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The Tree Performance and Physical Attributes Determination for Outdoor Student Education Learning Centre Project Proposal

Atikah Fukaihah Amir [1], Ruwaidah Borhan [1], Helmi Hamzah [1], Fatemeh Khozaei Ravari [2]

[1] Program of Landscape Architecture, Department of Built Environment Studies and Technology, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA Perak Branch, 32610, Seri Iskandar, Perak, Malaysia. [2] Department of Architectural Engineering, Dhofar University, Salalah, Sultanate of Oman

atika250@uitm.edu.my, aidah866@uitm.edu.my, helmi692@uitm.edu.my, fatemehkhozaei@du.edu.om
Tel: +60 19 401 3784

Abstract

University students deserve proper outdoor learning centers to accelerate their academic development. However, dealing with dynamic physical outdoor elements, especially the existing tree species, is challenging in the design phase. Failing to understand their character and conditions will lead to design failures that involve losses of ecosystem benefits and ultimately have a negative impact on students' academic development. This research proposes composite maps by analyzing qualitative and quantitative data from physical attributes. The proposed overlayed composite maps present the association of comfort, movement, aesthetic, and social relation criteria for the outdoor student learning centres.

Keywords: Plant Community, Plant Identification, Tree Conditions, Map Overlay

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1.0 Introduction

Outdoor learning education has many experiences to offer students and proves it can benefit both students and lecturers. Learning is not limited inside of the classroom. The learning experience that needs to be obtained online can be accessed everywhere. According to Yaman (2018), a study conducted among Landscape Architecture and Architecture students at the university level in Universiti Putra Malaysia (UPM), International Islamic University Malaysia (IIUM), and Universiti Teknologi MARA (UiTM) stated that outdoor learning spaces provide varying experiences and enhance students' learning performances, especially in Problem Based Learning (PBL) approach. Learning outside of the classroom also gives health benefits and promotes healing through the engagement of nature. According to O'Brien (2011), health and well-being benefits are gained through outdoor learning approaches that are intensive 'hands'-on' and or in the long term. Thus, in general, outdoor learning education gives other experiences and benefits students.

Teaching and learning in university should be versatile, and providing outdoor spaces or green spaces for teaching and learning environment should be considered. The potential spaces for outdoor learning are many in this university. The university can use existing trees and surrounding nature as a key subject for outdoor education. Universiti Teknologi MARA Perak Branch, Seri Iskandar campus is planning to develop an Outdoor Student Education Centre project at Dataran Usahawan. The proposed project consists of a 3,600m^2 area with various tree species and a building known as Dataran Usahawan. Therefore, many phases are being strategized; one is identifying tree species and tree conditions. This identification composes as part of the site inventory and site analysis process under the study of the

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biological attributes. This phase also included a further ecological investigation to understand the basic ground need of many habitats around. Thus, the research aims to propose outdoor space for teaching and learning environment. The objectives are narrowed into three, which are to produce the physical attribute layout by measuring the site conditions. Secondly is to investigate the tree species and their condition in the site project. Lastly, to produce a composite map for proposal of Outdoor Student Education Centre Project. These three stages of data are essential for the researcher to understand the potential or need of the site.

2.0 Literature Review

2.1 The Existing Tree Conditions Assessment

A tree assessment task is a specific type of information to present a tree conditions status. The task has been practised for more than a century to sustain urban green initiatives. Landscape designers are also well aware of the success of the planting programs in the tree assessment task provided. It is mentioned that the assessment task for the existing tree in a particular site is the core component in the design proses because it is premeditated to reveal the tree performance status for practical design solutions (Koeser et al., 2016). It guides the designer through realistic data obtained (Roman et al., 2013). This way, systematic design practices are ideal to ensure outstanding tree performance and the continuity of the ecosystem services that existing trees provide.

The unhealthy tree is often related to primary stress factors, such as temperature, mineral deficiencies, and lack of watering. The attack by insects or disease is a secondary factor that attacks weakened trees. Diagnosing a tree on-site can consider six important keys suggested by Lily (2001), which were (a) accurately identify the plant, (b) look for a pattern or abnormality, (c) carefully examine the site, (d) note the colour, size, and thickness of the foliage, (e) check the trunk and branches, and (f) examine the roots and root collar. The researchers managed to build a checklist for general study when diagnosing trees on site.

