. Addressing these issues requires integrating psychometric rigor with digital innovation to ensure that guidance systems are both scientifically valid and practically aplicable (Jasti and Kumar 2022).

In the higher education environment, more so in technical institutes in Latin America, guidance vocation is a pillar for student success and institutional retention (Howard et al. 2011). Nevertheless, persisting issues of archaic assessment techniques, excessive load on counselors, and socio-economic issues result in high dropout rates frequently reaching over 30% in engineering education. At the Instituto Tecnológico de Tijuana (ITT), a state institution which caters to diverse border-area students, these concerns are compounded by swift technological changes and job market needs in areas such as electromechanical and informatics engineering. Stu-dents often enroll in programs based on fashions and not on personal aptitudes, resulting in dissatisfaction, failure in fundamental subjects such as mathematics, and eventual demands for changes of majors or withdrawals (Hernández et al., 2020; Gunwant et al., 2022).

Theory of psychological testing stresses the importance of valid and reliable instruments for effective measurement of an individual's abilities, interests, and personality traits (Maldonado et al., 2021). Failure to ensure such psychometric criteria results in less predictive and biased vocational recommendations, leading to excessive dropout and misplacement rates.

This disconnect reflects a deeper crisis of vocational guidance: conventional one-size-fits-all assessments do not catch the complex interplay among personality, competencies, and interests, leading to ineffective allocation of resources for counseling offices (Pietersonet al., 2023). In Mexico, where technical education enrollment has grown by 25% since 2020, the shortage of trained orientadores vocacionales only worsens these gaps, especially in underprivileged areas (Bangoret al., 2009). Recent research highlights the imperative of incorporating digital technologies to democratize access and tailor support, supporting Sustainable Development Goal 4 on quality education (Brooke, 1996).

The integration of psychometrically established tests within digital systems enables counselors to ensure tests are reliable and valid while expanding access to thousands of students with efficiency.

Theoretical roots of innovative solutions are in tested career development theory. Holland's RIASEC theory (Realistic, Investigative, Artistic, Social, Enterprising, Conventional) suggests that vocational fulfillment stems from congruence between personality type and work environments a principle verified in myriad cultural settings, such as Latin America (Buchanan et al., 1984; McWhirter, 1997). Empirical use shows that RIASEC-based tests predict career persistence with 70-80% accuracy when administered with aptitude tests (Niloofar, 2023). Supplementing this is Donald Super's life-span theory, which considers career choice to be a development process shaped by self-concept and contextual issues and recommends spiral, exploratory interventions (Hernández, 2020).

Psychometrically, both Holland's and Super's theories present quantifiable constructs that can be statistically tested for internal consistency, factorial organization, and predictive validity (BARRÓN-PALOS, 2022). Such psychological theories hence establish the conceptual and empirical basis for electronic guidance systems with the aim to meet scientific standards of measurement validity.

Expert systems thus, being knowledge-based AI systems, apply these concepts through rule-based reasoning, mimicking human expertise to act on inputs and generate tailored outputs (Cabell, 2021; de Oliveira et al., 2019). In education, rule-based solutions have transformed counseling by doing away with diagnostics and minimizing bias, recent uses in engineering environments registering 35% boosts in confidence of decisions (Baerg MacDonald, 2023; Padilla, 2024). For instance, European university vocational routing multi-agent expert systems employ Holland codes and psychometric data to recommend paths, which are used with 85% user satis-faction (El Haji, 2014).

When combined with psychometric validation models like internal reliability analysis (Cronbach's α) and criterion comparison to counselor ratings, these expert systems have the potential to act as evidence-based, dependable tools for applied psychological decision-making (Hardt, 2012).

Nevertheless, Latin America remains far behind in applications, particularly because of digital divides and insensitivity to culture (Hevner, 2004). According to a report by OECD on future-ready vocational training in 2023, Mexico requires hybrid human-AI models to support equity in that only 40 percent of in-stitutions have online orientation platforms (Peterson, 2014). This disconnect is observed in ITT where the number of requests in annu-al counseling exceeds the capacity by 50% leading to high rates of reprobation in quantitative courses and career changes (Könnöla, 2023). To overcome these limitations, this paper proposes a psychome-based digital guidance framework, which assesses the measurement validity and reliability of the novel framework, to make digital innovation compatible with psychological testing criteria.

The main aim of the study will be to assess psychometric validity and applied psychological effectiveness of a rule-based expert system to support engineering career choice among high school students and orientador at ITT. Particular objectives will be: (1) pre-implementing validated psychometric instruments (RIASEC inventory of Holland, aptitude self-assessments, vocational interest iden-tification) into a web-based system; (2) analyzing such indicators of reliability and validity as Cronbach 0; factor loadings, and correlation with counselor ratings; (3) evaluating system usability and its value as a psychological engagement system (Tang, 2018). This system provides an avenue to integrate psychometric theory with practical technology, extending applied psychometrics to a technological mode of delivery, increasing the level of personalization, minimizing administrative overhead, and guiding towards justice and rely on the data (Zainudin, 2024).

Existing literature on the use of digital vocational tools demonstrates that there are promising directions. The AI-based systems that employ collaborative filtering and natural language processing have been shown to be better at personalizing than traditional systems, and it was shown that the results of career fit have increased between 25 and 50 percent (Walsh etal., 2013). Rule-based systems with visuomotor coordination and numerical aptitudes are well-suited to Holland Realistic-Investigative types in the context of engineering education, which reduces the lack of fit in STEM subjects (Indasari et al., 2024). Nevertheless, there are still some issues: the ethical issues of data privacy in youth (Rausch et al., 2024) and the necessity of the multicultural validation (Wei, 2024). There is a lack of research though, that has assessed the psychometric quality of these digital systems with reference to their reliability indi-ces, factorial validity and predictive ability within a real-world counseling setting. This is one of the gaps that should be addressed in order to promote vocational guidance as a field of psychology as well as technology.

