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Research Article

The Relationship of Contractor Characteristics with the Application of Project Management Tools and Techniques Using the Mann-Whitney and Kruskal Wallis Method

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ABSTRACT

Introduction: It is highly hoped that the use of tools or management tools and techniques will be implemented by every company providing construction services to achieve quality timeliness and costs. Several contractors running projects from 2022 to 2024 experienced losses as a result of delay claims, due to discrepancies between planning and implementation, as well as contractor performance experiencing a decline due to a lack of management techniques in project control.

Objective: To make the projects carried out effective and efficient, researchers conducted an analysis of the implementation of project management by assessing the use of project management tools and techniques and their effectiveness in supporting projects running for several contractors in Denpasar.

Method: This was done by distributing questionnaires to respondents based on the characteristics of gender, age, education, experience, position, and project scale related to projects being implemented during 2022 to 2024. Identification of respondents' characteristics in terms of gender, age, education, experience, position, and project scale after testing their significance using the Mann-Whitney and Kruskal-Wallis tests.

Result: The results showed that respondents' characteristics did not have a significant effect on the application of project management tools and techniques by contractor companies in Denpasar City.

Conclusion: However, what causes the application of management tools and techniques is the uniqueness of projects with diverse and very complex solutions. Projects with the complexity of their work, both small and large-scale, require contractors to innovate in applying management tools and techniques to achieve efficient and effective project success.

Keywords: contractor characteristics, application of tools and techniques; project management; innovation, effective, efficient

INTRODUCTION

The use of *project management tools* brings stakeholders closer together who prioritize coordination, collaboration, speed and change. *Tools are* not a guarantee, but facilitating work based on the same paradigm and effective communication is the beginning of an organization that is ready to accept change[1] . The use of tools or management tools and techniques is highly expected in every construction service provider company to achieve quality timeliness and cost. Management *tools* are applications designed to help individuals and teams plan, implement and monitor projects more efficiently. Project management tools are applications or programs used in planning, implementing and monitoring a project. The purpose of implementing management *tools* is to make it easier for teams to manage projects efficiently and effectively and help teams to obtain information in *real time* about the status of the project and enable them to take appropriate action to keep the project on track. [2]
The concept of project success is efficient and effective in managing resources (*man, money, method, machine, material*), time according to plan, quality according to technical specifications and also *safety (zero accident)*. In managing a project from start to finish, an organizational structure led by a *Project Manager* (PM) is required.

According to[3] , a PM must be responsible for three important things, namely coordination, comprehensive planning and financing.

Contractors are construction service providers as project implementers. Contractors can be individuals or legal entities contracted or hired by the project owner to carry out work in accordance with the agreed contract agreement and in accordance with their expertise. The growth of contractors in Bali, especially Denpasar, is so rapid, both from state-owned and private companies with small, medium and large qualifications. The impact of the rapid growth of contractors in Denpasar, there is competition to get projects both private and government. Based on this impact, it is very necessary to innovate based on digitalization, to achieve efficiency and effectiveness in project completion, namely by applying the right management *tools* and techniques.

Research by Serrador and Turner found that the use of project management tools and techniques has a positive correlation with the success and efficiency of construction projects [5]. This is in line with the standards described in PMI's PMBOK® Guide which highlights the importance of methods, tools, and techniques in project management to achieve optimal results [6]. The research also suggests that a systematic approach to project management, such as good planning and control, can increase the effectiveness of project management tools implementation [7].

Furthermore, research by Dwivedi et al. analyzed the impact of using project management software on the performance of the construction industry, showing that the adoption of digital technology can improve efficiency [8]. In the context of digitalization, Gunasekaran et al. discussed the challenges and opportunities in the application of digital technology in project management, which is in line with this article's discussion of digital innovation in construction projects in Denpasar [9]. Research by Marzouk and Enaba further strengthens this argument by highlighting how Building Information Modeling (BIM) can improve project efficiency and sustainability [10]. In addition to technological aspects, research by Love et al. showed that one of the main causes of inefficiency in construction projects is rework, which can be reduced with the implementation of better project management tools [11]. Leadership factors also play an important role, as discussed by Albert et al. who found that the effectiveness of applying project management techniques depends heavily on the leadership of a project manager or site manager [12].