According to Lily (2001), around 70-90 percent of tree health problems are caused by environmental conditions such as soil compaction, drought, moisture fluctuations, temperature extremes, mechanical injuries, or poor species selection on site. The cause is usually in combination or complex with nonliving stresses and living human/animal contributors. Thus, no direct or single solution can be suggested when analyzing the tree health problems. When analyzing the tree heath, the researchers look at the symptoms and signs to determine the cause. According to Lily (2001), a problem on the tree was rarely diagnosed with a single symptom. For example, the wilting symptoms might be caused by a lack of watering or root problems.

Therefore, various tree assessment approaches have been created to aid professionals through the tree inspection process. The Basic Tree Assessment Method was developed in conjunction with the International Society of Arboriculture's (ISA) Tree Risk Assessment Best Management Practice (BMP) Manual (Smiley et al., 2017). Depending on the extent of the assessment, this tree assessment methodology is divided into three levels:

1. Level 1 is a limited Visual Assessment (eyes only inspection, drive-by, or a walk-by assessment).
2. Level 2 is a basic Visual Assessment (ground level inspection with simple hand tools).
3. Level 3 is an advanced Assessment (human climbing on a tree may involve together with a piece of diagnostic equipment).

The tree condition index contains a risk-rating assessment characterized by four levels - low, moderate, high, and extreme (Chuon et al., 2011), equivalent to tree health status into good, moderate, poor, and very poor. This assessment is being done especially in future development settings. It would help identify tree defects in the proposed areas, calculating the hazard of the existing trees and the possibilities of their failures. This likely damage rigorousness could happen due to their failures and, most importantly, recommending pre-incident preventive and corrective design solutions. This would help in preventing unnecessary losses due to future tree failures.

2.2 Mapping Overlay

Ian McHarg (1920–2001) was a significant innovator and proponent of the map overlay method (Steiner, 2019). He studied how to design new roadways damaging as less as possible natural heritage and biodiversity to develop an eligibility analysis through a technique he called 'overlay mapping,' which consists of overlapping different thematic maps. The map overlay is often used by landscape architects, planners, and geographers to analyze 'the green landscape pattern (Kuitert, 2013). In this study, the overlay map techniques identify two related programs: the trees spatial program and the path circulation human behavior program. The overlay is a GIS operation that superimposes multiple data sets to identify relationships between the data programs. In this study, overlaying techniques identify the plant species and trees condition with the human behaviour pattern circulation in the sites. Thus, the overlay techniques create a composite map by combining the geometry (circulation behaviour) and attributes (plant identification and tree conditions) of the input data sets for the inventory and analysis data before the design development stage. Overlay features in a map in AutoCAD is a simple technique to identify the critical features being considered. It can also make the comparison of spatial related. According to Autodesk (2018), overlays are used to compare two feature classes or spatially related layers. According to Vemuri (2016), the transparency of layers is reduced and controlled to allow the researcher to compare each data visually.

3.0 Methodology

This study employed a mixed-method approach, and the researcher analyzed both qualitative and quantitative data. There were two types of data collection techniques: first, a physical attribute survey, and second, a tree health condition assessment. A physical attribute survey was considered quantitative data. As a measurement tool, a unit of theodolite was used to GPS log the location of any structure and levelling found on site. It is an optical instrument for measuring angles between designated visible points in the horizontal and vertical planes (Figure 1). Site surveys completed by licensed surveyors will typically include the locations of existing trees.The site was calculated with a 3,600m2 area, and the measurement was done in approximately a week when the sky was clear. The GPS log then was transferred into AutoCAD drawing and presented quantitative data in the form of drawing.

Tree health condition assessment as a second data collection is a part of qualitative data. Before the tree and site environment were assessed, the drawing from the physical attribute survey was used to carefully highlight the different tree species on site. The tree identification was made by understanding the different colours, forms, and patterns on leaves, trunks, flowers, fruit, and tree shape. Assessments of tree health are narrowed into four quality levels: good condition to represent low tree risk rating, moderate condition to represent a medium risk, bad condition to represent high risk and very bad condition to represent extreme tree risk rate. This quality data were done in approximately a week of observation. Other site qualities being assessed are human behaviour patterns, which were conducted in roughly a week.