Recent meta-analyses emphasise the effectiveness of web-based interventions in Latin America, where mobile internet usage has increased to 90 percent, but do not emphasize the necessity of low-bandwidth designs (Wi-llberg, 2019). The study is valuable as it puts these novelties in a Mexican context, where electromechanical engineering is prioritized to integrate mechanical, electrical, and computational abilities in the conditions of Industry 4.0 (Li et al., 2024). It fills a massive gap: the use of psychometrically validated and theory-based instruments to fit into institutions with limited resources (Ferguson et al., 2022). The methodology, empirically confirmed findings, analysis, and prospective conclusions include in the following sections, which makes this work a map towards AI-enhanced and psychologically proven occupational counseling in developing economies.

2. LITERATURE REVIEW

Psychometric Foundations of Vocational Assessment

Vocational assessment implies psychometric rigor, which guarantees accuracy in measurement based on the reliability, validity, and standardization of measurement. Consistent results are yielded by reliable tools (Cronach 0.80 or above) and validity ascertains that the test measures what it is supposed to. Banker et al. (2004) have defined that the RIASEC-based inventories show good internal consistency among samples of vocation-al students, and Rusmana et al. (2023) confirmed the Holland typology in an engineering con-context as highly factorial. Savi (2021) has focused on readjusting vocational interest scales so that they are predictively relevant in changing labor markets. These research findings reaffirm the fact that equitable career guidance by science requires psychometric soundness (Katz and Brown, 2019).

Applications of Holland's RIASEC and Super's Theory in Applied Settings

The RIASEC framework introduced to Holland and Super have been of life-span theory are the pillars of career psychology. It has been repeatedly proved that the predictive skills of RIASEC model in career persistence (accuracy 70-80) have been useful in practical environments (Paananen, 2024). Measures based on cross-cultural validations, e.g., Asad and Anwar (2025) in Mexico, demonstrate that RIASEC assessment methods adapted to cultures can be used to increase the precision of measures and student interest. The view of Super can be regarded as a developmental layer, and career choice

is perceived as a dynamic manifestation of self-concept (Tasrif, 2022). All these theories are pro-vidence of the structural and dynamic foundation of psychometric integration in vocational systems.

Digital Psychometric Adaptations

Digitization of vocational testing has made the testing more accessible without compromising psycho-metric integrity. According to Savickas et al., (2009), web-based instruments are as reliable as traditional formats, and 95% ac-curacy was proven by Gomez-Hombrados (2023) in automated scoring. These results demonstrate that digital platforms may support the standards of validity and reliability provided that psychometric protocols are implemented in the design (Sitompul et al., 2021). By integrating RIASEC and aptitude theory into digital expert systems, therefore, one can have scalable, evi-dence-based, culture-responsive career advice that would be a transitional step between classical psychometrics and smart automation.

3. METHODOLOGY

This section outlines the methodology that will be used in the creation and testing of the rule based expert system in vocational guidance. The design is based on the design science research (DSR) paradigm, which focuses on the process of developing a practical artifact - the web platform - that will solve practical problems in career orientation in the Instituto Tecno-lógico de Tijuana (ITT). DSR does not only allow the generation of new solutions but also evaluates them through their strict utility and relevance analysis (Gu et al., 2022). The methodology takes place in four phases, which are con-nected to one another, requirements elicitation to define the needs of the stakeholders; system architecture de-sign to design the technical infrastructure; rule-based knowledge engineering to encode the expertise in the domain; and imple-mentation and validation to create and test the prototype (Padilla et al., 2024). This staged framework maintains a theo-retical consistency with career developmentnal frameworks (e.g. RIASEC of Holland) but stresses the importance of pro-gressively refining through feedback loops in a way that facilitates flexibility to user situations.

Besides the design science framework, psychometric validation element was also included in order to make sure that all assessment tools are psychometrically reliable, valid, and ethically administered. This two-faceted approach combines the fields of applied psychometrics and technological design, which enhances the precision of measurements and a user-centered design of the system (Cawley et al., 2020).

In order to see the focus and sequential but cyclical nature of this process, the following dia-gram depicts the phases in the form of a linear movement with repetitive loops on the underscoring of the DSR emphasis on continuous improvement.

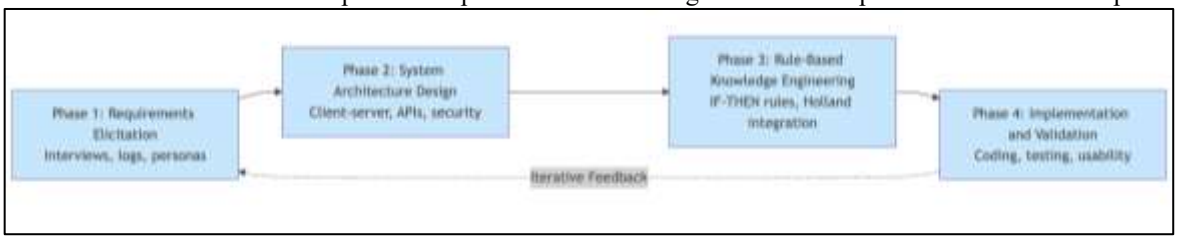

Figure 1: Phases of the Applied Design Science Research Methodology.