From a theoretical perspective, Koskela and Howell proposed the Lean Construction approach, which emphasizes efficiency and waste reduction, aligning with the main objectives of implementing project management tools [13]. Finally, research by Liu et al. showed that artificial intelligence is starting to play a role in construction project management, helping to plan, monitor and control projects more accurately [14].

OBJECTIVES

Since several years it has continued to carry out innovation and improvisation activities to improve the efficiency of contractor performance. In the projects running in several contractors from 2022 to 2024, there were losses due to delay claims, due to the mismatch between planning and implementation, and the contractor's performance decreased due to the lack of management techniques in project control. Project management evaluation is determined based on the list of activities, progress meetings, scheduling, and basic project planning of the contractor. The objective to be achieved is to determine the relationship between the respondent's characteristic factors on the contractor in Denpasar City with the application of project management tools and techniques.

METHODS

The analysis method used in this research is quantitative descriptive method with inferential analysis. Quantitative methods can be interpreted as research methods based on the philosophy of postivism, used to research on certain populations or samples, data collection using research instruments, data analysis is quantitative statistics, with the aim of testing predetermined hypotheses [4]. The data sources used in the study are Primary Data, namely data obtained from interviews, observations (observations), and documentation on contractors who live in Denpasar City. Secondary data, namely data obtained from references and from previous research reports that have relevance to the issues discussed in this study. The population and sample in this study were respondents who served as Director of Project Operations, *Project Manager* or *Site Manager* who handled the implementation of construction projects at contractor companies in Denpasar City with a total of 30 respondents.

RESULTS AND DISCUSSIONS

Validity and reliability tests were carried out before the questionnaire was distributed to each respondent, very important to do with the aim of knowing whether the questionnaire was feasible or valid and reliable to be distributed to 30 respondents in terms of getting answers.

Mann Whitney

The Mann Whitney test in this study used SPSS. The use of the Mann Whitney test, if the normality test results sig value (p value) <0.05 means not normally distributed. The mean test with uses the *Independent-Samples T Test test* for non-parametric statistics (*Man Whitney U-Test*) with a significance level of 0.05.

The criteria for the homogeneity test results use the Levene's test method, this test is recommended if the data is not normally distributed. The homogeneity test shows if sig (p value) > 0.05, it means that the two groups are homogeneous. Furthermore, to test the hypothesis is with the following criteria:

Sig (P value) <0.05 means H0 is rejected and Ha is accepted

Sig (P value > 0.05 means H0 is accepted and Ha is rejected

Kruskal Wallis

The Kruskal Wallis test for three or more independent samples is intended to test comparative hypotheses, namely by comparing the calculated *Chi-Square* value with the *Chi-Square table*. The rule used is if *Chi-Square* count> *Chi-Square table*, then the hypothesis is rejected and vice versa if *Chi-Square* count < *Chi-Square table*, then the hypothesis is accepted. To see the *Chi-Square table* price, it is based on the degree of freedom (dk) or *degree of freedom* (df). To prove hypothesis one by looking at the *degree of freedom* (dk) or *degree of freedom* (df)= k - 1= 5 - 1= 4, and the significance level (α) is set at 0.05 (5%).

The variables in this study are variables of respondent characteristics and project management tools and techniques, The type of hypothesis used is a relationship hypothesis (associative), which shows the relationship between two or more variables. The formula used to test the hypothesis is the Chi-Quadrat formula (χ^2), namely:

$$H = \frac{12}{N(N+1)} \sum_{j-1}^{k} \frac{R2j}{nj} - 3(N+1) \quad \text{.....(3.1)}$$

Description:

N = number of rows in the

K = number of columns

Rj= number of ranks in a column

In the Kruskall Wallis test research using SPSS, the answer to the Kruskall Wallis hypothesis output with SPSS is:

The Asymp.sig value shown in SPSS is the P value. The hypothesis decision is as follows:

- P value < 0.05: H0 is rejected and Ha is accepted (there is a significant influence between the characteristics of project management tools and techniques).
- P value > 0.05: H0 is accepted and Ha is rejected (there is no significant influence between the characteristics of project management tools and techniques).

