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Developing an instrument to measure students' technopreneurship skill levels in starting new businesses using the rasch model

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Abstract

The rapidly evolving digital economy and Industry 4.0 have heightened the demand for graduates equipped with technopreneurship skills, which combine entrepreneurial capabilities with technological innovation. Although entrepreneurship programs are widespread within higher education institutions, there are few well-established tools available to accurately measure students' specific knowledge types. This study addresses this gap by developing and validating an instrument designed to assess the technopreneurship skills of university students, focusing on dimensions such as opportunity recognition, digital competence, innovation, risk management, and leadership. A research and development (R&D) model was employed to create the instrument, based on the McMillan and Schumacher framework. The study involved 207 undergraduate students from two universities in Gorontalo, Indonesia. A structured Likert-scale questionnaire was designed and finalized through expert validity judgment, followed by validation using Rasch Model analysis. The results demonstrated strong psychometric properties, including a person reliability of 0.87, item reliability of 0.80, a person separation index of 2.56, and an item separation index of 2.02. INFIT and OUTFIT statistics approached 1.00, indicating that the model conformed well to student responses without significant deviations, and no problematic misfitting items were identified. The findings validate the instrument's reliability and effectiveness in categorizing students into distinct ability groups. This research contributes to the existing body of knowledge by moving beyond perception-based assessments to a formal, empirically grounded method for evaluating technopreneurship competence. Such tools are essential for accurately measuring and fostering entrepreneurial skills in the context of technological advancements, ultimately supporting the development of a workforce capable of thriving in the digital economy.

Keywords: Higher Education, Indonesia, Rasch Model, Students' Skill, Technology in Business, Technopreneurship.

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1. Introduction

The rapidly changing global economy in the digital age has changed the skill set needed for future graduates to succeed in an increasingly competitive job market [1, 2]. The face of higher education needs to change to replace the authoring of critical, autonomous thinkers with an entrepreneurial spirit and digital business skills. This is increasingly the case in Indonesia. As evidenced by data from the Central Bureau of Statistics [3], unemployment among university graduates in the country is still relatively high, accounting for 5.25% of the labour force. Meanwhile, over 70 percent of startups fail within their first three years primarily due to a lack of digital and business skills. These facts underpin the necessity for an organised strategy to educate students with technopreneurship capabilities [4] that are sturdily required in the era of the Fourth Industrial Revolution.

Confronting this challenge, higher education institutions in Indonesia have introduced and implemented several curricular and extracurricular programs to promote entrepreneurship [5, 6], such as lessons on entrepreneurship, business incubators, internships with companies, and technopreneurship training [7]. The objective of such programmes is to direct the mindset of students from job seekers to job creators who can set up businesses based on technology [8]. The fusion of entrepreneurial attitude with technical innovation, known as technopreneurship, has become an essential economic growth and sustainability factor in the 21st century. However, as these programs grow, comparing the viability of such programmes without measurement instruments that can measure students' technopreneurship competencies remains challenging.

Although previous research has pointed out the advantages of taking entrepreneurship education in that it promotes entrepreneurial mindsets, increases business planning skills and leads to more innovative citizens [9-11]. There has also been research on strategic models of fostering entrepreneurial interest, the importance of leadership in successful technopreneurship, and how digital enablers contribute to entrepreneurial ecosystems [12]. However, most of these research studies have either concentrated on developing a learning material and analysing perceptions and interests or examining the factors that induce leadership. Few researchers have endeavoured to develop standardised, validated, reliable instruments to measure the quantitative level of specific competencies related to technopreneurship among university students even further. This is a serious gap, because the lack of sound measuring instruments deprives universities and policymakers of the means to track learning outcomes, assess programs' effectiveness, and make evidence-based recommendations for curricular development [13]. For instance, in the case of textbooks and training materials developed to promote entrepreneurial autonomy and digital readiness, such interventions typically do not provide concrete evidence of skill acquisition. In addition, the current methods of measuring are often based on self-reports, which could fail to capture a comprehensive perspective of technopreneurship skills, including opportunity recognition, digital skills, innovation, risk assumption and leadership.

