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# Students' Perceptions of JASP Use and Its Impact on Statistics Learning: A TAM-Based Study

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**a b s t r a c t**

This study aims to analyze the influence of students' perceptions regarding the use of the JASP application and its relationship to statistics learning outcomes through the Technology Acceptance Model (TAM) approach. The four main TAM constructs analyzed include perceived ease of use, perceived usefulness, attitude toward use, and behavioral intention to use. This research employed a quantitative associative method using simple and multiple linear regression analyses. The sample consisted of 90 fourth-semester PGSD UNM students who had completed a statistics course, selected through simple random sampling. The results indicate that three out of the four perception variables—perceived ease of use, perceived usefulness, and attitude toward use—significantly influenced students' learning outcomes, with attitude toward use emerging as the strongest predictor. In contrast, behavioral intention to use did not show a significant effect. The multiple regression model revealed that the four TAM constructs collectively explained 55.7% of the variance in learning outcomes. These findings affirm that students' positive perceptions of JASP have a tangible impact on academic achievement and support the effectiveness of the application as a learning tool for statistics in the PGSD context.

**Keywords:**
JASP, Learning Outcomes, Statistics, TAM, PGSD, Technology Perception

Open Access

## INTRODUCTION

Statistics plays a strategic role in elementary education as it supports the development of critical thinking, analytical skills, and data-driven decision-making abilities. In the elementary school mathematics curriculum, statistical material is taught to equip students with the ability to understand quantitative information encountered in daily life. Therefore, students in the Primary Teacher Education Program (PGSD) are required to have both conceptual and practical understanding of statistics, not only in academic contexts during their studies but also in professional practice as future teachers (Blomberg, 2025).

In practice, however, many PGSD students struggle to grasp and apply basic statistical concepts. At the PGSD Program of Universitas Negeri Makassar (UNM), for instance, the Statistics course is often perceived as challenging. Students face difficulties in understanding terms such as data distribution, measures of central tendency, and hypothesis testing. These challenges emerge not only during lectures but also when students are working on final projects or theses that involve quantitative data analysis. They often struggle with selecting appropriate analytical methods, using statistical software, and interpreting results in a logical and accurate manner.

Findings from various studies support this phenomenon. Gaviria-Bedoya et al. (2022) reported that although training can improve students' attitudes toward statistics, many still hold basic misconceptions and lack confidence when conducting statistical analysis. Similarly, Leavy et al. (2019) found that students' perceptions of statistics tend to be negative, particularly when they feel they lack a sufficient mathematical background. These perceptions often lead to increased anxiety and stress in learning statistics, ultimately affecting their academic performance.

Learning difficulties in statistics are further exacerbated by students' limited ability to use conventional statistical software such as SPSS. PGSD students generally lack the technical skills to operate such software, which tends to be complex and requires an understanding of syntax or special licensing. These technical barriers reduce students' active engagement in the data analysis process and indirectly contribute to lower academic achievement in statistics courses.

One promising approach to address these challenges is the use of practical and user-friendly educational technology. JASP (Jeffrey's Amazing Statistics Program) is an open-source statistical software developed with a simple and intuitive user interface. Unlike SPSS or R, which require knowledge of syntax and special licenses, JASP allows students to perform statistical analyses quickly and efficiently through a user-friendly point-and-click interface.

The use of JASP is particularly relevant in the context of statistics education for PGSD students, who typically lack a technical background in statistical software. With JASP, students can easily perform statistical tests such as linear regression, path analysis, and t-tests visually, and receive results in the form of tables and graphs that are easy to interpret (Li, 2021). Research conducted by Ghazali, Zohri, Lestari, Purnamasari, and Fitriati (2023) demonstrated that intensive training in using JASP can significantly transform students' statistical analysis skills. This highlights the important role of JASP in enhancing students' statistical literacy, especially for those without a strong background in data analysis.