The total observation was approximately two months, from February until April 2022. Site observations for quantitative and qualitative data were needed, as the data obtained in this phase will guide the design proposal of the Outdoor Student Education Centre project. The inventory and analysis data attributes highlighted in this proposal are cultural, physical, and biological attributes, including human movement, topography, hydrology, climate, and vegetation. The site analysis summarizes the site's suitability based on the attributes that influence the project under consideration. Therefore, the opportunities associated with a site are unique natural resources that warrant protection. In this context of site projects, the opportunities that may enhance the site's aesthetic and environmental quality are the existing trees that have contributed to a pleasing ambience and comfortable environment.

Fig. 1: Surveyors obtain topographic survey by using a theodolite, an essential survey instrument. *(Source:) Author*

4.0 Results

4.1 Physical Attribute Layout

Due to the minimal data of the existing base map that the clients have provided, the topographic survey needs to be mapped and locate the distance of the existing trees and the contour of the existing sites (Table 1). Data from the topographic survey was produced, as in Figure 2. The outcome from the survey is presented in Table 1. With the data, a Certified Arborist and a Landscape Architect identify and investigate the tree's location and conditions by observing the site and digitally recording the boundaries and elements on site. Taking a colour photograph and specimens of leaves to investigate the conditions of trees' health and recording in a comprehensive notebook can help orient the analysis and make the digital mapping process more efficient.

Table 1. Site data conveyed on a topographic survey

Category	Locational Data
Topography	Elevation contours
	Spot elevations for high points and low points
Vegetation	Isolated trees
	a. Species
	b. Condition of Trees
Hydrology	Surface water
	Stormwater flow
Structures	Buildings
Circulation	Streets
	Curbs and gutters
	Parking areas

(Source:) Author

Fig. 2: Topographic Survey Plan by a licensed surveyor
(Source:) Author

4.2 Plant Collecting and Identifying

Data of plant identification was conducted on 24-25 February 2022 and was recorded in a comprehensive notebook. Elements of trees such as leaves, branches, flowers, and fruit were recorded. The purposes of collecting plants are to obtain records and specimens of the plant for personal collection and a dataset of UiTM's tree collection. It can also have a great value as a reference for identification (Bowles, 2004). Another purpose of plant collecting is for the researcher to identify an unknown species during fieldwork later. According to Bowles (2004), the researcher should collect at least one specimen of each species. For example, during the fieldwork study, the researcher found that modification leaves appeared in several leaves and that specimens were collected and studied for possible causes on site. Figure 3 shows specimens of modified leaves being collected and recorded in a comprehensive notebook.

A knife was used to obtain leaves from the stem during plant sampling. According to Bowles (2004), twigs should always be cut off cleanly with a sharp knife or pruners, and breaking the twig can ruin a specimen or cause unnecessary harm to the tree. However, the research is limited to the on-ground sampling and not until the underground portion like roots, trailing, or underground stems. The researchers can still identify the plants from the above-ground sampling, so they did not go further underground, as Bowles (2004) suggested. During plant tree sampling, the researcher took a comprehensive note of the collection number, the plant's name (if the researcher can be identified on-site), description of the tree, specific details of micro-habitat, and date of sampling.

Fig. 3: Example of Mempari leaves and flowers being collected. The leaves sample also has modified or disfigured leaves with yellowish symptoms.
(Source:) Author

4.3 Plant Identification and Tree Health Conditions

The researchers identified seven tree species with 59 numbers in the designated plot. *Swietenia macrophylla* tree is the highest number (30 nos) of trees found on the site. Followed by *Pongamia pinnata* (11 nos), *Syzigium companulatum* (7 nos), *Cinnamomum iners* (5 nos), *Mimusops elengi* (4 nos), *Michelia champaca* (1 nos), and one new tree that just has been planted *Annona muricata*. The basic tree assessment method (Smiley et al., 2017) was used in this study to investigate tree health conditions. These showed a diverse range of tree vigorousness, foliage size and colour, pests or biotic affection, abiotic effects, and species failure profiles in the branches, trunk, or roots. Table 2 presents the health profiles of the trees in the study. Most of the trees in this study had a high vigour classification, accounting for 84.7% (N = 50) of the total trees. This was followed by trees with standard vigour classification, which made up 11.9% (N = 7), and only 3.4% (N = 2) had low vigour classification. This study discovered that most trees have a standard foliage profile of 96.6%, which accounted for 57 trees. However, two species, namely *Pongamia pinnata* (Mempari), have chlorotic and necrotic problems. Only 15.3% of the trees had problems with biotic effects, which came to 9 trees. This situation only involved nine *Pongamia pinnata* (Mempari) species affected by the competition for sunlight from an adjacent tree and compacted soil. This causes the trees to be prone to failure in the branches and roots.