The current study attempts to fill this gap; it suggests constructing a scale to assess university technopreneurship skills when starting new businesses. Utilising McMillan and Schumacher's [14] model for instrument development and conducting analysis focusing on the Rasch Model, this study aims to develop a valid and reliable multi-dimensional scale for technopreneurship. Unlike previous studies, which have concentrated mainly on interest and perception, this research fills a gap in the literature by explicating technopreneurship skills as concrete constructs that can be measured empirically in various higher education contexts [15, 16]. The proposed study makes two contributions. First, it is a methodological contribution integrating the quantitative (psychometric Rasch Model validation) and qualitative analysis (unwrapping coding with NVivo) [17]. This combination metric statistical contextualness is responsible for measuring the instrument's psychometric reliability, stability, and modularity, enabling it to adapt. Second, from a practical point of view, the study provides implications for universities and policymakers by developing a model that can be replicated and scaled up to serve as a possible national benchmark for evaluating technopreneurship competencies among students. Such an instrument would be extremely valuable for assessing and developing entrepreneurship teaching materials [16, 18], especially those related to national innovation and digital economy strategy.

Overall, this research contributes to the entrepreneurship and higher education conversation by extending beyond program implementation and perception-based evaluations through developing a scientifically sound assessment tool of technopreneurship skills [19-21]. In doing so, it contributes to addressing the crucial need for instruments that adequately assess university students' readiness to engage in technology-based entrepreneurship [22-24]. This research, ultimately, is anticipated to influence curriculum development, improve program accountability and sustain this lens of higher education that can help raise tomorrow's technopreneurs as engines of economic revitalisation at home and beyond.

2. Literature Reviews

2.1. Technopreneurship Skill among University Students

Technopreneurship gained a paramount place in education [25, 26], especially with the rise of the digital economy and Industry 4.0, combining entrepreneurship and technological advancement. For academics, techno-entrepreneurship capabilities are seen as essential for improving graduates' employability and promoting self-reliance and innovation in establishing new businesses [27]. These competencies cover cross-cutting skills such as: the identification of opportunities; digital literacy, management of innovation; and readiness to deal with technological change. Mentioned interest in technopreneurship has been identified as pervasive; some world-class universities have integrated technopreneurship elements into their curriculum, such as entrepreneurship course modules, incubation programs and practical experience. Different studies have emphasised that entrepreneurship education gives students basic knowledge of how to manage a business and start a new business. However, what sets technopreneurship apart is its significant dependence on technical skills [28, 29]. For example, the possibility of embedding digital tool-packages, or utilising e-commerce platforms and modern technologies such as artificial intelligence (AI) or blockchain in business models differentiates technopreneurs from classic entrepreneurs. Therefore, the literature argues that students should learn business skills and develop digital and technical competencies as key drivers of entrepreneurial achievement.

Aside from digital skills, innovation is often emphasised as one of the central aspects in technopreneurship competencies, concerning “multimedia authoring knowledge and abilities [30]. The innovation in focus is the ability to realise technological ideas into products, services or processes that markets are willing to pay for. Studies have shown that innovative students are more likely to found scaleups and be successful in turbulent business environments. To this end, the universities have been promoting innovation through project-based learning, hackathons and collaborations with tech-oriented businesses as a way for academic material to be matched up with entrepreneurial practice in real life [31]. Furthermore, risk-taking skills and resilience are also found to be essential parts of technopreneurship skills. Technology ventures usually entail a great deal of uncertainty, so students have to develop the analytical skills necessary for appraising risk and the strategic decision-making abilities needed to minimise it. Research indicates that resilience plays a vital role in young entrepreneurs, as it involves the capacity to recover from business failures, because early failures are endemic in entrepreneurs’ science parks. Therefore, incorporating risk management training into entrepreneurship programs is a strategic intervention to equip students with the required knowledge and skills in technopreneurship.

Both leadership and teamwork are also other capabilities that support the successful technopreneurship. Students at universities involved in technology ventures as part of their degree work together in teams that must integrate across different disciplines – whether it be programming, marketing or finance [32]. Good leadership allows us to consolidate these two roles and cooperate to achieve our common goal. Studies within the tertiary education domain suggest that a practical leadership skill can strengthen the other technopreneurship competencies, since it can motivate team members, handle conflicts and navigate ventures through turbulent periods [28-30]. While the significance of technopreneurship competencies in an academic setting is gaining recognition, assessment methods/social routines are underdeveloped, as supported by the literature. Much research is about designing training or measuring students' attitudes and intentions to train, not skill acquisition. Therefore, there is an absence of consistency in the tools to assess the degree to which students have developed foundational technopreneurship competencies [33]. This void in the literature hinders efforts to maximise program effectiveness across institutions and as a foundation for empirically based pedagogical improvements in teaching and course design.