Other studies have also supported the effectiveness of technology use in mathematics and statistics education. Subekti et al. (2017) demonstrated that the use of technology-based multimedia significantly enhances focus, motivation, and learning outcomes among PGSD students. Rosyidah (2020) found that information technology can serve as an effective medium for improving academic achievement by fostering creativity and learning efficiency. Similarly, Lumba (2012) emphasized that open-source technology, when used with the right approach, can act as a catalyst in developing students' learning creativity and technological competence.

However, the use of JASP in statistics learning within PGSD programs, particularly in Indonesia, remains relatively uncommon and unsystematic. At UNM's PGSD program, the main obstacle does not lie in access to the application, but rather in students' acceptance of using JASP. Students' perceptions of its ease of use, usefulness, and their attitudes toward the application play a crucial role in determining whether the technology will be meaningfully utilized in the learning process.

It is in this context that the Technology Acceptance Model (TAM) becomes relevant. Developed by Davis (1989), this model aims to explain the factors that influence users' acceptance of technology. TAM posits that two core constructs—perceived ease of use and perceived usefulness—directly affect attitude toward use and behavioral intention to use, which in turn influence actual user behavior in adopting technology.

Previous research has shown that TAM can be flexibly applied across various educational contexts. Sukackė (2019) emphasized that TAM can be extended and adapted with contextual variables to better understand technology adoption in education. In a study by Wati (2023), TAM was used to evaluate user perceptions of JASP as a data collection tool in surveys. The findings revealed that JASP was perceived as both easy to use and useful by respondents from diverse backgrounds. However, the study did not specifically explore the perceptions of PGSD students or how these perceptions impact learning outcomes.

Accordingly, this study occupies a strategic position in addressing two underexplored gaps: (1) the integration of JASP as a learning tool for statistics among PGSD students, and (2) the application of the TAM framework to evaluate students' perceptions of JASP and its relationship with their statistics learning outcomes. This research not only aims to explain the factors shaping students' perceptions of technology but also to examine the extent to which these perceptions affect academic performance, focusing on fourth-semester PGSD students at UNM in 2025.

## METHODS

This study employed a quantitative approach using an associative research design. The aim was to examine the influence of students' perceptions of using the JASP application on their learning outcomes in statistics. This approach was chosen because it allows for the measurement and analysis of relationships between variables numerically through statistical techniques.

The population of this study consisted of all fourth-semester students in the Primary Teacher Education Program (PGSD) at Universitas Negeri Makassar (UNM), specifically

those from the Makassar campus who had completed the Statistics course in 2025. The total population included 395 students.

The sampling technique used was simple random sampling, which provides equal opportunity for each member of the population to be selected as a sample. The sample size was determined using Slovin's formula with a margin of error (e) of 10%. Based on the calculation, a sample of 80 respondents was obtained (Nasir, 2016).

The research instrument was a student perception questionnaire regarding the use of JASP, developed based on the four core constructs of the Technology Acceptance Model (TAM): perceived ease of use, perceived usefulness, attitude toward use, and behavioral intention to use. Each indicator was presented as a statement measured using a five-point Likert scale, ranging from strongly disagree to strongly agree. In addition, students' learning outcomes were obtained from their final grades in the Statistics course.

