Assessing Technology Sophistication in Providing Blended Learning System Using Technometric Approach (Case Study: SMA Unggul Del)

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Abstract. The Covid-19 pandemic that has hit Indonesia since March 2020 has resulted in face-to-face learning at SMA Unggul Del whose characteristic is that a distance learning system replaces boarding schools. The easing of the Covid-19 pandemic has forced school management to continue to prepare themselves to implement a blended learning system. In these conditions, the level of sophistication and up-to-date technology that supports blended learning is needed. This study aims to assess the level of technological sophistication in implementing blended learning at SMA Unggul Del. The method used in this research is Teknometric, equipped with a SWOT analysis. The technometric method identifies the contribution of technology components and the level of technological sophistication through four aspects: technoware, humanware, infoware and orgaware. These four aspects are derived into 10 criteria, 43 sub-criteria and 94 sub-criteria, which were developed with a combination of literature studies and expert opinion. The state-of-the-art assessment of each component was carried out using the triangulation method, namely observation, documentation, and interviews. Based on technometric calculations, the contribution value of technoware components is 0.76, humanware is 0.84, infoware is 0.96 and orgaware is 0.86. This value is then aggregated into the Technology Contribution Coefficient (TCC) index for blended learning at SMA Unggul Del, which is 0.83, which is included in the excellent and modern category. Based on the SWOT analysis, all components (technoware, humanware, infoware and orgaware) are in quadrant I with the relevant strategy of aggressive growth.

Keywords: assessment, technometrics, strategy, blended learning, SMA Unggul Del.

1 Introduction

SMA Unggul Del is a private high school established in 2011 and officially operating on June 1, 2012 [1],[2]. SMA Unggul Del is one of the senior high schools in Indonesia that has achieved various academic and non-academic achievements. For example, the successes achieved by this

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school are winning the third best high school diploma in Indonesia, winning multiple national and regional competitions such as 1st place at the provincial level German language Olympiad and 2nd place ranking for National Level Biology Precise Quick Contest (LCTB). Since the Covid-19 pandemic, teaching and learning activities at SMA Unggul Del whose characteristic is that it is a boarding school have been replaced by a distance learning system. This transition resulted in education, where every activity was carried out virtually, from classes, exams, quizzes, and assignments to practicum. The easing of the Covid-19 pandemic has yet to make learning run as before. The condition of the surrounding environment has forced school management to continue to prepare themselves to implement a blended learning system. Blended learning is learning refers to a learning or education style where students learn with traditional teaching directly or in classrooms and online media. Blended learning combines e-learning and multimedia technologies, such as video streaming, virtual classes, and online animated texts with traditional classroom learning forms[3]. Changes in conditions, styles and learning systems can decrease student achievement and school achievement. In these conditions, the level of sophistication and up-to-date technology that supports blended learning is needed to maintain and improve school performance. Therefore, this study was conducted to assess the level of technological sophistication in implementing blended learning at SMA Unggul Del. The method used in this research is Teknometric, which is equipped with SWOT analysis. The technometric method identifies the contribution of technology components and the level of technological sophistication through four aspects: technoware, humanware, infoware and orgaware. The application of this approach will provide an overview of the blended learning conducted by SMA Unggul Del based on the four aspects of THIO.

2 Method

The methodology used in completing this research is shown in Figure 1.

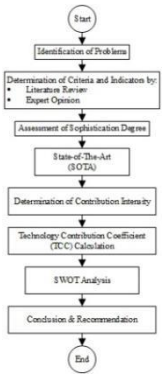

Fig. 1. Research methodology

This research begins with a literature study to examine technology assessment with technometrics and mixed learning[5], [6], [6], [8]. Several literatures have been reviewed from which information on technometric and blended learning methods was obtained and some required information[8], [9]. The data used in this study is qualitative data from questionnaires and interviews, which are then adjusted to the assessment instrument. Most of this research is

subjective, where statements and assessments result from observation, interpretation and perception. Therefore, the assessment carried out is strengthened by the presence of references and expert views to reduce the subjective element.

