MAPPING SMA/MA IN SURAKARTA CITY USING MULTIDIMENSIONAL SCALING

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ABSTRACT
The Competency-Based National Examination (CBNE) was held in 2019. The quality of schools can be determined based on the results of it. The purpose of the study was to map high schools / MA in Surakarta City based on its scores in 2018/2019. The number of SMA/MA is 33, both public and private. Data analysis using multidimensional scaling based on the characteristics of CBNE scores in the Indonesian, English, Mathematics, Physics, Chemistry, and Biology exam subjects. The results showed that there were four groups. They were mapped based on the level of similarity of CBNE scores with the characteristics in each exam. SMA/MA mapping is expected to help the community in choosing schools based on the competencies to be developed by students. School clustering means that there is educational inequality in the context of learning outcomes. This is influenced by a wide variety of factors. This research is expected to be the first step for further research in improving student learning outcomes.
Keywords: Learning Achievement, Mapping, Classification

PRELIMINARY

Indonesia implemented the Computer-Based National Examination (CBNE) in the 2018/2019 academic year. Students take the National Examination using a computer as their examination medium. CBNE is carried out to determine student achievements at each level of education based on competency. CBNE was implemented for the first time in 2014 on a limited basis in several junior high schools. The implementation of the CBNE is carried out in stages every year by increasing the participation of schools, both at the SMP/MTs and SMA/MA levels (Pernamawati et al., 2021).

Every school at Indonesia has different facilities. Not all schools have adequate computers to carry out CBNE (Ula & Nawangsari, 2018). The CBNE is carried out using computer media, replacing the paper-based National Examination or what is called the Paper-Based Test (PBT). The Ministry of Education and Culture allows schools with limited availability of computers to be able to carry out CBNE in other schools where the availability of computers is greater. The CBNE was last implemented in 2019. The CBNE

is used as a guideline in determining school quality. The exam subjects at CBNE at the SMA/MA level include Indonesian, English, Mathematics, Physics, Chemistry and Biology.

The higher the level of education, the fewer the number of schools in each region. The choice of educational level at the top level is a separate consideration. The upper level of education was chosen to be researched concerning school mapping. SMA/MA, both public and private, will be mapped based on the level of similarity between CBNE scores and the characteristics of each exam subject. The SMA/MA that will be mapped is in the city of Surakarta. It is hoped that the SMA/MA mapping will help the community in choosing schools based on the competencies that will be developed by students.

Multidimensional scaling (MDS) is a technique for mapping SMA/MA in the city of Surakarta. Mapping is done by looking for the closest distance. MDS is used to classify many indicators to determine an attribute (Khademi, 2023). The attribute used in this research is the CBNE score with the characteristics of the scores in each exam subject.

Multidimensional scaling is an algorithm technique in multivariate analysis by determining the coordinates of object points in a dimensional space based on the shortest distance between one point and another (Lichtenberg & Tasissa, 2023) . In multivariate analysis, data is expressed in matrix, for example, a matrix A with a size $n \times m$, n is the number of rows and m is the number of columns. The matrix A can be expressed as follows.

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1m} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nm} \end{bmatrix}$$

MDS aims to find a matrix A with size $n \times m$ and produces point coordinates based on the closest distance between one object and another (Mair et al., 2016).

The purpose of this research was to map SMA/MA in Surakarta based on CBNE scores in 2018/2019. They were mapped based on the level of similarity of CBNE scores with the characteristics in each exam. CBNE score consists of English, Mathematics, Physics, Chemistry, and Biology. SMA/MA mapping is expected to help the community in choosing schools based on the competencies to be developed by students.

Space- Euclidean$n$

Definition. If n is a positive integer, ordered-n-tuple is a sequence of real numbers n $(a_1, a_2, a_3, \ldots, a_n)$. The collection of all *ordered-n-tuples* is called Euclidean n-space and is expressed as R^n.

Theorem. If $u = (u_1, u_2, \ldots, u_n)$ and $v = (vektor\ inside\ R^n)$

a.   The Euclidean inner product between vectors u and v is expressed as

$$u.v = u_1 v_1 - u_2 v_2 - \cdots - u_n v_n$$

b.   The Euclidean length of the vector u inside R^n is expressed

$$|u| = (u.u)^{\frac{1}{2}} = \sqrt{u_1^2 + u_2^2 + u_3^2 + \cdots + u_n^2}$$

Euclidean distance

Distance Eucledian is one of the distance concepts in multivariate analysis. Other distance concepts are statistical distance and Mahalanobis distance. Euclidean distance is the direct and straight distance from one point to another. In the second dimension, distance calculations use the Pythagorean formula. The Euclidean distance equation in dimension two is