An analysis of the tree health profiles discovered three health condition classifications: good, moderate, and poor (Table. 3). The trees with poor health conditions were less than 4% of the total, only 3.4% (N= 2) from 59 trees. 11.9% (N = 7) were in moderate health condition, and the majority, 84.7% (N = 50) of trees, were at the level of good health condition. Trees identification and location plans, as in Figure 4 and Figure 5, are examples of images of the existing tree on site.

Table 2. The Health Profiles of Existing Trees within Dataran Usahawan

No	Species	Vigour			Foliage			Pests/ living things/ Biotic factor	Non-living things/ Abiotic factor	Species failure profile		
		Low	Normal	High	Normal	Chlorotic	Necrotic			Branches	Trunk	Upper Roots
1	*Annona muricata* (Durian Belanda)	-	-	1	1	-	-	-	-	-	-	-
2	*Cinnamomum iners* (Kayu Manis)	-	-	5	5	-	-	-	-	-	-	-
3	*Mimusops elengi* (Bunga Tanjung)	-	-	4	4	-	-	-	-	-	-	-
4	*Michelia champaca* (Cempaka Kuning)	-	-	1	1	-	-	-	-	-	-	-
5	*Pongamia pinnata* (Mempari)	2	7	2	9	2	2	-	9	7	-	2
6	*Swietania macrophylla* (Mahogany)	-	-	30	30	-	-	-	-	-	-	-
7	*Syzigium companulatum* (Kelat)	-	-	7	7	-	-	-	-	-	-	-
	Total	**2**	**7**	**50**	**57**	**2**	**2**	**-**	**9**	**7**	**-**	**2**

(Source: Author)

Table 3. The Health Condition of Existing Trees within Dataran Usahawan

No	Species	Tree Health				Total	Notes
		Good	Moderate	Poor	Very Poor		
1	*Annona muricata* (Durian Belanda)	1	-	-	-	1	
2	*Cinnamomum iners* (Kayu Manis)	5	-	-	-	5	
3	*Mimusops elengi* (Bunga Tanjung)	4	-	-	-	4	
4	*Michelia champaca* (Cempaka Kuning)	1	-	-	-	1	
5	*Pongamia pinnata* (Mempari)	2	7	2		11	Adjacent trees compete for sunlight and compacted soil.
6	*Swietania macrophylla* (Mahogany)	30	-	-	-	30	
7	*Syzigium companulatum* (Kelat)	7	-	-	-	7	
	Total	**50**	**7**	**2**	**-**	**59**	

(Source: Author)