Recent developments indicate a rise in the development of frameworks and instruments to measure technoprenuership skills among university students. While a few papers suggested various competency models like entrepreneurship knowledge in combination with digital and leadership skills, a few others also vet mixed methodological tools to encompass both qualitative and quantitative aspects of skill development [33-35]. Yet these initiatives are piecemeal, and there is no agreement on a properly validated, reliable instrument for HE. This delimitation highlights the necessity for further investigation that clearly defines technopreneurship competencies and establishes them as constructs that can be empirically captured, allowing universities to systematically assess and improve student readiness for technology entrepreneurship.

2.2. Rasch Model in Business Contexts

The Rasch Model has emerged as a valuable model for the construction and validation of measures in both educational and business research [36, 37]. Initially developed in psychometrics, IRT offer a conceptual model for examining the relationship between latent traits and observable responses by which instruments are used to measure constructs consistently or dependably. The Rasch Model has been used in business and entrepreneurship education to measure competence, leadership qualities, entrepreneurial orientations and employability skills. Its value is in converting ordinal survey data into interval scales that can be used for more precise comparisons and stronger statistical analysis. A significant advantage of the Rasch Model is that it allows for assessing performance at the individual item level, helping determine whether specific items are too easy, too complex or misfitting compared to the measured broader latent trait [38]. This is particularly important in entrepreneurial education as the student skill level can vary significantly from one context to another, as well as by discipline and exposure to entrepreneurial training. Through the form of Rasch analysis, enhanced instruments can be developed that adequately measure student ability across specific testing demands.

The Rasch measurement model has been applied in business and management to assess leadership competence, teamwork ability, and entrepreneurial intention [36]. Instruments developed within the Rasch model (RM) have demonstrated improved accuracy in evaluating leadership by differentiating between knowledge at a superficial versus a deeper level of

behavioural competencies, for example. Likewise, entrepreneurial orientation and innovation readiness have been reflected in Rasch-calibrated instruments for higher education to measure change with more reliability than generic survey tools [39].

Cross-context comparability is a further significant contribution of the Rasch Model for business application [40]. As the model generates sample- or item-independent measures, validated instruments can be reused across cultures or institutions without sacrificing psychometric integrity. This is especially crucial for entrepreneurship and technopreneurship studies since standardisation is hard to achieve due to the diversity of context [41]. Using Rasch analysis, tools developed at a single centre can be comfortably modified and used elsewhere within PC settings, thus increasing the generalizability of the outcome. Rasch analysis has also been combined with qualitative business and management education research methodologies. A more complete picture of the measured construct is obtained by integrating qualitative interviews, focus groups or case studies with the Rasch results. This mixed-method design is more advantageous in understanding complex, multi-dimensional constructs like technopreneurship skills, encompassing cognitive, behavioural and attitudinal aspects. This integration not only contributes to the validity of the test but also increases its interpretative power, which is in line with the call for a comprehensive assessment of students' ability. Despite its increasing popularity, the literature has shown that Rasch uses in business are still less frequent than in psychology and education [42, 43]. Even in entrepreneurship, most studies use old-school factor analysis and regression models that do not necessarily control for measurement invariance and/or item-level misfit. This dependence restricts the fidelity of skill assessment and hinders the creation of strong, generalizable tools. In sum, there is a pressing need for increased usage of Rasch-based approaches in research into entrepreneurship and technopreneurship, such as in higher education settings where measurements of skills are essential.

In this aspect, the current study further contributes in exploiting the advantages of the Rasch Model used to develop a technopreneurship skills instrument for university students. In so doing, it takes the Rasch analysis approach further from that used to measure leadership and generic entrepreneurship constructs into an area relatively specific to technopreneurship. The study also creates new methodological knowledge by synthesising Rasch analyses with qualitative validation to qualify the instrument's statistical reliability and contextual validity. This will not only help fill some existing measurement gaps but may also be a stride toward developing a standardised measure for evaluating technopreneurship skills in different educational contexts.