In this study, data analysis was carried out by inferential analysis, namely the *mann whitney* test and *the kruskall wallis test* using SPSS version 23. The aim is to determine the relationship between respondent characteristic factors and the application of project management tools and techniques. The *mann whitney* test was performed on characteristics based on gender, while the *kruskall wallis* test was used on the characteristics of age, education, position, experience and project scale.

***Mann Whitney* Test on Gender Factor**

The Mann Whitney test on the gender characteristics factor consisting of two variables, namely male and female, on the variable application of project management tools and techniques, assuming that the two variables are not normally distributed. In the *mann whitney* test there are two variables in the test using the term method, namely method 1 (male), method 2 (female). From the results of data processing using the excel program, the *mean* value is obtained as table 1.

Table 1 Mean values of gender characteristics

Methods	Value
1	3.83
1	3.70
1	4.41

1	3.91
2	3.90
1	3.87
1	3.74
1	3.81
1	3.30
1	3.11
1	2.91
1	2.57
1	2.47
1	2.34
2	2.29
1	2.43
1	2.33
1	2.69
1	3.66
2	4.39
1	3.96
1	3.96
1	3.80
1	4.14
1	4.56
1	4.16
1	4.03
1	3.74
2	4.01
1	3.81

(Source: Data Processing 2024)

Based on table 1, the next step is processed with the SPSS program, to find out whether there is a difference in value between method 1 and method 2. By following the *mann whitney* tutorial, after entering the data in SPSS, the next step is to click *graph, legacy dialogs* and then histogram, then the results of the histogram image are obtained as shown in Figure 1.

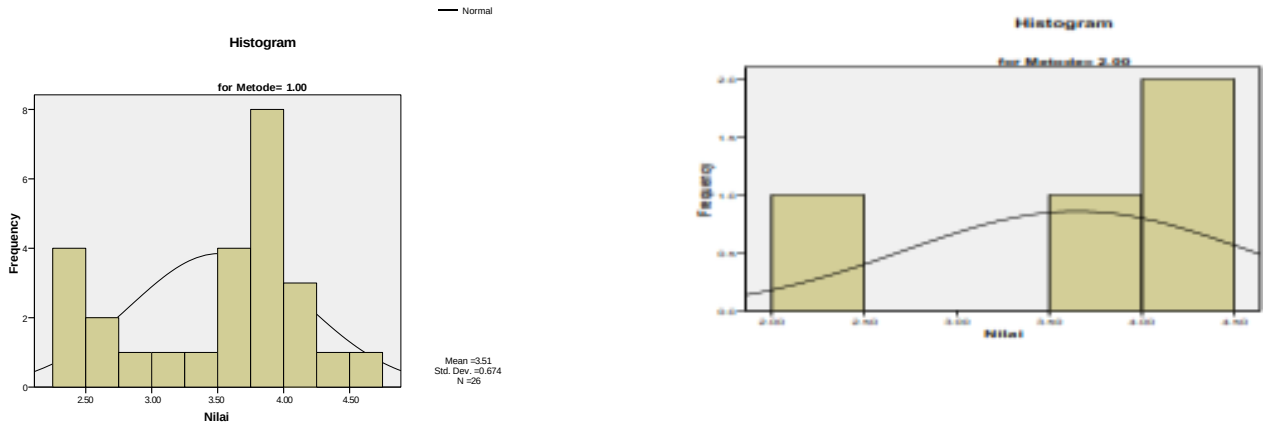

Figure 1 Histogram of SPSS output

(Source: Data Processing Results 2024)

Based on Figure 1, it shows that the two histograms do not have the same slope and width, this means that the data distribution is not the same, the factor that causes the inequality of data distribution is because method 1 (male) is more dominant than method 2 (female). Judging from the peaks, the two histograms show different peaks, which means there is a difference in median.

From both methods there is a difference in *mean in mann whitney*, with the difference being tested whether the difference has statistical meaning or is not meaningful, by conducting a normality test and homogeneity test. The normality test *output* can be seen as table 2 and the homogeneity test output can be seen as table 3.

Table 2 SPSS Output Normality Test

	Methods	Kolmogorov-Smirnov(a)			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Value	1.00	.242	26	.000	.888	26	.008
	2.00	.357	4	.	.825	4	.155

a Lilliefors Significance Correction

(Source: SPSS 2024 Data Processing Results)

Based on table 2, the results of the normality test show that the *sig* value for method 1 is 0.008 <0.05, this means that the data is not normally distributed, so the *mann whitney* test is suitable for use, while for method 2 it has a sig value = 0.155 > 0.05, which means that it is normally distributed.