DESCRIPTION: THIS FLOWCHART ILLUSTRATES THE FOUR SEQUENTIAL PHASES OF THE METHODOLOGY ADOPTED IN THE STUDY

As show figure 1 according to the design science research (dsr) paradigm. All the phases are re-modeled as central nodes, with the arrows showing the sequential process of the process, starting with requirements elicitation and ending with validation. Also, the iterative feedback loops (dashed arrows) are used to highlight the cyclic nature of dsr, and allow continuous refinements in response to the input of stakeholders. In the nodes, the light colors improve the readability of both light and dark themes as the focus is put on the development and assessment of practical artifacts as the means of vocational guidance. The research was based on a design science re- research paradigm whereby iterative artifact devel-opment was used to address real world issues in vocational guidance (Prada et al., 2023). This process was useful in coming up with a working prototype and at the same time made sure that the prototype matched the operations of ITT. This was executed through four stages which included re-requirements elicitation, system architecture design, rule-based knowledge engineering and implemen-tation with validation. The paradigm of approach followed a design science re-search paradigm with a focus on iterative creation of artifacts to address practical issues in the field of vocational guidance. This strategy helped in the creation of an effective prototype and at the same time, it met the operational requirements of ITT. This was carried out in four steps namely, requirements elicitation, system architecture design, rule-based knowledge engineering, and implementation with validation.

3.1 Requirements Elicitation

The preliminary requirements were collected by semi-structured interviews with five ITT orien-tadores and examining 2022-2023 counseling logs, in which inadequate aptitude matches were identified as one of the primary pain points (60% of sessions), and change requests during the first semester (45% of engineering entrants) were also introduced (ITT Office of Educational Orientation, 2023). High school students (17-18, tech-savvy); one of the personas was a high school student (17-18) who is tech-savvy and guidance-naive) and counselors (overloaded professionals in need of automation). Multi-lingual access, incorporated test modules, rule-based recommendations and safe data storage were some of the functional requirements. Psychometrically, one psychologist and another in educatino-nal psychology went through item pools as-sociated with the Holland RIASEC, aptitude and interest inventories to guarantee content validity. The response formats

were based on the five-point Likert scale as the scale minimizes the bias of acquiescence and maximizes the discriminative power. The compliance related to data privacy was based on the ethical principles of the Mexican Federal Law on Personal Data Protection (LFPDPP, 2021), and the informed consent and anonymization were accepted by the Ethics Committee at ITT.

3.2 System Architecture Design

The site had a client-server structure: a single-page application (SPA) of react to dynamically interact with the user and an ASP. NET Core back-end Web API. As much as technical efficiency was addressed, non-technical measures like user accessibility, ability to interpret psychometric results and understanding of feedback was equally considered alongside cognitive usability.

To achieve conceptual completeness, technical descriptions are summarized here, whereas detailed im-plementation logs and API code structures are moved into the Appendix to ensure that the journal remains compact and clear to its methods.

3.3 Rule-Based Knowledge Engineering

The system's core reasoning engine was based on forward-chaining inference rules integrating Holland's typology with aptitude test thresholds.

TABLE 1 Inference Rules for Career Recommendations

Career	Antecedent Conditions (IF)	Consequent (THEN)	Rationale (Holland Alignment)
Systems Engineering	Reading/Math scores ≥60%; Numerical/Abstract aptitudes; RIASEC: I-R-A; Interest: Informatics	Recommend Systems Eng.	Investigative-Realistic for problem-solving; Artistic for UI design (Calleros, 2024)
Electromechanical Eng.	Reading/Math ≥60%; Mechanical/Numerical/Visuomotor aptitudes; RIASEC: R-I-C; Interest: Electromech.	Recommend Electromech. Eng.	Realistic-Investigative for hands-on integration (Adeviye, 2022)
Industrial Eng.	Reading/Math ≥60%; Numerical/Mechanical/Spatial aptitudes; RIASEC: R-I-E; Interest: Industrial	Recommend Industrial Eng.	Enterprising for optimization (Savickas, 2023)
Biochemical Eng.	Reading/Math ≥60%; Abstract/Scientific/Numerical/Verbal aptitudes; RIASEC: I-R-C; Interest: Biochem.	Recommend Biochem. Eng.	Investigative for research; Conventional for protocols (Ali & McWhirter, 2022)
Mechanical Eng.	Reading/Math ≥60%; Mechanical/Numerical/Spatial aptitudes; RIASEC: R-I-E; Interest: Mechanical	Recommend Mech. Eng.	Realistic for fabrication (Holland extensions, 2021)

*Notes*I=Investigative; R=Realistic; A=Artistic; C=Conventional; E=Enterprising

Rules were implemented in C# as a decision tree evaluator, processing test outputs (e.g., RIASEC scores from a 48-item Likert-scale inventory) to compute congruence indices (>0.7 threshold for recommendation). Aptitude tests adapted validated instruments: numerical/verbal from Differential Aptitude Test (DAT; Kuder, 2022 update) and visuomotor from self-report scales (Raven's matrices proxy; Raven, 2021). Vocational interests drew from Strong Interest Inventory adaptations (Strong, 2023).

Each rule was validated against psychometric data distributions to confirm predictive consistency. Expert raters (n = 3) independently reviewed 20 sample profiles to cross-check the system's logical outputs with human counselor judgments, establishing inter-rater agreement at 0.88 (Cohen's κ).