3. Research Method

3.1. Data Collection

Systematic and structured procedures were used for data gathering in the present study; thus, reliability and validity were guaranteed at all levels of the investigation. We selected undergraduate students as the primary target group, focusing particularly on university technopreneurship/ entrepreneurship internship participants. A total of 207 students were recruited as the main sample in the first testing phase, and were taken from Universitas Bina Mandiri Gorontalo (UBMG) and Universitas Negeri Gorontalo (UNG). Sampling allowed through this also brought diverse representation in the form of academic background, gender and extent of previous entrepreneurship experience. The instrument development and data collection followed the McMillan, et al. [44] model of orderly instrument construction. The conceptual dimensions of technopreneurship skills were initially determined through a review of related literature, expert interviews and initial field observation. These dimensions were opportunity recognition, digital literacy, innovation, risk management and leadership. A preliminary item pool was generated based on these dimensions, and experts (academicians, entrepreneurship practitioners and policy makers) reviewed them.

After the draft tool was prepared, it was delivered as a structured questionnaire through an administered Likert scale (4–5 points), illustrating varying levels of agreement or frequency. The measurement device was disseminated electronically and in hardcopy format to enable a diverse participation rate, making responding easy to attend. The response was strong because the survey was embedded in ongoing entrepreneurship internships, so students were encouraged to take it seriously. To increase the validity of answers, clear instructions were presented at the opening of the questionnaire, and participants were notified that their responses would be treated confidentially and anonymously. This reduced the probability of social desirability bias and promoted truthful self-reporting. Research assistants were also trained to help participants clarify any vagueness during the data collection process, so that all respondents could interpret items similarly.

In addition to the questionnaire, additional qualitative data were collected through informal interviews and observations. These offered qualitative resonance to student experiences of entrepreneurship programs and contributed to the interpretation of quantitative findings. Despite seeking Rasch-based psychometric validation in the current phase, including qualitative data meant that results were based on the realities of students# lived experiences.

The data collection was thoughtfully constructed to reflect a blend of methodological integrity and real-world applications, yielding a rich dataset with 207 students' contributions. This sample was used as the dataset to perform Rasch analysis and examine the scale's psychometric properties.

3.2. Data Analysis

Data were analysed using the Rasch Model and assisted by Winsteps software (version 4.7.0). We chose this analytical framework because it enables a strong approach to test the validity of self-report measures, especially in educational and behavioural studies. What sets the Rasch Model apart from traditional factor analysis approaches, instrument development is that items and people are tested together, so we can tell whether the test works well across various ability levels. The analysis was initiated by scaling items and participants to produce logit measures. The person measures represented the stature of students in essential skills, and the item measures indicated the difficulty level for each instrument. This combination of

calibrations produced a person-item map (or "Wright Map") that visually represented how well individual student skill levels corresponded with item difficulties.

Reliability estimates were subsequently calculated, including person reliability (0.87) and item reliability (0.80). Added to these scales, separation statistics (person 2.56; item 2.02) were obtained, giving evidence of the instrument's ability to distinguish among multiple ability levels and item challenge strengths. These figures verified that the instrument could differentiate students at different technopreneurship skills levels as hypothesised. Fit statistics were also considered, including INFIT and OUTFIT Mean Squares (MNSQ). The means (approximately 1.00–1.01) were within an acceptable range (0.7–1.3 for most educational uses), suggesting that student responses matched model expectations. Standardised Z-values (ZSTD) were also acceptable and revealed no marked divergence from the Rasch assumptions. These findings demonstrated the psychometric stability and construct validity of both items and responses.

More diagnostics were conducted to find the misfitting items or extreme responses. Nevertheless, without material misfit, all items are considered to provide meaningful contributions to constructing technopreneurship skills—this enhanced confidence in the integrity and validity of the tool. Lastly, qualitative interpretation was used to supplement the Rasch results and interpret statistical findings further. Specifically, changes in item difficulty were analysed concerning student evaluative comments and the context (e.g. previous exposure to entrepreneurship). This mixed-method orientation of the study enabled it to validate the instrument statistically and ensure that the captured constructs were meaningful and applicable in practical educational contexts.

4. Findings

The following sub-sections present the findings of the Rasch Model analysis as shown in Figure 1.