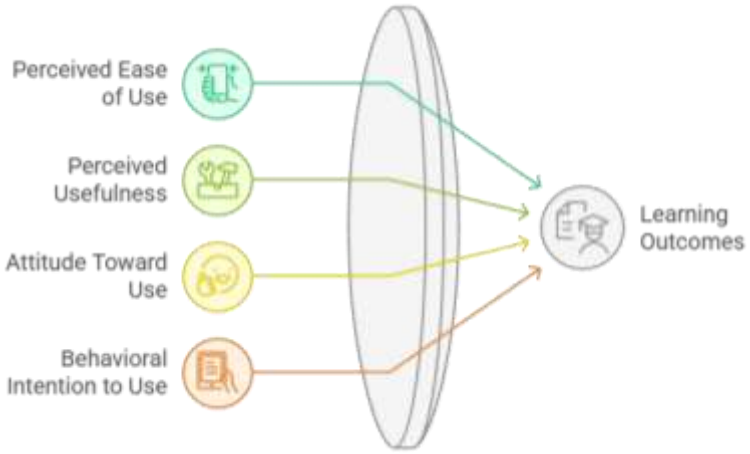


**Figure 1**
Conceptual Framework Based on the Technology Acceptance Model (TAM)

The data analysis technique used was linear regression analysis. First, simple linear regression analyses were conducted to examine the individual influence of each perception variable (ease of use, usefulness, attitude, and intention to use) on students' statistics learning outcomes. Subsequently, multiple linear regression analysis was performed to assess the simultaneous effect of all four perception variables on students' learning outcomes. All data processing and analysis were carried out with the assistance of statistical software.

## RESULT AND DISCUSSION

### Descriptive Statistics

Descriptive analysis was conducted to provide a general overview of students' perceptions regarding the use of the JASP application and their learning outcomes in the Statistics course. The analyzed variables consist of the four main constructs within the Technology Acceptance Model (TAM): perceived ease of use ($X_1$), perceived usefulness ($X_2$), attitude toward use ($X_3$), and behavioral intention to use ($X_4$), with statistics learning outcomes (Y) serving as the dependent variable. The descriptive statistics include minimum and maximum values, mean, standard deviation, and variance.

Table 1

Descriptive Statistics of Research Variables

| Variabel | N | Mean | Std. Deviation | Variance | Min | Max |
|---|---|---|---|---|---|---|
| Perceived Ease of Use ($X_1$) | 90 | 70,200 | 11,837 | 140,117 | 32,00 | 95,00 |
| Perceived Usefulness ($X_2$) | 90 | 75,222 | 15,240 | 232,265 | 30,00 | 97,00 |
| Attitude Toward Use ($X_3$) | 90 | 77,056 | 12,287 | 150,974 | 40,00 | 97,00 |
| Behavioral Intention to Use ($X_4$) | 90 | 78,389 | 14,397 | 207,274 | 30,00 | 98,00 |
| Statistics Learning Outcome (Y) | 90 | 79,567 | 9,332 | 87,078 | 41,25 | 99,00 |

Based on Table 1, the Statistics Learning Outcome (Y) variable had the highest mean score of 79,567, with a standard deviation of 9,332 and a maximum value of 99,00. This indicates that, in general, students' academic performance in the Statistics course was relatively high and evenly distributed. Among the perception variables, the highest average score was found in Behavioral Intention to Use ($X_4$) at 78,389, reflecting a strong student intention to use the JASP application. Conversely, Perceived Ease of Use ($X_1$) had the lowest average score of 70,200, although this still falls within a relatively high category, suggesting a generally positive perception of the application's ease of use.

In terms of data dispersion, Perceived Usefulness ($X_2$) and Behavioral Intention to Use ($X_4$) showed relatively higher variance and standard deviation compared to the other constructs, indicating more diverse student perceptions regarding the usefulness of JASP and their intention to use it. Meanwhile, Perceived Ease of Use ($X_1$) and Statistics Learning Outcome (Y) had lower variability, suggesting more homogeneous responses in these areas.

Overall, the descriptive analysis results indicate that students hold positive perceptions toward the use of JASP in learning statistics, in terms of ease of use, usefulness, attitude, and intention to use. This positive perception aligns with their generally high learning outcomes.

**Simple Linear Regression Analysis**

Simple linear regression analysis was conducted to determine the individual effects of each construct within the TAM framework—namely, perceived ease of use ($X_1$), perceived usefulness ($X_2$), attitude toward use ($X_3$), and behavioral intention to use ($X_4$)—on students' statistics learning outcomes (Y). The results of the analysis are presented in Table 2 below.