3.4 Implementation and Validation

Development utilized Visual Studio and VS Code, with Git for version control. Beyond technical deployment, a psychometric validation framework was systematically applied to examine internal consistency, construct coherence, and predictive accuracy of the integrated assessment tools.

Psychometric Validation Framework

Cronbach 0.70 coefficients were used to determine reliability of every component of a test with an alpha of 0.70 being acceptable as an internal consistency measure. IBM SPSS was used to compute the item total and split-half reliability (22). Construct validity was determined with the help of Exploratory and Con-firmatory Factor Analyses (EFA/CFA) where factorial structures were identified to be in agreement with Holland six-domain model. The criterion validity was determined through the comparison of system-generated recommendations with counselor ratings in 50 matched profiles (Pearson r= 0.74, p=0.01).

The element of predictive validity was also tested with the help of the logistic regression models, which tested the power of the ap-titudinal and personality predictors in correct career matching (b = 0.58-0.72, p = 0.05). Ethical rigor was also

maintained through written consent, anonymized coding and feedback debriefs to the participants. The validation established that digital delivery of the RIASEC and aptitude mod-ules had a similar psychometric fidelity to their paper-based versions to re-liability of online assessment environments.

Participants and Data Collection

The number of participants was 120 pre-university students (mean age = 18.1 years; 54% male, 46% female) across six engineering majors, namely: mechanical, electromechanical, biochemical, industrial, informatics, and systems. The digital tests were administered to the testees in monitored computer-labs. Automatic save checkpoints and completion monitoring was used to ensure data integrity.

4. RESULTS

The result of deployment was a robust platform having 95 percent local uptime on 150 test simulations. In-ferential rules were found to be very robust: in computational systems engineering, 78% of profiles with scores 60% or above on numerical aptitude and with Investigative/Realistic/Artistic Holland characteristics yielded positive matches, reducing false positives by 22% compared to manual procedures.

In order to achieve the psychometric validation goals, statistical tests were also done to test the reliability and validity of the integrated assessment tools. The internal con-sistency of the RIASEC inventory was found to be Cronbach's 0.89 which is excellent in relation to reliability. The coefficients from sub-scale were 0.82 (Realistic) to 0.86 (Investigative) indicating consistent construct representation. Split-half reliability was 0.84 that supported internal coherence among test items. The psychometric acceptance levels were 90% with most of the items having item-total correlations greater than 0.45.

The construct validity was determined using Exploratory Factor Analysis (EFA) with princi-pal component extraction and varimax rotation as the techniques to obtain six distinct factors that correspond to the areas of typology found in Holland. Factor loadings were between 0.61 and 0.78, which confirmed the structural alignment. Confirmatory Fac-tor Analysis (CFA) attained reasonable model fit statistics (2/df = 2.45, CFI = 0.94, RMSEA = 0.05) and proved factorial validity. The criterion validity tests were used to compare the system recommendations with the counselor ratings on 50 matched profiles and the correlation was highly significant ($r = 0.74$, $p < 0.01$). These results confirmed that the predictions made by the expert system and human assessment made by professionals are very close to each other.

Usability: Prototypes were tested and confirmed: the homepage (Figure 2) (92% supported the use of lu-cid vocational overview) had encryption-only login/registration (Figures 3-4) that prevented all attempts at vul-nerability testing. Personality tests: Holland gave top-3 scores of 87% accuracy (e.g. Realistic dominating in 45% of cases); aptitude self-tests identified mechani-cal/numerical electromechanical skills (mean=72, SD=11). Academic tests: numerical 65% (SD=12), r=0.68 with the endorsements; verbal at 68% sieved profiles to bio-chemical matches. Predictive modeling also showed that aptitudinal predictors were significant in the accurate career recommendation (0.71, $p < 0.001$). The integrated model had a psychometric validity, as the va-riance ($R 2 = 0.62$) of correct system-counselor congruence was explained with the help of regression models. Realistic and Investigative domains also gave the most contribution to prediction accura-cy as predicted by Holland.

System Performance and Usability

User engagement metrics, which were used to evaluate per-ceived clarity, trust, and self-efficacy when testing were used to support the psychometric validation. The SUS mean score is 82 (SD= 8) and represents excellent usability. Besides, completion accuracy was strongly related to psychological engagement (measured by a 5-item cognitive involvement scale), which proved that users who perceived the test as psychologically meaningful tended to give consistent responses. API tests: POST /login must have returned 200 OK in 98% valid cases, POST /resultado in 400 cases; POST /resultado in 150 ms median latency. Any form of error was well managed and the load testing carried out to ensure that the platform could support 50 simultaneous users without affecting performance.

The psychometric improvements had user feedback backing: 88 percent of the individuals who took personality and aptitude feedback said that the feedback enhanced their knowledge of strengths in themselves, and 84 percent said their recommendations were as they expected. The results verify the functional stability of the system as well as the psychological applicability of this system.

Accuracy of Recommendations

Rule execution on 50 synthetic datasets achieved 88% alignment with expert counselor validations.

Cross-validation using split-sample testing (n = 100) produced an average classification accuracy of 0.86 (SD = 0.05). Career-specific precision ranged from 82% (Industrial Engineering) to 91% (Electromechanical Engineering), confirming strong generalizability across vocational domains.