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 Calculating Fit Statistics
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Time for estimation: 0:0:0.450
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Data Mentah Untuk Di Olah.xlsx
-------------------------------------------------------------------------------
| PERSON     207 INPUT     207 MEASURED              INFIT        OUTFIT   |
|          TOTAL     COUNT     MEASURE  REALSE     IMNSQ   ZSTD  OMNSQ   ZSTD|
| MEAN      44.8      14.0        3.17     .74      1.00    -.3   1.01    -.3|
| P.SD       7.6        .0        2.35     .42       .66    2.1    .67    2.0|
| REAL RMSE    .86 TRUE SD    2.19  SEPARATION  2.56  PERSON RELIABILITY  .87|
|-----------------------------------------------------------------------------|
| ITEM      14 INPUT      14 MEASURED               INFIT        OUTFIT   |
|          TOTAL     COUNT     MEASURE  REALSE     IMNSQ   ZSTD  OMNSQ   ZSTD|
| MEAN     662.7     207.0         .00     .15      1.00    -.3   1.01    -.2|
| P.SD      16.3        .0         .35     .01       .31    2.7    .38    2.9|
| REAL RMSE    .15 TRUE SD     .31  SEPARATION  2.02  ITEM   RELIABILITY  .80|
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CODES= 1234
Measures constructed: use "Diagnosis" and "Output Tables" menus
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Figure 1.
Findings from the Rasch Model analysis.

4.1. Reliability and Validity of the Instrument

The reliability statistics from the Rasch analysis show that the developed instrument has the strength to support it. The Person Reliability score was 0.87, which is a high value in psychometric research and indicates that the instrument reliably differentiates between students with low and high technopreneurship competencies. This stability represents the aptitude of the instrument to generate invariant results across samples of students. Furthermore, the item reliability value of 80shows that test items vary in a broad range of difficulty levels to capture technopreneurship competencies.

These results prove that the instrument does not just measure at a low band of student skills, but reflects a continuum from basic to advanced levels. For instance, students with less exposure to entrepreneurial programs will find certain items challenging, while the more experienced ones may find it more manageable. Thus, the range of item difficulty spreads so that they do not favour or penalise any groups of students. Moreover, validity is additionally affirmed in the agreement of the statistical results of the tool with the assumptions of the Rasch Model. The near-perfect INFIT and OUTFIT values indicate that the instrument functions according to the theory, enhancing its construct validity. The tool performs what it was designed to accomplish: technopreneurship competencies.

The consistency and validity results combine to give assurance that the instrument is both valid and fair, which can, in turn, help universities make decisions when determining student technopreneurship support and evaluation. This is an essential result for educators who want students to learn the competencies required by a technology-dependent society.

4.2. Separation Indices and Skill Differentiation

The person separation index of 2.56 indicates that the tool can discriminate students into at least three ability levels (poor, average, excellent). This is important, however, because it allows for a more generalised evaluation format, such as the answering scheme instead of a fundamental one-size-fits-all benchmark. For instance, program evaluators will be able to differentiate students who require an intense firm spirit from those at the entrepreneurial level I. This finding is supported by

a high item separation index of 2.02, which indicates that the responses of the items are spread over different difficulty levels of QuickScreen. This means the test is not all clumped around one difficulty level, but ranges along a spectrum to suit both beginners and more advanced students. It avoids ceiling effects (items too easy for most students) and floor effects (too difficult for most students).

These separation measures suggest the instrument is sensitive and can discriminate between discriminants. It is sensitive enough to distinguish slight differences in student ability but discriminative enough to make these variants meaningful distinctions. This distinction is not only theoretical but also has an applied message. Universities can implement specific measures for each group: remedial programs for low-skill students, enrichment activities to broaden the capabilities of medium-level-school graduates, and advanced incubator programs reserved for high-level students. Via addresses these concerns and makes entrepreneurship education programs more effective by being bespoke.

4.3. Model Fit and Consistency of Responses

Rasch analysis yielded INFIT and OUTFIT Mean Squares (MNSQ) of approximately 1.00, which is adequate. These values indicate that student responses were strongly connected to what is expected from the model, which suggests that the data is consistent. There are no random fluctuations or anomalies. This degree of fit is sufficient for the instrument functions to be employed in a sample of 207 students. An appropriate range of ZSTD values for your responses was also presented – proof that random never went crazy or biased while processing the words. This indicates that students interpreted the items as intended and responded without excessive guessing or disengagement.

Another key indicator of quality is the lack of ill-fitting paraphernalia. Mal-fitting items risk undermining an instrument's validity because they are tapping unintended constructs or unduly challenging respondents. As no such items are missing, the instrument is consistent and well-organised.

This excellent model fit implies confidence in the findings obtained from the instrument. For higher education institutions, this would help ensure that student assessment outcomes can be used as an early and credible indicator for program evaluation, curricular revision, and student support.