Table 2
Results of Simple Linear Regression between Perception Variables and Statistics Learning Outcomes

| Model | Independent Variable | R | $R^2$ | Adjusted $R^2$ | B | t | Sig. (p) |
|---|---|---|---|---|---|---|---|
| $M_1$ | Perceived Ease of Use ($X_1$) | 0,489 | 0,239 | 0,230 | 0,385 | 5,258 | < 0,001 |
| $M_2$ | Perceived Usefulness ($X_2$) | 0,579 | 0,336 | 0,328 | 0,355 | 6,666 | < 0,001 |
| $M_3$ | Attitude Toward Use ($X_3$) | 0,575 | 0,330 | 0,323 | 0,436 | 6,588 | < 0,001 |
| $M_4$ | Behavioral Intention to Use ($X_4$) | 0,078 | 0,006 | -0,005 | 0,050 | 0,732 | 0,466 |

Based on Table 2, three out of the four TAM constructs—perceived ease of use ($X_1$), perceived usefulness ($X_2$), and attitude toward use ($X_3$)—showed a significant influence on students' statistics learning outcomes, each with a significance value of $p < 0,001$. In

contrast, behavioral intention to use ($X_4$) did not demonstrate a significant effect, as indicated by a significance value of 0,466 ($p > 0,05$).

Among the four variables, perceived usefulness ($X_2$) had the largest individual contribution to learning outcomes, with a coefficient of determination ($R^2$) of 0,336. This means that approximately 33,6% of the variation in learning outcomes can be explained by students' perceptions of the usefulness of the JASP application. This suggests that the more students perceive JASP as beneficial, the more likely they are to achieve higher academic performance in statistics. This is followed by attitude toward use ($X_3$) with $R^2$ = 0,330, and perceived ease of use ($X_1$) with $R^2$ = 0,239, both of which also contribute significantly. These findings indicate that a positive attitude toward using JASP and the perception that it is easy to use are important factors in supporting student learning outcomes.

Meanwhile, behavioral intention to use ($X_4$)—although theoretically a key indicator within the TAM framework—did not show a statistically significant impact on learning outcomes. This may suggest that students' intention to use JASP has not yet been fully translated into actual behaviors that affect academic performance, or that this intention is influenced by external factors not captured within the scope of this model.

**Multiple Linear Regression Analysis**

After being analyzed individually through simple linear regression, the four constructs of the Technology Acceptance Model (TAM)—perceived ease of use ($X_1$), perceived usefulness ($X_2$), attitude toward use ($X_3$), and behavioral intention to use ($X_4$)—were then analyzed simultaneously in relation to students' statistics learning outcomes (Y) using multiple linear regression.

This multiple linear regression model was used to evaluate the collective contribution of the four perception variables in explaining the variance in students' academic performance. This analysis not only examines their combined influence but also allows for the assessment of the partial effects of each variable when controlled for the presence of the others within a single model.

This approach is crucial in ensuring both the theoretical and empirical validity of the TAM framework in the context of utilizing the JASP application in statistics education. By analyzing the simultaneous relationship between students' perceptions and learning outcomes, this study provides a more comprehensive understanding of how students' attitudes and perceptions toward technology support their academic success.

Before interpreting the regression results, preliminary testing of the classical assumptions of the model was conducted, particularly regarding residual normality and multicollinearity among the independent variables, to ensure the statistical validity of the model.

**Normality Test of Residuals**

The normality test was conducted using a Q-Q Plot of the standardized residuals. Figure 2 presents the visualization of the residual distribution in the multiple linear regression model.

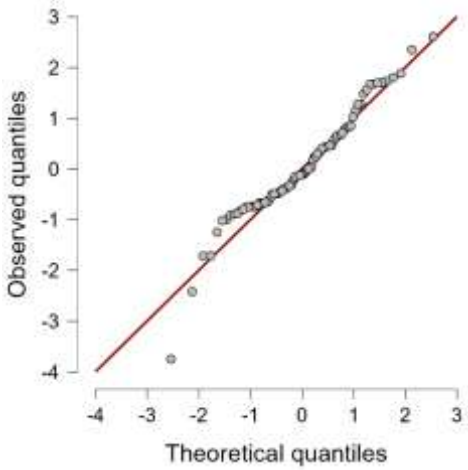


**Figure 2**
Q-Q Plot of Standardized Residuals

Based on Figure 2, most of the residual points lie on or near the diagonal line. Although there is slight deviation at the extremes, the overall distribution of the residuals shows a tendency toward normality. Therefore, it can be concluded that the assumption of residual normality is met, and the model is appropriate for further analysis.