Technometrics is a method used to evaluate the contribution of four technology components, technoware, humanware, infoware and orgaware [10]. This method is commonly used in assessing the level of technological sophistication [5], [6], [**7**]. Technoware is a technology attached to an object (object embodied technology), also known as a physical facility. Humanware is a technology inherent in humans (human embodied technology), also known as human capabilities. Infoware is technology attached to documents (document embodied technology) are also referred to as documented facts. Orgaware is a technology attached to the institution (institution embodied technology), also known as the organizational framework. This study also used SWOT analysis to identify various factors to formulate a company strategy. The SWOT analysis results will show the right development strategy used for the object under study.

3 Result and Discussion

3.1 Determination of criteria and indicators

The technology component will be specified in the form of criteria and sub-criteria from literature studies of several journals[11], articles and books and expert views. The author builds an instrument for assessing the degree of technological sophistication to support blended learning from 4 components in 10 criteria, 43 sub-criteria and 94 sub-criteria developed with a combination of literature studies and expert opinion. Table 1 shows several criteria and indicators for assessing each component used in this study.

Table 1. Technology Component Assessment Criteria and Indicators

Technology Components	Criteria	Sub Criteria	Sub-Sub Criteria	Reference
Technoware	Traditional Class Facilities	Projector	Resolution	[12]
			Lamp life	[13]; Permendikbud No. 8 Year 2018
	online class	Computer	Processor type	[14];[12]
	Hybrid	External webcam	Resolution	[15]
			Frame rate	[15];[16]
			…	
Humanware	Direct human	Teacher	Academic qualification	SMA/MA Accreditation Toolkit, BANS (2017)
			Educator certificate	
			…	
Infoware		Syllabus	Syllabus components	

Technology Components	Criteria	Sub Criteria	Sub-Sub Criteria	Reference
	Characteristics of the learning process	RPP	Development of lesson plans according to the syllabus	SMA/MA Accreditation Toolkit, BANS (2017)
			…	
Orgaware	Additional amenities	Subsidy	Data plan subsidies	Regulation of the Secretary General of the Ministry of Education and Culture, Research and Technology, No. 17 year 2021
			…	

3.2 Sophistication rating

The degree of sophistication assessment is contained in 7 levels of assessment (123; 234; 345; 456; 567; 678; 789)[10] where then, for each criterion, the upper limit (UL) and lower limit (LL) will be determined according to the score obtained. The average upper limit (UL) and lower limit (LL) values for each technology component can be seen in Table 2.

Table 2. Average UL and LL

NO.	Component	LL	UL
1	*Technoware*	5,12	7.42
2	*Humanware*	5.92	7.92
3	*Infoware*	6.71	8.71
4	*Orgaware*	6	8

Based on the average LL and UL for each component, it can be seen that the average criteria have a good level of sophistication with LL being above 5 and UL above 7. Among the four components, infoware is the component with the highest complexity with LL 6.71 and UL 8.71 where this value is close to the maximum value (LL = 7 and UL = 9).

3.3 State-of-The-Art (SOTA)

The SOTA value is obtained using a score range of 1 (the minimum condition) to 10 (the best condition). Meanwhile, the author's score in the range of values mentioned is assessed by interpolation. After the SOTA score is obtained, it will be continued by calculating the SOTA value for each component of the blended learning technology of SMA Unggul Del. To calculate the SOTA value, Equations (1), (2), (3) and (4) are used[10]. The calculation results are shown in Table 3.

$$ST = \frac{1}{10}\left[\frac{\sum_{k=1}^{k_t} t_k}{k_t}\right] \quad (1)$$

$$SH = \frac{1}{10}\left[\frac{\sum_{i=1}^{i_h} h_i}{i_h}\right] \quad (2)$$

$$SI = \frac{1}{10}\left[\frac{\sum_{m=1}^{m_f} f_m}{m_f}\right] \quad (3)$$

$$SO = \frac{1}{10}\left[\frac{\sum_{n=1}^{n_o} o_n}{n_o}\right] \quad (4)$$

The calculation result is shown that the SOTA for technoware, humanware, infoware and orgaware are 0.76, 0.84, 0.96 and 0.85. The highest level or condition of the component will be indicated by the SOTA value reaching 1[10]. Of the four technology components in blended learning at SMA Unggul Del, the component of blended learning technology has yet to reach the highest or most recent condition. The best SOTA value owned by SMA Unggul Del for mixed learning technology is the infoware component, where the SOTA value is 0.96. While the technoware component is the component with the smallest SOTA value, which is 0.76. Therefore, the technoware component is a component that requires more development or updating when compared to other components.