4.4. Achievements of the Research Objective

Developing a valid and reliable research instrument for measuring technopreneurship skills was one of the significant purposes of this study. The Calibration of the RIPS. This criterion has been fulfilled (see Rasch analysis). 3. The process, comprised of instrument development, expert validation, pilot test and data analysis, was guided by the model set out by McMillan & Schumacher to ensure methodological quality. The empirical confirmation of the instrument, in a sample of 207 students as respondents, certainly demonstrates its fair capability in actual use. Not prevalent Soundness. We believe that this dataset proves the soundness of the tool and also its usefulness. Results indicate that the instrument is poised to be further used within higher education institutions.

Achieving these aims also corresponds to the study's proposed outcomes in its research proposal. The newly developed validated measure will be a key step in accomplishing the planned international publication and evaluating the instrument's effectiveness in 2026. This demonstration of success provides the momentum for the next level in the research roadmap – large-scale use and optimisation/development. Thus, it makes the study relevant to academic literature and practical education policy in entrepreneurship.

4.5. Practical Implications for Higher Education

The validated instrument has immediate implications for higher education. By clustering students into skill groups, universities can more precisely target those who require what level of support. This supports providing learning processes and instruments that adapt more closely to each of them, to improve the effectiveness of entrepreneurship education.

This skill differentiation also has curriculum implications. Customised programs can be designed to fill those gaps in students' assessments, offering an ever more comprehensive coverage of levels of technopreneuring learning. For instance, students with low digital literacy could be directed to beginner workshops, and those with high innovation skills might be interested in startup incubators. In addition, the tool is reliable and can be applied as an assessment instrument. Universities could use it periodically to check in on student progress and whether entrepreneurship programs are working. Over time, this results in a feedback cycle as data drives the incremental refinement of pedagogy.

Finally, the device enhances higher education institutions' efforts to educate students for an economy dominated by technology. Offering credible proof of student competencies gives institutions the data they require to make wise decisions based on program design and resource allocation.

5. Discussions

The results of this study provide evidence that the developed instrument is valid and reliable in measuring technopreneurship skills among university students. The instrument demonstrates strong psychometric stability with a person reliability of 0.87 and an item reliability value of 0.80. These results show that the instrument can differentiate students at different levels of ability with reliability and assess multiple target competencies. This precision is essential in postsecondary education, where greater emphasis is placed on using empirically developed instruments for curriculum assessment and accreditation systems [4, 14]. One of this study's key contributions is mapping student skills across various dimensions of technopreneurship such as opportunity recognition, digital competence, innovation, risk management and leadership. Rasch analysis provided evidence that students could be classified into different ability groups using the instrument with greater

depth of understanding than conventional survey measures [36, 42]. This aligns with the broader educational move towards competency-based learning, whereby knowledge, practical and behavioural abilities evaluate results.

The fitness index also indicates the stability and reliability of this tool. INFIT and OUTFIT MNSQ values were close to 1.00, which suggests that the testing items worked as expected, and students answered the questions according to the grading criteria. This gives confidence that the instrument measures the technopreneurship skills construct, not any other constructs, such as guessing or test-taking strategies [4, 25, 26]. It also indicates that there are no outliers or misfit items, demonstrating the extent to which the tool is internally consistent and would raise optimistic expectations regarding its replicability in various educational settings. In addition to being statistically robust, the results have significant implications for higher education [4, 10]. The categorisation into low, medium, and high ability students enables the appropriate interventions to be devised. For example, this can include targeted intervention in digital literacy or innovation for students identified as being lower-skilled, as well as advanced mentorship or access to startup incubators for higher-level learners. This fits in nicely with the personalised learning wave, as education has become more geared to students' individual needs and career paths.

The research further addresses an urgent national and international need in the light of high graduate unemployment and the precariousness of new startups within their formative years. With the provision of a standardised and validated instrument, it is now possible for the universities to measure entrepreneurship's and technopreneurship's real impact as opposed to depending solely on self-reported perceptions or program outputs [4, 25, 34]. This evidence-based approach is essential in developing policies and practices that genuinely add value to students' employability and entrepreneurial performance.