Table 3 SPSS Output Homogeneity Test

		Levene Statistic		df1	df2	Sig.
Value	Based on Mean	.308		1	28	.583
	Based on Median	.022		1	28	.884
	Based on Median and with adjusted df	.022		1	24.945	.884
	Based on trimmed mean	.220		1	28	.643

(Source: SPSS 2024 Data Processing Results)

The homogeneity test shown in table 3 uses the *Levene's test* method because the dominant data in method 1, produces data that is not normally distributed. The test is indicated by the *sig* value *Based on Mean* is 0.583>0.05, which means that the variance of the two methods is homogeneous. After the homogeneity assumption is fulfilled, then the next step is to test the hypothesis, by continuing the next step by clicking the *analyze* menu, *non parametric test, 2 independent samples*, entering the value into the *variable* and method into the *grouping variable*. After that, it produces *output ranks* like table 4.

Table 4 *Output Ranks*

	Methods	N	Mean Rank	Sum of Ranks
Value	1.00	26	15.08	392.00
	2.00	4	18.25	73.00
	Total	30		

(Source: Data Processing Results 2024)

Table 4 shows the difference in rank between method 1 and method 2. Method 1 *mean rank* value is 15.08 while method 2 *mean rank* value is 18.25. Method 1 has a lower *mean rank* value compared to method 2, because method 1 (male gender) has more respondents than the female gender. The difference was statistically tested to determine the meaning of the difference in mean rank, which can be seen in Table 5.

Table 5 Output Test Statistics

	Value
Mann-Whitney U	41.000
Wilcoxon W	392.000
Z	-.671
Asymp. Sig. (2-tailed)	.502
Exact Sig. [2*(1-tailed Sig.)]	.536(a)

(Source: SPSS 2024 Data Processing Results)

Table 5 shows that the *Mann Whitney U* value is 41 and *the Wilcoxon W* is 392. And if converted to Z value is -0.671. While the *sig* value or *P value* is 0.502> 0.05. This means that H0 is accepted and H1 is rejected. There is no significant influence between gender characteristics on the application of project management tools and techniques in contractor companies in Denpasar City.

***Kruskall Wallis* Test**

Kruskall Wallis Test Age Characteristics

The age difference of respondents in the study was divided into 5 criteria, namely <25 years called method 1, between 26 years and 30 years method 2, between 31 years and 40 years method 3, between 41 years and 49 years method 4 and greater than or equal to 50 years method 5. The results of data processing then obtained the *mean* value, as shown in table 6.

Table 6 Age Characteristic Methods and Values

Methods	Value
1	4.16
2	3.74
3	3.61
4	2.97
5	3.05

(Source: Data Processing Results 2024)

Table 6, shows method 1 mean value 4.16, method 2 mean value 3.74, method 3 mean value 3.61, method 4 mean value 2.97 and method 5 mean value 3.05. From the mean value, the *output of* data processing with the *Kruskall Wallis* test is as shown in Table 7.

Table 7 SPSS Mean Rank *Output* Age Characteristics

	Age	N	Mean Rank
Value	1.00	1	5.00
	2.00	1	4.00
	3.00	1	3.00
	4.00	1	1.00
	5.00	1	2.00
	Total	5	

(Source: Data Processing Results 2024)

Table 7 shows that there are differences in the ranking of the five methods. The first lowest rank is method 4, the second lowest rank is method 5, the third lowest rank is method 3, the fourth lowest rank is method 2 while the highest rank is method 1. With the difference in mean rank, the *Kruskall Wallis* test is needed to determine the significance between these variables which can be seen in table 8.

Table 8 SPSS *Output* Statistical Test of Age Characteristics

	Value
Chi-Square	4.000
df	4
Asymp. Sig.	.406

(Source: Data Processing Results 2024)

Table 8 shows that the *sig* value or *P value* is 0.406> 0.05, this means that H0 is accepted and H1 is rejected, which means that the age factor has no significant effect on the application of project management tools and techniques in contractor companies in Denpasar city.