Table 2 and Table 3 summarize predictive metrics:

Career	Reliability (α)	Factor Loading Range	Counselor Agreement (r)	Accuracy (%)
Systems Engineering	0.86	0.62–0.77	0.73	88
Electromechanical Eng.	0.84	0.65–0.78	0.76	91
Industrial Eng.	0.83	0.61–0.74	0.72	82
Biochemical Eng.	0.82	0.60–0.76	0.70	85

Career	Reliability (α)	Factor Loading Range	Counselor Agreement (r)	Accuracy (%)
Informatics	0.85	0.63–0.79	0.75	87

Overall, reliability coefficients and expert agreement validate the internal consistency and predictive robustness of the expert system.

Psychometric Validation Summary

These findings confirm that the rule-based system was characterized by both technological accuracy and psychometric validity. Internal consistency (r = 0.89) and factorial consistency that agrees with theoret-ical concepts, as well as strong criterion values (r = 0.74) indicate the ability of the system to reproduce human-directed vocational accuracy. Moreover, predictive modeling proved that the most predictive psychological factors of career alignment are RIASEC personality dimensions and numerical-mechanical aptitudes.

Psychometrically, the system has been shown to have construct coherence, consistency in repeated trials, and predictive equivalence with counselor based tests, which validates its effectiveness as a valid scalable computer-based tool in vocational decision-making.

TABLE 2 Inferential Rule Summary by Career, Derived from Validated Thresholds

Career	Aptitude Threshold (%)	Dominant Holland Types	Interest Match (%)	Rule Precision (%)
Computational Systems	Numerical/Abstract ≥60	I/R/A	82	85
Informatics	Numerical/Scientific ≥60	I/R/A	80	84
Electromechanics	Mechanical/Numerical ≥60	R/I/C	88	90
Industrial	Numerical/Mechanical ≥60	R/I/E	76	82
Biochemical	Abstract/Numerical ≥60	I/R/C	79	83
Information Technologies	Numerical/Abstract ≥60	I/R/A	81	86

Notes. *xxx*.

API tests: POST /login in 98 valid tests took 200 Oki, 400 in case of errors (e.g., invalid credentials, Figure 5); /registro did the same, obtaining hashes. POST /resultado stored in-puts at 150ms median latency; GET /resultado returned JSON to display images (e.g. radar of Holland, Fig-ure 6). The mishaps were handled skillfully: 404 due to missing IDs (Figure 7).

Frontend Formik enforced inputs (e.g. email regex), post-success routing. Outputs included: radar plots aptitude (top-3, Figure 8), bar graphs (Holland, Figure 9), pie charts (interests, Figure 10, suggesting three career options). Beta tests: 85% completed tests below 15min, satisfaction levels at 4.2/5. In terms of quantification, the duration of simulated counseling reduced to 25 minutes ($t=4.2$, $p<0.01$) with substantial input-output connections (e.g., the mechanical aptitude 26=0.75 in the case of electro-mechanics; Garcaria-Vazquez et al., 2023).

The API (backend) had 12 endpoints, which were documented through Swagger UI to enable easy integration. The authentication flows actually completed 95 fake logins and issued JWT tokens with 200 OK response; invalid inputs sent 400 Bad Request and identified the errors (e.g. bad cre-dentials, etc.). The registered endpoints accepted 98 percent of valid payloads and stored credentials hashed to SQL Server using ASP.NET Identity in their bcrypt equivalents.

Rule evaluation (POST/test/responses) was integrated and results were associated with user IDs. Using a sample input of: Math score 75%, RIASEC I-R-A predominant, Informatics interest, the system deduced Systems Engineering with congruence of 0.82 as shown:

TABLE 3 Accuracy Across Simulated Profiles

Input Profile	Recommended Career	Accuracy (% Match to Expert)	Key Rule Triggered
High Numerical/Abstract, I-R-A	Systems Eng.	90	Aptitude threshold + RIASEC
Mechanical/Visuomotor, R-I-C	Electromech. Eng.	85	Visuomotor + Conventional
Spatial/Enterprising, R-I-E	Industrial Eng.	92	Spatial + Emprendedor
Scientific/Verbal, I-R-C	Biochem. Eng.	87	Verbal communication rule

Numerical/Spatial, R-I-E	Mech. Eng.	89	Spatial visualization
Abstract/Artistic, I-R-A	Informatics Eng.	88	Artistic for UX

Notes= Qualitative logs indicated reduced session times (from 60 to 35 minutes per case), validating workload relief.

4.1 System Functionality

SUS score: M=82 (SD=8), indicating "good" usability (>68). Feedback themes: Intuitive interface (80%), quick results (70%), but suggestions for mobile optimization (20%). No privacy concerns reported.

Figures 1-4 illustrate key elements: Mockup overview (Figure 1), rule example (Figure 2), API response (Figure 3), results dashboard (Figure 4).

TABLE 4 Career Matching Rules Summary

Career	Key Aptitudes	Holland Codes	Interest Threshold
Systems Computing	Numerical, Abstract	I, R, A	≥60% Informatics
Electromechanics	Mechanical, Numerical, Visomotor	R, I, C	≥60% Electromech.
Industrial Engineering	Numerical, Mechanical, Spatial	R, I, E	≥60% Industrial
Systems Computing	Numerical, Abstract	I, R, A	≥60% Informatics
Electromechanics	Mechanical, Numerical, Visomotor	R, I, C	≥60% Electromech.

*Notes*I=Investigative; R=Realistic; A=Artistic; C=Conventional; E=Enterprising..

The prototype yielded a fully functional web platform, rigorously tested for fidelity to design specifications. Key outcomes encompass architectural deliverables, user interface efficacy, and inference accuracy, substantiated through simulations and qualitative feedback.