**Multicollinearity Test**

Multicollinearity occurs when the independent variables in the model are highly correlated, which can lead to unstable coefficient estimations. To detect multicollinearity, the Condition Index and Variance Proportions were used as indicators, as shown in Table 3 below.

Table 3
Collinearity Diagnostics: Condition Index and Variance Proportions

| Dimension | Condition Index | Dominant Variance Proportion* |
|---|---|---|
| 1 | 1,000 | None |
| 2 | 10,250 | $X_4$ (0,928) |
| 3 | 13,412 | $X_1$ (0,757) |
| 4 | 14,774 | $X_2$ (0,842), $X_3$ (0,458) |

*Note: A variance proportion ≥ 0,5 for more than one variable in a dimension with a Condition Index >15 typically indicates serious multicollinearity (Hair et al., 2010).*

From Table 3, the highest Condition Index is 14,774, which remains below the critical threshold of 15. Although high variance proportions were observed for two variables ($X_2$ and $X_3$) in the fourth dimension, these do not exceed the general limit indicating severe multicollinearity. Therefore, it can be concluded that the indication of multicollinearity in the model is low and remains within an acceptable tolerance level.

**Multiple Linear Regression Results**

After confirming that the model meets the classical assumptions, the multiple linear regression analysis was interpreted. This model was used to examine the simultaneous effect of the four TAM constructs—perceived ease of use ($X_1$), perceived usefulness ($X_2$), attitude toward use ($X_3$), and behavioral intention to use ($X_4$)—on students' statistics learning outcomes (Y).

Table 4
Multiple Linear Regression Results for $X_1$, $X_2$, $X_3$, $X_4$ on Y

| Model | R | $R^2$ | Adjusted $R^2$ | RMSE | F | Sig. (p) |
|---|---|---|---|---|---|---|
| $M_1$ | 0,746 | 0,557 | 0,536 | 6,358 | 26,675 | < 0,001 |

Table 5
Regression Coefficients and Partial Significance Tests

| Independent Variable | B | Std. Error | β (Beta) | t | Sig. (p) |
|---|---|---|---|---|---|
| (Constant) | 21,241 | 6,666 | – | 3,186 | 0,002 |
| Perceived Ease of Use ($X_1$) | 0,244 | 0,062 | 0,310 | 3,910 | < ,001 |
| Perceived Usefulness ($X_2$) | 0,171 | 0,053 | 0,279 | 3,249 | 0,002 |
| Attitude Toward Use ($X_3$) | 0,313 | 0,060 | 0,412 | 5,197 | < ,001 |
| Behavioral Intention to Use ($X_4$) | 0,053 | 0,047 | 0,082 | 1,138 | 0,258 |

The results of the multiple linear regression analysis indicate that the four TAM constructs collectively explain 55.7% of the variance in students' statistics learning outcomes. This is reflected in the coefficient of determination ($R^2 = 0.557$) and the adjusted $R^2$ of 0.536. This suggests that over half of the variation in academic performance can be explained by students' perceptions of using the JASP application. The F-value of 26.675, with a significance level of $p < 0.001$, shows that the regression model is statistically significant and can reliably predict learning outcomes based on the four perception variables.

In the partial analysis, three out of four independent variables were found to have a significant effect on learning outcomes. The strongest predictor was attitude toward use ($X_3$), with a standardized beta coefficient (β) of 0.412 and $p < 0.001$. This suggests that the more positive students' attitudes are toward using JASP, the more likely they are to achieve better learning outcomes.