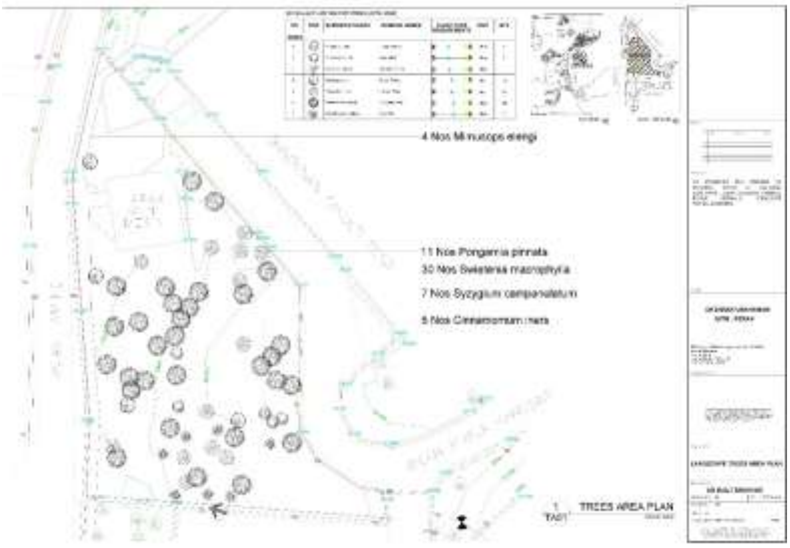

Fig. 4: Tree identification and location (Trees Plan Area)
(Source:) Author

(a) *Swietania macrophylla*

(b) *Pongamia pinnata*

(c) *Mimusops elengi*

(d) *Cinnamomum iners*

(e) *Syzigium companulatum*

(f) *Michelia champaca*

(g) *Annona muricata*

Fig. 5: The seven species found on site

(Source:) Author

4.4 Overlaying Composite Maps

The analysis of physical attribute layout and existing tree health conditions were mapped together in Figure 6 to produce overlaying composite maps. A total of nine out of 11 trees (82%) from *Pongamia pinnata* species were categorized in moderate and poor conditions health is not suitable on the site. Sustainable or 'green' development respects the natural environment and ensures, for example, that the trees are protected and incorporated into the site plan (Petit et al., 2004). After considering all the attributes and the site analysis process, especially on the tree's identification and analysis, the proposal design vision narrows down to the sustainable design planning paradigms for building a better student centre community on campus. Sustainable in this proposal design has three fundamental precepts:

1. Design with nature which are existing natural resources such as existing trees
2. Design with campus culture where the more outdoor classroom centre
3. Design a place for students to interact and recreational

According to the quotes by John Sawhill, former president of The Nature Conservancy, in the end, our society will be defined not only by what we create but also by what we refuse to destroy. Thus, the idea of the proposal is more on mitigating the impacts of the previous site uses, such as maintaining the existing tree and applying the best management practices in implementing the design through the part of sustainable site design planning.