From a methodological perspective, combining Rasch analysis with qualitative feedback makes an original contribution. While Rasch analysis can be stringent regarding statistics [36, 42], the qualitative data can elaborate upon some of the cultural and contextual circumstances that form student reactions. Such mixed methods guarantee the validity and reliability of the instrument and its relevance amidst a local context. Subsequently, further studies can take one step forward by combining interviews, focus group discussions and/or case studies systematically to enhance the picture of technopreneurship skills.

But the research has limitations. The dataset was only collected from 207 students in two universities in Gorontalo as a sample, which I believe is large enough for Rasch analysis. Still, it does not seem varied much compared to other Indonesian higher education contexts. Thus, the following research step shall aim for a larger, different target to check the generalisation of the tool. Moreover, the wide-ranging instrument may need to be extended further for contemporary competences such as sustainability entrepreneurship and digital global co-operation. In general, it adds both theoretically and practically by turning technopreneurship skills into operational constructs which can be measured and validated using machines with psychometric rigour. The framework moves the conversation beyond descriptive practices of entrepreneurship education and into an instrument that may be used to assess student competencies in a structured manner. The study lays the groundwork for further investigation, generation of curriculum and policy that will support higher education contributions in the preparation of technopreneurs who would drive innovation and economic development in the digital age [25, 29, 32, 34].

6. Conclusions

This research aimed to develop and validate an instrument for assessing technopreneurship skills among university students, filling a critical vacuum in entrepreneurship education. Due to the Rasch Model analysis, the instrument showed high reliability and validity (person reliability 87; item reliability 80). These findings provide evidence that the instrument can differentiate among different levels of students' abilities and tap into the multidimensionality of technopreneurship competencies. The examination also showed that students could be classified into separate ability levels by the instrument, person and item separation indices above 2.0. This imbues HEIs with a pragmatic tool to discern gradations of student preparedness, between those needing moderate assistance and those capable of preparing for heightened entrepreneurial challenges. The good model fit and lack of misfitting items confirm the stability and unidimensionality of the instrument, making it appropriate for replication in broader contexts.

Through operationalising technopreneurship skills as measurable constructs, this study goes beyond prior research that typically focused on perceptions, intentions, or interest in entrepreneurship. This instrument has been validated to facilitate a systematic and evidence-based assessment of educational programs, such that interventions are based on credible information regarding student performance. This contribution comes at an opportune time, with the high rates of failure for startups and graduate unemployment reflecting the need for focused entrepreneurship education. The instrument also has immediate implications for universities wanting to enhance the design of their programs, monitoring the effectiveness of their offerings and making student outcomes locally and globally stronger in innovative action and digital entrepreneurship. Its application in the higher education system likewise can aid institutions to recognise learning deficiencies, offer tailored support and groom a generation of students who are not only digitally literate but able to use technology for entrepreneurial achievement.

Future research should instead focus on large-scale implementation across varied higher education settings using concurrent qualitative methods to capture context-bound meanings. This will enhance the instrument's generalizability and its refinement. In the final analysis, this study makes a worthy contribution, enhancing entrepreneurship education by providing a valid and reliable measuring instrument for technopreneurship skills that can help support the greater cause of developing students as change agents in fostering innovation and economic development in an information age.

This study has created and validated an instrument that is valid and reliable for assessing technopreneurship skills, but there are also limitations that need to be considered. Firstly, the sample of empirical data in the amount of 207 students, though sufficient for Rasch analysis, was collected only from two universities in Gorontalo. Suppose the current findings can be generalised to Indonesian or other university contexts with curricular differences, institutional resources disparities, and student background variations. In that case, such a scope may not truly represent the diversity of higher education in Indonesia.

Another disadvantage is that the constructs measured were not comprehensive. The instrument includes essential factors of venture formation, such as opportunity recognition, digital competence, innovation, risk management, and leadership-related dimensions of technopreneurship. Still, it may not cover emerging aspects such as sustainability-oriented entrepreneurship, global digital collaboration or ethical attitudes for tech-driven ventures. These changing dimensions imply that the IST instrument needs to be kept up-to-date in a dynamic entrepreneurship environment. This instrument should be tested in various institutional and cultural contexts (in the more general sense, at the national and international level) to confirm its applicability. Mixed-method approaches will also be helpful, combining large-scale Rasch analysis with qualitative data from interviews, focus groups or longitudinal case studies. These efforts will enhance the instrument's reliability and allow a deeper, contextually grounded understanding of the process by which technopreneurship skills are acquired, sustained, and leveraged towards entrepreneurial success.

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