Next, perceived ease of use ($X_1$) also had a significant effect, with $\beta = 0.310$ and $p < 0.001$, indicating that students who perceive JASP as easy to use tend to perform better. Similarly, perceived usefulness ($X_2$) showed a significant influence, with $\beta = 0.279$ and $p = 0.002$, meaning that students who perceive JASP as useful are more likely to achieve better results.

Conversely, behavioral intention to use ($X_4$) did not show a statistically significant effect on learning outcomes. Its beta coefficient was 0.082 with a p-value of 0.258. Although students reported a high intention to use JASP, this intention did not appear to translate into improved academic performance when other perception variables were controlled for in the model.

Based on the unstandardized coefficients (B), the multiple linear regression equation for this study can be formulated as follows:

$$Y = 21{,}241 + 0{,}244X_1 + 0{,}171X_2 + 0{,}313X_3 + 0{,}053X_4 + \varepsilon$$

This equation shows that increases in variables $X_1$, $X_2$, and $X_3$ lead to significant increases in Y. In contrast, $X_4$'s contribution is not strong enough to serve as a determinant of learning outcomes within this model.

**Student Responses to the Use of JASP**

As a complement to the quantitative analysis, the researcher included an open-ended question in the questionnaire to gain deeper insights into students' responses regarding their experience with the JASP application. These responses reflect students' firsthand experiences, both in terms of the benefits and the challenges they encountered while using JASP in statistics learning.

In general, students gave positive feedback regarding the use of JASP. Most reported that JASP helped them understand statistical concepts more concretely and practically. They appreciated that JASP presents analysis results directly in the form of tables and graphs and does not require syntax commands like other statistical software. However, several students also expressed difficulties, such as trouble understanding English-language terms in the interface, lack of adequate technical guidance, and limited knowledge of the types of statistical tests available in the application. These responses provide important contextual information and reinforce the earlier quantitative findings, especially regarding the variables *perceived ease of use* and *attitude toward use*. A summary of students' responses is presented below:

Table 6
Summary of Student Feedback on the Use of JASP

| Perceived Benefits | Reported Challenges |
|---|---|
| "JASP really helped me with my thesis data analysis." — *Nova Oktavia* | "The English language in JASP's interface confuses me." — *Amirah* |
| "It's easier than SPSS, no syntax needed." — *Nadela* | "There's no complete guide in Indonesian yet." — *Wahdaniyah* |
| "I understand test types better because the interface is clear." — *Siisliya* | "I still don't know when to use which test—it wasn't explained in class." — *Nur Azizah* |
| "I could self-learn just by exploring JASP's menu." — *Adinda* | "I had some trouble installing it on my laptop." — *Fitriani* |

These responses enrich the understanding of the regression analysis results, which showed that students' positive perceptions of JASP's usability and usefulness significantly impact their learning outcomes. Nonetheless, several concerns related to technical challenges and the need for further training also highlight the importance of providing guidance and support to optimize the use of JASP in PGSD learning environments.

**Discussion**

The findings of this study confirm that three out of four constructs within the Technology Acceptance Model (TAM)—namely *perceived ease of use*, *perceived usefulness*, and *attitude toward use*—significantly influence the statistics learning outcomes of PGSD UNM students. These results align with the core assumptions of TAM, which posit that users' perceptions of the ease and usefulness of a technology play a crucial role in shaping their attitudes and behaviors toward adopting that technology (Davis, 1989; Sukackė, 2019). In this context, the JASP application, used as a learning tool, received positive responses from students—both descriptively and analytically—and contributed to relatively high academic performance.

First, *perceived usefulness* was found to be the strongest contributor to learning outcomes. Students who viewed JASP as a beneficial tool tended to achieve better academic performance. This supports prior research showing that perceived usefulness of a technology directly impacts learning performance, especially when students can relate its application to their academic success (Alnagrat et al., 2023). It also reinforces the argument made by Ghazali et al. (2023) that intensive training in JASP significantly enhances students' statistical analysis skills, suggesting that a strong perception of usefulness can drive better academic achievement.