3.4 Determination of the contribution of technology components

The calculation of the contribution of technology components is carried out to see the level of contribution of each component in blended learning at SMA Unggul Del. The contribution of this technology component is obtained through calculations using equations (5), (6), (7) and (8)[10]. The calculation results of the contribution of technology components are 0.76 for technoware, 0.84 for humanware, 0.96 for infoware and 0.86 for orgaware. Each of these technological component contributions is also mapped into a radar chart to see the orbital point of each component, as shown in Figure 2.

$$T = \frac{1}{9}[LT + ST(UT - LT)] \quad (5)$$

$$H = \frac{1}{9}[LH + SH(UH - LH)] \quad (6)$$

$$I = \frac{1}{9}[LI + SI(UI - LI)] \quad (7)$$

$$O = \frac{1}{9}[LO + SO(UO - LO)] \quad (8)$$

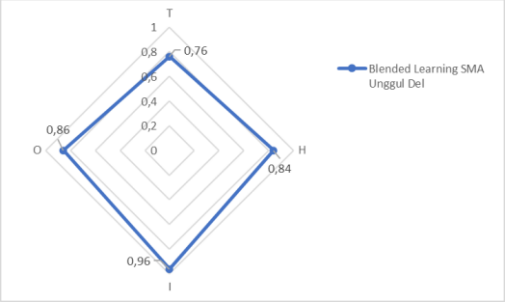

Fig. 2. Radar Chart

Based on the results of the calculations in Figure 2, it can be seen that the technology component with the highest contribution and the lowest contribution in blended learning at SMA Unggul Del. The highest contribution is on the infoware component and the lowest contribution is on the technoware component. The average value of the technology component's contribution to blended learning at SMA Unggul Del is classified as very good.

3.5 Intensity of technology contribution

The intensity of the technology contribution (β) is obtained by conducting a pairwise comparison that shows the relative importance of one technology component to the other. The results of pairwise comparisons are loaded into the matrix. In the matrix, the opposite value applies with a relative assessment of aij = 1/aij. The comparison matrix can be seen in Table 5.

Table 3. Comparison Matrix

	T	H	I	O
T	1	0.57	3.5	0.6
H	1.75	1	6	5.5
I	0.29	0.17	1	0.58
O	1.67	0.18	1.71	1

Based on the matrix table, calculations are carried out to obtain the priority weight value. Before finding the priority weights, we first normalize the matrix. Matrix normalization is performed to normalize the matrix values to remain in the range 0 to 1. The results of weight calculations are 0.22 for technoware, 0.53 for humanware, 0.08 for infoware and 0.18 for orgaware. Then analyses are carried out to determine the value of λ (lamda), CI, RI, and CR. The following is the calculation and results of the values of λ (lamda), CI, RI, and CR.

Table 4. Value of λ (Lamda), CI, RI and CR

	λ	CI	RI	CR
Score	4,531	0.088	0.90	0.098

The random index value (RI) used is 0.90, this is because the matrix has 4 components[17]. The calculations resulted in a consistency ratio (CR) value of 0.098 where the value was less than 0.1, it can be said that the data obtained were consistent and could be used. The following is the contribution intensity value for each technology component.

βT = 0.22; β H = 0.53; β I = 0.08; β O = 0.18
Based on this value, the humanware component has the highest contribution intensity value of 0.53 or 53%. Therefore, the humanware component becomes the main priority or the highest level of importance based on expert views.