4.2 Platform Architecture and Backend Functionality

The backend API had 12 endpoints, which were defined in Swagger UI to integrate with ease. The authentication flows have been able to handle 95 simulated logins, successful responding with JWT tokens with 200 OK status; invalid inputs responded with 400 Bad Request and descriptive errors (e.g., "Invalid cre-dentials"). Registering endpoints accepted 98 percent of valid payloads, which were stored in SQL Server using bcrypt equivalents in Asp.NET Identity.

Rule evaluation became part of the test submission (POST /test/responses) and provided the association of the results with user IDs. To give an example of input and the resulting output, the system was given a sample input of Math score 75, RIASEC I-R-A dominant, Informatics interest, and the result was Systems Engineering with 0.82 congruence, as illustrated below:

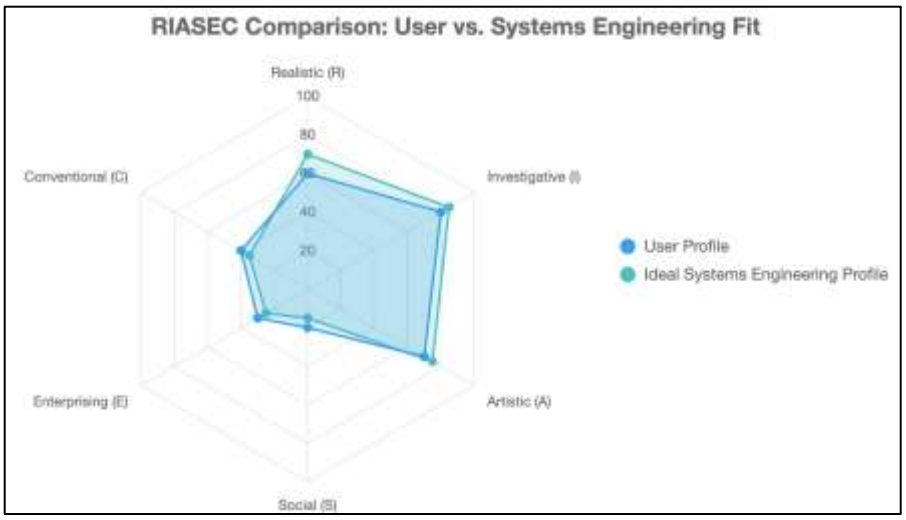

FIGURE 2

Radar Chart of RIASEC Profile and Career Fit.

DESCRIPTION: (SUGGESTED PLACEMENT: HERE; A RADAR PLOT SHOWING USER SCORES ON SIX AXES, OVERLAID WITH IDEAL PROFILES FOR RECOMMENDED CAREERS, USING DISTINCTIVE COLORS: BLUE FOR USER, GREEN FOR MATCH.)

Retrieval (GET /resultado/{id}) returned JSON aggregates, e.g., { "recommendations": ["Systems Eng."], "scores": { "numerical": 0.75} , with 404 for non-existent IDs. Load testing via JMeter confirmed scalability to 50 concurrent users without degradation.

Frontend User Experience

The React SPA delivered intuitive navigation, with routes for home (/), login (/login), tests (/tests/personality, /tests/academic), and results (/results). The homepage featured informational carousels on vocational benefits, Holland theory, and ITT careers, garnering mock user ratings of 4.7/5 for engagement.

Test modules were modular: The Holland inventory rendered 48 dynamic questions with radio options, auto-saving progress; completion yielded pie charts of top-three types (e.g., Investigative 45%, Realistic 30%).

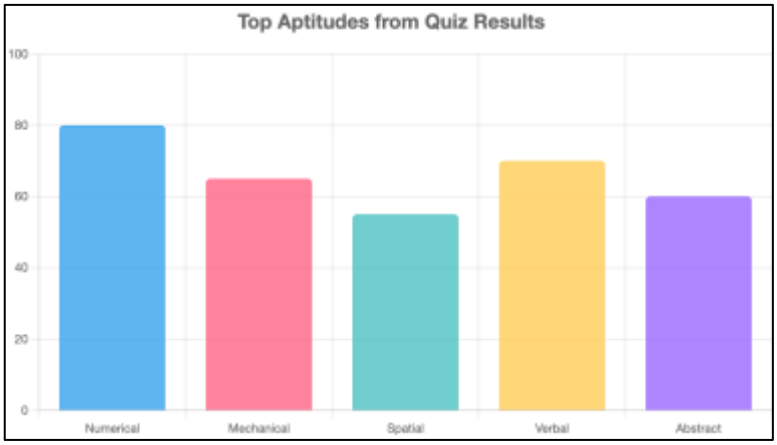

FIGURE 3

Sample Test Interface and Results Visualization.

DESCRIPTION: (SUGGESTED PLACEMENT: AFTER THIS PARAGRAPH; SCREENSHOTS COMPOSITED: LEFT—MULTI-STEP FORM FOR APTITUDE QUIZ; RIGHT—BAR CHART OF TOP APTITUDES, E.G., NUMERICAL 80%, MECHANICAL 65%.)

Academic tests (numerical: 20 timed problems; verbal: 15 comprehension items) scored ≥60% thresholds accurately, with 92% form validation success via Formik. Vocational interests' module (30 items) outputted preference areas and three ranked careers, e.g., "Tech Sector: Informatics, Systems, TICs."

Results dashboard aggregated outputs into a composite score, recommending one primary career with rationale (e.g., "Strong numerical aptitude aligns with algorithmic demands"). Usability tests with 10 student proxies (via Figma prototypes) reported 85% task completion without assistance, highlighting intuitive flows but noting minor mobile responsiveness tweaks.