***Kruskall Wallis* Test Education Characteristics**

Educational characteristics in this study are divided into 4 criteria or 4 methods, namely SMK called method 1, S1 method 2, and correspondents who have a doctoral degree in testing are called method 3. Statistical data processing each has a *mean* value, which can be valued as shown in Table 9.

Table 9 Mean values of education characteristics

Methods	Value
1	3.54
2	4.01

3	2.34

(Source: Data Processing Results 2024)

Data processing with SPSS by generating the mean rank of each method. *The Mean Rank output* can be seen in table 10

Table 10 Mean Rank Output of Education Characteristics

	Education	N	Mean Rank
Value	1.00	1	2.00
	2.00	1	3.00
	3.00	1	1.00
	Total	3	

(Source: Data Processing Results 2024)

Table 10 shows that the lowest mean rank is method 3 with S3 characteristics, method 1 with SMK characteristics is higher than method 3, and the highest mean rank is method 2 (S1 education). With the difference in ranking, it was statistically tested using the *Kruskall Wallis* test, the SPSS output of the statistical test can be seen in table 11.

Table 11 SPSS Output Statistical Test of Education Characteristics

	Value
Chi-Square	2.000
df	2
Asymp. Sig.	.368

(Source: Data Processing Results 2024)

Based on statistical tests, the *chi square* value is 2 and *sig* or *P* value> 0.05, which means that H0 is accepted and H1 is rejected. So educational characteristics do not have a significant effect on the application of project management tools and techniques.

***Kruskall Wallis* Test Experience Characteristics**

Kruskall Wallis test analysis based on experience characteristics using 4 criteria (4 methods). Method 1 respondents with experience < 5 years, method 2 who have experience between 6 years and 10 years, method 3 experience between 11 years and 20 years. While method 4 with experience between 21 years and 30 years. Methods and *mean* values based on the results of data processing can be seen in Table 12.

Table 12 Mean values of experience characteristics

Methods	Experience
1	3.84
2	3.47
3	3.22
4	3.03

(Source: Data Processing Results 2024)

Table 13 Mean Rank Output of Experience Characteristics

	EXPERIENCE	N	Mean Rank
VALUE	1.00	1	4.00
	2.00	1	3.00
	3.00	1	2.00
	4.00	1	1.00
	Total	4	

Table 13 shows that the lowest average rank is the experience of method 4 (respondents with 21 years to 30 years of experience, then the next lowest is method 3 with 11 years to 20 years of experience, method 2 is higher in average rank than method 3, and the highest average value is method 1 (respondents who have <5 years of experience). With different mean rankings, the statistical significance was tested using the *Kruskall Wallis* test, which can be seen in Table 14.

Table 14 SPSS Output Statistical Test of Experience Characteristics

	VALUE
Chi-Square	3.000
df	3
Asymp. Sig.	.392

(Source: Data Processing Results 2024)

Table 14 shows that the *chi-square* value is 3, while the sig or P *value* = 0.392>0.05 means that H0 is accepted and H1 is rejected. Thus, between the experience characteristics variables do not significantly affect the application of project management tools and techniques in contractor companies in Denpasar City.

***Kruskall Wallis* Test Position Characteristics**

The results of data processing between the characteristics of respondent positions are divided into 3 criteria (methods), namely the positions of *Site Manager* (SM), *Project Manager* (PM) and director. The mean value can be seen as table 15.

Table 15 Mean Value of Position Characteristics

Methods	Position
1	3.78
2	3.40
3	2.51

(Source: Data Processing Results 2024)

Table 16 Mean Rank Output of Position Characteristics

	JOB	N	Mean Rank
VAL UE	1.00	1	3.00
	2.00	1	2.00
	3.00	1	1.00
	Total	3	

(Source: Data Processing Results 2024)

Based on the mean rank output of job characteristics, the mean of the director position is the lowest, after that the PM position and the highest mean rank is the SM position. From the difference in rank, a statistical test is needed, the statistical test output can be seen in Table 17.

Table 17 SPSS Output Statistical Test of Position Characteristics

	VALUE
Chi-Square	2.000
df	2
Asymp. Sig.	.368

(Source: Data Processing Results 2024)

Table 17 shows that the *chi square* value is 2 and the *sig* value or *P value* is 0.368> 0.05, which means that H0 is accepted and H1 is rejected. Thus, between job characteristics do not have a significant influence on the application of project management tools and techniques in contractor companies in Denpasar City.