3.6 Technology Contribution Coefficient (TCC)

The Technology Contribution Coefficient (TCC) is a value that describes the level of sophistication or involvement of technology in transformation in blended learning at SMA Unggul Del. The TCC value is obtained by calculation using equation (9)[10].

$$TCC = T^{\beta_t} \times H^{\beta_h} \times I^{\beta_i} \times O^{\beta_o} \quad (9)$$

TCC $= 0.76^{0.22} \times 0.840.53 \times 0.960.08 \times 0.860.18 = 0.83$

The TCC value for mixed learning at SMA Unggul Del is 0.83. Based on the TCC values obtained, SMA Unggul Del is qualified with very good quality and the level of technological sophistication is at a modern level[4].

3.7 SWOT analysis

To reach a more advanced level, it is necessary to develop a strategy for developing each technology component. Therefore, a SWOT analysis is carried out on each element to see the right and targeted development strategy. The first thing to do is to determine strategic factors for internal and external conditions for each technology component. Next, the weight and rating of each element will be calculated. Next, the score, IFAS and EFAS scores and the x and y points will be calculated for each component. Point x and y are then drawn into the Grand Matric SWOT diagram, as shown in Figure 3.

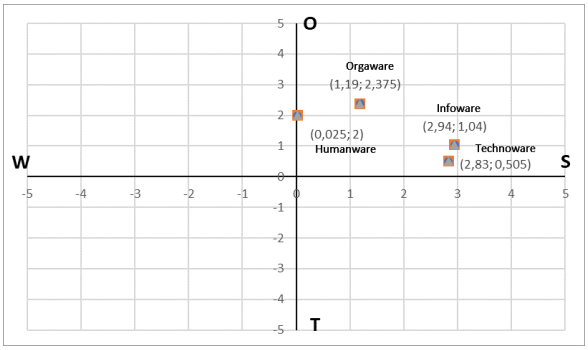

Fig. 3. SWOT Grand Matric Diagram

The results of the calculation of the IFAS and EFAS values can be seen in Table 9.

Table 5. Total IFAS and EFAS Score

Component	IFAS Total Score	Total EFAS Score
Technoware	3.79	3,555
Humanware	3.025	3.60
Infoware	3.50	3.28
Orgaware	3.50	3,575

IFAS and EFAS values of technoware components are interpreted into the IE (Internal-External) matrix to see the type of strategy used by the research object. The mapping results in the IE matrix show that a good strategy used in managing the four technology components is in a growth and survival position, which occupies the cell I position. The strategy adopted by SMA Unggul Del on the technoware component is to increase the specifications on each device that is not yet up to date. As well as developing and updating each facility on a regular basis. In the humanware component, maintaining the qualifications of school principals, laboratory assistants, librarians and special service officers. SMA Unggul Del also needs to improve teacher qualifications by increasing the percentage of teachers with educator certificates. Adjustment of the ratio of BK teachers and students to the correct number is also needed, namely a ratio of 1:150). In the infoware component, maintaining the characteristics of the syllabus and developing 100% lesson plans and qualified learning documents. It is also necessary to use existing technology to the maximum extent possible in the learning process. In the orgaware component, maintain budget management that supports the development of students and the workforce and the facilities used while still adjusting to needs and standards.

4 Conclusion

Based on the research, it can be concluded that an assessment instrument is obtained for the degree of technological sophistication of the four technology components. The instrument made consists of 10 criteria, 43 sub-criteria and 94 sub-criteria that are relevant to the study. The contribution value of the blended learning technology component of SMA Unggul Del in the components of technoware, humanware, infoware and orgaware are 0.76, 0.84, 0.96 and 0.86, respectively. The highest component contribution is the infoware component, and the lowest contribution is the technoware component. The Technology Contribution Coefficient (TCC) value of the four components of blended learning technology at SMA Unggul Del is 0.83, which is classified as an excellent qualification with modern sophistication. Based on the SWOT analysis, all components (technoware, humanware, infoware and orgaware) are in quadrant I with the relevant aggressive growth strategy.

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