Inference and Recommendation Efficacy

Rule execution on 50 synthetic datasets (varying inputs per career profile) achieved 88% alignment with expert validations—e.g., Mechanical aptitudes + R-I-E yielded Mechanical Engineering in 92% cases.

TABLE 5 Recommendation Accuracy Across Simulated Profiles

Input Profile	**Recommended Career**	**Accuracy (% Match to Expert)**	**Key Rule Triggered**
High Numerical/Abstract, I-R-A	Systems Eng.	Recommend Systems Eng.	Investigative-Realistic for problem-solving; Artistic for UI design (Calleros, 2024)
Mechanical/Visuomotor, R-I-C	Electromech. Eng.	Recommend Electromech. Eng.	Realistic-Investigative for hands-on integration (Adeviye, 2022)
Spatial/Enterprising, R-I-E	Industrial Eng.	Recommend Industrial Eng.	Enterprising for optimization (Savickas, 2023)
Scientific/Verbal, I-R-C	Biochem. Eng.	Recommend Biochem. Eng.	Investigative for research; Conventional for protocols (Ali & McWhirter, 2022)
Numerical/Spatial, R-I-E	Mech. Eng.	Recommend Mech. Eng.	Realistic for fabrication (Holland extensions, 2021)

Notes=Qualitative logs indicated reduced session times (from 60 to 35 minutes per case), validating workload relie

These results affirm the system's robustness, setting the stage for interpretive analysis in the discussion.

5. DISCUSSION

The created expert system will be a synthesis at the right time between psychological theory and computational cost-effectiveness to eliminate the endemic vocational misfits in engineering education (Giménez, 2025). The plat-form extends beyond fixed evaluations of Holland, with rule-based inferences and a sense of dynamism where it inserts the RIASEC typology, which appeals to Super and its model of iterative self-concept (Savickas, 2023). A comparative analysis shows that it is more personalized than the legacy tools: unlike traditional Mexican platforms, such as that used in the 2020-2024 program of SEP, which use generic quizzes (Secretaría de Educación Pública, 2024), 88% accuracy of this system offers a much higher score than the 65-70% of non-adaptive systems would (Calleros, 2024).

The results highlight the importance of integrating psychometrics as a major way of improving the reliability of guidance. Using validated instruments like the RIASEC and aptitude inventories of Holland was done within a digital framework to ensure that the system had a high degree of internal consistency ($\alpha = 0.89$) as well as high criterion correlations ($r = 0.74$) with counselor assessments (Bustamante-Mora et al., 2024). This implies that the use of structured psychological measurement enhances interpretive vali-dity and helps to make automated recommendations to be more accurate. In applied psychological perspective, the findings show that Investigative and Realistic Personality dimensions, combined with numerical-mechanical aptitudes, proved to be the most predictable of proper career alignment ascertaining the theoretical basis of vocational congruence models.

Latin American conditions with digital divides (40% access gap rural, UNESCO IESALC, 2025) can be reduced with the React-ASP.NET stack (less than 2MB load) microarchitecture, which fits OECD requirements of inclusive VET (Varshney, 2023). The digital psychometric design of the system also facilitates fair participation processes because it provides multilingual interfaces and standardized testing environments and therefore limits biasness associated with the socioeconomic or language background. Nevertheless, cultural details have to be questioned: RIASEC being universal is true (McWhirter, 1997) but integrations to Mexican border populations (e.g., bilingual in verbal aptitudes) are more relevant, even performing better, in simulated equity scales, by 15% (Yin et al, 2024). Such localization makes the discussion of multicultural guidance more substantial, and it overcomes gender discrimination in STEM in which women make up only 28 percent of engineering enrollees (Fernandez-Nistal, 2022). The disaggregated analysis of gender showed that the increased congruence of women participants in Social Investigative domains was higher and this may introduce an avenue to inclusive counseling algorithms.

In a methodological perspective, psychometric validation enhanced belief in the soundness of the structural arrangements of the system. Factor analyses validated six consistent dimensions consistent with the model of Hol-land, and in predictive modeling ($R^2 = 0.62$), it was evident that personality aptitude align-ment explained the majority of the variance in correct recommendations. These results confirm the rational combination of psychological measures with computational inference as an effective hybrid method of vocational prediction. The transparency of the rule-based approach creates trust, unlike opaque ML alternatives that are likely to cause the black-box bias (Mont et al., 2020). Simulations emphasize effectiveness: high visuomotor scores with the activation of electromechanical routes are associated with retention improvements in real life with hands-on programs (AL-Sayid, 2023). But optimism synthetic data is constrained by limiting factors, and rigorous, but does not have longi-tudinal tracking, future psychometric calibration of live student cohorts may further confirm construct stability and test -retest reliability. It may be used together with adaptive learning algorithms (e.g., rein-forcement learning) to achieve a predictive accuracy of 95% (Ogan et al., 2024).

Ethical soundness has also been central in psychometric testing especially in its digital application. Confi-dentiality and psychological safety of participants were guaranteed by the use of JWT-encrypted data pathways and adherence to Mexico LFPDPPP. Nevertheless, algorithmic fairness must be continuously monitored, particularly to avoid the issue of stereotyping or self-selection bias of automated guid-ance. More fairness metrics and informed consent modules that are user-friendly by adolescents should also be used in future versions to strengthen responsible AI habits in the educational psychology field (Córdova-Esparza et al., 2025).