Next, *perceived ease of use* also showed a significant influence. Students who found JASP easy to use were more likely to demonstrate improved learning outcomes. This confirms Blomberg's (2025) assertion that one of the main barriers to statistics learning in PGSD is students' technical limitations in using conventional statistical software like SPSS. The student experience of JASP being more intuitive and not requiring syntax-based commands becomes a key factor in building confidence and engagement in data analysis. This finding is also supported by Amahan & Amahan (2023), who emphasized that visual clarity and user-friendly interaction in digital learning platforms are strong predictors of students' positive perceptions toward technology.

The *attitude toward use* construct emerged as the most dominant factor in explaining the variation in learning outcomes. This finding strengthens the understanding that a positive attitude toward technology is not merely a result of perceived usefulness and ease of use, but also a direct driver of active engagement in learning. Consistent with Mohamad et al. (2021), attitude toward technology has been proven to be a key indicator of successful e-learning adoption, as it fosters sustained intrinsic motivation.

Interestingly, although *behavioral intention to use* is theoretically the final stage in the TAM model leading to actual technology use, this variable did not significantly affect learning outcomes in this study. This suggests a gap between intention and realization. While students expressed an intention to use JASP, this did not necessarily translate into concrete actions that influenced their academic performance. Several contextual factors—such as limited technical training, English-language interface barriers, and insufficient understanding of statistical tests—may hinder the actualization of that intention. Similar findings were reported by Bhattarai & Maharjan (2020), who highlighted that external obstacles such as infrastructure availability and technology self-efficacy strongly influence the success of digital learning implementation.

Overall, the regression model in this study explained 55.7% of the variance in students' learning outcomes, a relatively high value in the context of elementary education. This suggests that TAM is effective in capturing the key dynamics of technology acceptance in the PGSD environment. However, the results also open up opportunities for further exploration of external variables not covered in the classical TAM framework. Recent studies, such as those by Mustafa & Garcia (2021), have suggested integrating TAM with other theories, such as Task-Technology Fit or the Theory of Planned Behavior, to better capture broader motivational, social, and structural dimensions.

Considering these various dimensions, it can be concluded that JASP, when positively received by students, can serve as an effective tool in statistics education. However, its effectiveness can only be maximized when systemic support from institutions, lecturers,

and curriculum design is in place to reinforce students' positive perceptions of technology and bridge the gap between intention and concrete action in the learning process.

## CONCLUSION AND IMPLICATION

### Conclusion

This study demonstrates that the application of the Technology Acceptance Model (TAM) in the context of JASP usage among PGSD UNM students provides a strong understanding of the relationship between technology perception and academic achievement in statistics. Three of the four core TAM constructs—*perceived ease of use*, *perceived usefulness*, and *attitude toward use*—were found to have a significant impact on students' learning outcomes, with *attitude toward use* emerging as the most dominant factor. These findings highlight that students' perceptions of the ease and usefulness of the application play a crucial role in determining its effectiveness in supporting statistics learning.

Conversely, *behavioral intention to use* did not show a significant effect, indicating potential barriers in translating intention into concrete action. Overall, the model accounted for more than half of the variance in learning outcomes, suggesting that the integration of simple technologies like JASP can serve as an effective pedagogical strategy—provided it is supported by positive student attitudes and perceptions.

### Implication

The findings of this study indicate that students' perceptions of the JASP application—particularly regarding ease of use, usefulness, and positive attitudes—have a significant influence on their statistics learning outcomes. Theoretically, these findings reinforce the validity of the Technology Acceptance Model (TAM) within the context of technology-based learning in primary education, particularly in mastering statistical concepts. Practically, the results highlight the importance of integrating user-friendly statistical applications into instruction to enhance students' conceptual understanding of complex subject matter. For lecturers and program coordinators in PGSD, these findings provide a foundation for designing more contextualized technology-based learning strategies, while also emphasizing the importance of technical training and infrastructure support as essential bridges between intention and actual technology use.

### Disclosure statement

The author declares that there are no potential conflicts of interest related to this research.

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