***Kruskall Wallis* Test Characteristics of Project Scale**

Characteristics of respondents based on the scale of the project there are 3 criteria (methods), respondents who carry out projects between 500 million and 5 billion (method 1), between 5 billion and 10 billion (method 2), and respondents who work on projects with a scale of more than 10 billion. The results of data processing obtained the *mean* value as shown in Table 18.

Table 18 Mean Value of Project Scale Characteristics

Methods	Project Scale
1	3.51
2	2.99
3	3.79

(Source: Data Processing Results 2024)

Table 19 Mean Rank *Output of* Project Scale Characteristics

	Skalaproyek	N	Mean Rank
Value	1.00	1	2.00
	2.00	1	1.00
	3.00	1	3.00
	Total	3	

(Source: Data Processing Results 2024)

Based on table 19, the highest *mean rank output* is method 3, then method 1, then the lowest is method 2. With this difference, the significance is tested using the *Kruskall Wallis* test, so that the statistical output is obtained as in table 20.

Table 20 SPSS *Output* Statistical Test of Project Scale Characteristics

	Value
Chi-Square	2.000
df	2
Asymp. Sig.	.368

(Source: Data Processing Results 2024)

SPSS output statistical test of project scale characteristics has no significant effect on the application of project management tools and techniques, because based on the *output sig* value is 0.368> 0.05, meaning H0 is accepted and H1 is rejected.

Based on the identification of respondents' characteristics of gender, age, education, experience, position and project scale after being tested for significance with the *Mann-Whitney* and *Kruskal Wallis* tests, there is no significant effect on the application of project management tools and techniques by contractor companies in Denpasar City. In the modern era, the female gender is not a rare thing to become an engineering graduate, so the application of project management tools and techniques does not look at the gender factor. The age factor, based on respondents' answers, the highest *mean* value in the application of tools and techniques is between the ages of 24 years and 30 years. If based on age, respondents include Gen Z and Millennials, these two generations are very dominant in the world of work, one of which is a contracting company. They grew up in the era of digitalization, so everything related to innovation is always faster to master to improve their abilities in the world of work. Likewise, other respondent characteristics such as education, experience and project scale do not have a significant influence on the application of project management tools and techniques. From the scale of the project both small scale and large scale, has its own uniqueness. Based on interviews, identification of the characteristics that most influence the application of project management tools and techniques is project characteristics. Project characteristics according to [15] are unique because between one project and another project is not the same, has a limited duration and is temporary, requires resources (5M) and also requires organization in project implementation. Project problems are very complex, each project has its own uniqueness in its implementation, especially those related to resources (5M). Based on interviews with respondents, the more complex the project, the company will always innovate in applying project management tools and techniques to facilitate work coordination. The steps taken in dealing with project complexity are utilizing information systems that are increasingly advanced in the digitalization era such as providing opportunities for employees such as QS, SM, and PM to attend trainings on technical control innovations in the field, system-specific training such as training in using project management applications in monitoring projects. The characteristics of the scale of the project compared to the complexity of the project, in essence the scale of the project is more to the principle of complexity, because based on the experience of the contractor the size of the scale of each project is unique. The scale is small but the stage of work is complex. The principle is that if you can complete a small but complex scale by analogy, you can complete a large scale with an even greater level of complexity. So that the uniqueness of the project itself has an influence on project management tools and techniques applied by contractor companies in Denpasar City. In the world of intense competition, especially in the era of the industrial revolution 4.0, a system is needed that handles problems related to quality cost and time.

CONCLUSION

Based on the results and discussion of the application of project management tools and techniques in contractor companies in Denpasar City, it is concluded that the identification of characteristics that cause the application of management tools and techniques is the uniqueness factor of the project with a variety of very complex solutions. While the factors of respondent characteristics both from gender, age, education, experience, position and project

scale after being tested for significance by mann-whitney and kruskal wallis tests, have no significant effect on the application of project management tools and techniques by contractor companies in Denpasar City. Therefore, for contractors and consulting service companies in maintaining the company, they must always innovate in the digitalization era.

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