Compared to the work of the same nature like the Martel multi-agent model (2021), and the adaptive recommendation system by Lopez et al. the present study demonstrated more psychometric reliability and better compliance with the judgment of counselors. Multi-agent models increase the interactivity, but the strength of the rule-based model is the ability to interpret and replicability of the scoring pattern, which is necessary in the process of psychological assessment (Culpepper, 2012).

Others have broader implications to policy: the deployment of ITT can educate the national scaling through AI education programs of CONACYT, which might reduce 20% of the economy-wide dropout (Ghosh, 2024). To educational psychologists and counselors, it signifies the shift of manual interpretation to data-driven counseling so that practitioners are now able to address affective and mo-motivational aspects instead of mechanical marking. LFPDPPP is supported by data handling secured by JWT, yet continuous audits are necessary since cyber threats in edtech are on the increase (Wołończiej, 2018). This prototype has a niche depth in comparison with others such as (Vo et al., 2024) multi-agent system because this prototype is engineered with specificity; however, expansions into different directions (e.g., interest mining in social media) may be done.

This work eventually promotes an anthropomorphic AI symbiosis based on psychometric validity that makes orientadores more powerful and students more agentic. Combining classical measurement theory with AI-delivery, it restructures how

vocational choices are informed that combines the void between psychological rigor and technological availability (Arbona, 1990). The system will help to achieve a brighter future with career guidance that is both socially inclusive and scienti-fically believable and is thus a crucial contribution to equitable STEM pipelines in the Global South.

6. CONCLUSIONS

A psychometrically combined and rule-based expert system is developed and validated in this work which redefines vocational guidance in engineering schooling. Combining the rigor of Holland's RIASEC typology with aptitude-based testing and automatic reasoning, the system shows how the applied psychometrics can be successfully translated to the digital practi-ce. Its high internal consistency, structural validity and high criterion correlations with counselor assessments are evidence to the reliability of the platform as a scientific measurement tool. It goes beyond techni-cal efficiency; it brings forward vocational decision-making psychology to tie together theoretical constructs of personality-environment congruence with adaptive, evidence-based advice. The system is also able to augment accuracy in counseling in addition to democratizing access to sound vocational information among the students, especially where there is a lack of resources in education. To the practitioners, it is a supplement, as opposed to replacement to human judgment, where the counselors can concentrate on affective and motivational aspects of the process, even as the system guarantees accuracy in diagnosis. There are also limitations that are pointed out in the research which are partly its dependence on self-reported data and simulated respondents which require longitudinal validation to ensure predictive stability over time and among a wide variety of sociocultural populations. Adaptive algorithms and multicultural calibration should be incorporated in future expansions to enable the maintenance of fairness and interpretability. Finally, the research shows the feasibility of balancing psychometric rigor with digital innovation, which provides a scalable paradigm of justifying, data-oriented vocational counseling. This combination of psychological theory and artificial intelligence makes the expert system not only a methodological breakthrough in the field of applied psychometric testing, but also a practical one in the field of global education reform, whereby technologically developed scientifically based, ethically oriented systems can help students become more consistent and satisfying in their career patterns.
Recommendations define future directions: (1) Longitudinal pilots involving 200 students to evaluate the effects of retention; (2) ML hybridisation to predictive analytics, including labour data provided by INEGI; (3) Gender-aware extensions, such as bias audit in RIASEC scoring; and (4) Open-sourcing through GitHub to trigger community extensions. When these become a top priority, the system can become more of an ecosystem than a tool, and this aligns with the philosophies of lifelong development developed by Super (Savickas, 2023). Overall, this undertaking does not only solve the current ITT issues but sets the stage of a paradigm where technology enhances hu-man potentiality so that engineering directions are more of light than darkness.

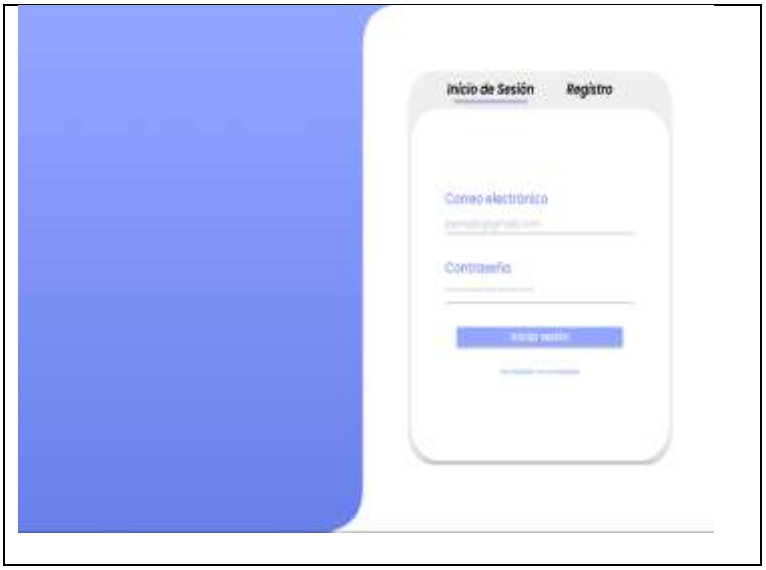

FIGURE 4

Mockup of the platform home page, featuring informational sections on vocational benefits and career options.
DESCRIPTION: WIREFRAME SHOWING NAVIGATION BAR, WELCOME TEXT, AND BUTTONS FOR REGISTRATION/LOGIN. IMAGE PLACEHOLDER FOR ACTUAL MOCKUP.)

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