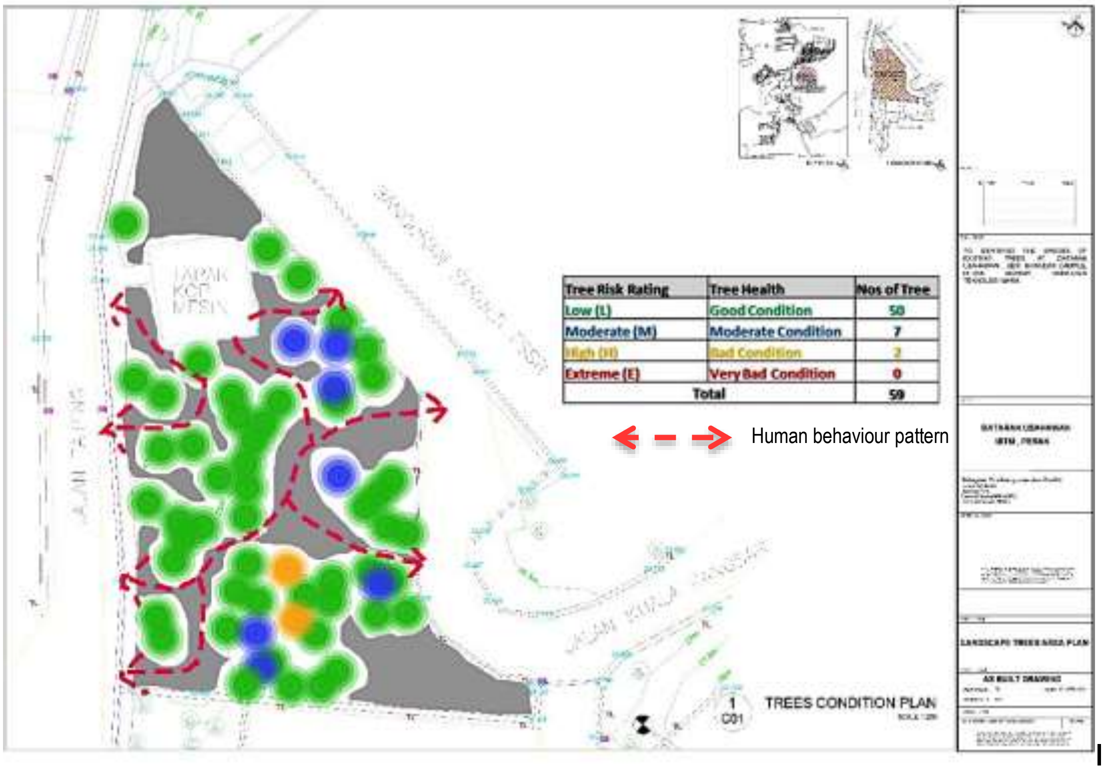

Fig. 6: Overlaying composite maps
(Source:) Author

5.0 Discussion

This study has addressed the subject of proper outdoor learning centres for university students by examining the existing physical element (Maheran et al., 2017). The study contributes to the field by presenting a composite map overlayed based on the physical attribute and existing tree condition factor, which may be a concealed but crucial guide in the design proposal. The outcomes of this study will assist and extend the understanding of preparing outdoor learning centres for university students. The findings of this study are consistent with the outcomes of previous research. Many studies from the literature review consider existing physical elements, including campus trees, a significant subject for outdoor learning centres (Abdullah et al., 2022; Maheran et al., 2017; Mann et al., 2021; Mirrahmi et al., 2011).

Based on a review, Maheran et al. (2017) concluded with the six criteria for proper outdoor learning spaces: flexibility and multiple-use, comfort, movement, technology and ICT tools, aesthetic, and social relation. This study presents the overlayed composite map, which is strongly associated with comfort, movement, aesthetic, and social relation criteria. While other two criteria, flexibility and multiple-use, and technology and ICT tools, are not analyzed in this research, thus, limiting the study. The consideration of comfort, movement, aesthetic and social relation criteria in this project has been thought in the form of appreciating existing trees as a 'comfortable' space for a learning environment, 'movement' in the form of human behaviour patterns on-site, 'aesthetic' in the form of space function or arrangement in the site, and 'social relation' in the form of connectivity space between existing building. Throughout the site analysis, trees are identified, examined, and acknowledged as assets that can yield multiple ecological, economic, and social benefits. Trees on site provide shade, reduce heat, and give a cooling effect near the Dataran Usahawan building. Trees at Dataran Usahawan serve multiple design functions that directly benefit users. The environment where they can provide shade serves as windbreaks, with the significant shape of trees also giving an aesthetic value and providing a spatial enclosure for an outdoor classroom.

Tree spatial programs focus on data tree conditions collected from the observation and photographs in the sites. Tree structures are considered on the root/formation, trunk condition and branch assembly and arrangement. Meanwhile, tree health considers the crown indicators, including vigour, density, leaf size, quality, and stem shoot extension. In addition, the circulation of the human pathway was analyzed its movement pattern to emphasize the effect of tree conditions and species influencing the behaviour pattern.

6.0 Conclusion & Recommendations

The research is limited with Level 1; limited Visual Assessment (eyes only inspection, drive-by or a walk by assessment) and Level 2; basic Visual Assessment (ground level inspection with simple hand tools). Level 3 involves climbing the tree to check that the crown is not involved, thus limiting the data collection.

The overlaying composite map in Figure 6 shows the area that needs to be considered when designing for future development. This data is vital for the researcher and designer to design the outdoor space for students that meet the needs of the quality environment and the convenience-walking ambience for the student to occupy the whole area as the outdoor classroom. In the context of future design development, the data on tree conditions and species existing is essential and significant to help the landscape architect design the area with the objective of sustainable development. As most of the areas were considered to receive good tree health conditions, thus, this area has a potential for core area space development of outdoor learning classroom. However, the area or tree locations of *Pongamia pinnata* categorized in moderate and poor tree conditions can be considered if the designer plans to improvise the site area. For future reference, the tree selection needs to be chosen wisely before it is planted, as *Pongamia pinnata* is not suitable for growing on-site based on abiotic factors (the competition for sunlight from an adjacent tree and compacted soil). This showed by the symptoms of failure in the branches and roots.

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Paper Contribution to Related Field of Study

This paper contributes knowledge to the field of the built environment study background of academicians, land surveyors, arborists, and landscape architects.

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