$$d_{ij} = \sqrt{\sum_{k=1}^{2} (x_{ik} - x_{jk})^2}$$

with d_{ij} = distance between the ith object and the jth object

x_{ik} = the results of measuring the ith object in the variable k

d_{jk} = the result of measuring the jth object in the variable k

$i\ dan\ j$ = index for object

Eigenvalues and Eigenvectors

Suppose matrix A is size $n \times n$, the eigenvectors of matrix A are scalar multiples (λ) of X. The equation can be written as follows

$$AX = \lambda X$$

Or

$$\begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ \cdots \\ x_n \end{pmatrix} = \lambda \begin{pmatrix} x_1 \\ x_2 \\ \cdots \\ x_n \end{pmatrix}$$

$$(a_{11} - \lambda)x_1 + a_{12}x_2 + \cdots + a_{1n}x_n = 0$$
$$a_{21}x_1 + (a_{22} - \lambda)x_2 + \cdots + a_{2n}x_n = 0$$

$$\ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots$$

$$a_{n1}x_1 + a_{n2}x_2 + \cdots + (a_{nn} - \lambda)x_n = 0$$

The equation will have a non-trivial solution if and only if $\det (A - \lambda I) = 0$. This equation will produce a multiterm equation of degree n in λ. The roots of the polynomial

equation are called eigenvalues. Meanwhile, the eigenvector is a non-trivial solution for each eigenvalue.

Stress (Standardized Residual Sum of Square) and R^2

Stress is a measure of incompatibility (a lock of fit measurement). The higher stress value, more unsuitable or ugly the mapping is. The stress value can be calculated using a formula (F Cox & Cox, 2000)

$$Stress = \sqrt{\frac{\sum_{i=1}^{n} \sum_{j=1}^{n} (d_{ij} - \hat{d}_{ij})^2}{\sum_{ij}^{n} d_{ij}^2}}$$

with $\quad d_{ij}$ = distance between the ith object and the jth object

$\hat{d}_{ij}$ = the difference from the coordinate points formed

At the Stress value, there is an iteration which is a movement of all points in the plot to produce the best solution. Iterations will run as minimally as possible (Mair et al., 2016). Interpretation of stress values according to Kruskal (NCSS Statistical Software, n.d.) regarding model suitability can be shown in Table 1.

Table 1. Model Suitability

Stress Value (%)	Criteria
0 – 2.49	Perfect
2.5 – 4.99	Very good
5 – 9.99	Good
10 – 19.99	Enough
>20	Bad

R-square can also be used to see how feasible the model that has been produced is. In MDS results, R-square shows the proportion of variance in the data that can form a model. R-square is said to be good if the resulting value is close to one (Chicco et al., 2021).

METHODS

The methodology in this research is quantitative with multidimensional scaling statistical methods. This research uses secondary data taken from https://puspendik.kemdikbud.go.id/. The number of SMA/MA, both public and private in Surakarta, is 33 schools. There are 10 public SMA/MA schools, while there are 23 private SMA/MA schools. The data used are the results of the CBNE (Competency-Based National Examination) for the 2018/2019 academic year. Test scores are taken in Indonesian Language, English, Mathematics, Physics, Chemistry and Biology.

The data analysis used in this research is multidimensional scaling (MDS). MDS algorithms are divided into two categories, namely metric MDS (if the scale used is an interval or ratio scale), and nonmetric MDS (if the scale used is an ordinal scale) (Gudono, 2017). The type of data in this research is a ratio scale, so the analysis used is the MDS metric. The ratio scale is the highest scale which has an absolute value of 0. This means that a value of 0 indicates that the attribute being measured does not exist at all (Azwar, 2021).

The multidimensional scaling concept in the research is to present a mapping of SMA/MA based on the characteristics of CBNE scores, namely Indonesian, English, Mathematics, Physics, Chemistry, and Biology exam subjects, into a set of coordinates in dimensional space. School objects A and B are said to be a pair if they have the closest distance between the other alternative pairs. So, it will produce a mapping of existing objects.

The stages in the MDS metric include:
1. Determine the distance matrix using the Euclidean formula
2. Determining eigenvectors
3. Determining object coordinates based on eigenvectors
4. Create an object mapping plot
5. Calculating Stress and RSQ values.

RESULT AND DISCUSSION

The initial step in MDS analysis is calculating the Euclidean distance. Then, carry out analysis with MDS. The coordinates of each SMA/MA in Surakarta can be determined in 2-dimensional space with MDS. The results can be seen in Table 2.

Table 2. Dimensions SMA/MA in Surakarta

Number	School	Dimensions	
		1	2
1	SMAN 1	2.4359	0.1309
2	SMAN2	0.725	0.1543
3	SMAN3	1.6883	0.3049
4	SMAN4	2.2382	0.151
5	SMAN5	1.0308	0.1564
6	SMAN6	0.2284	-0.1303
7	SMAN7	0.7679	0.115
8	SMAN8	-0.2908	-0.2232
9	SMAAlIsl	0.3224	-0.6857
10	AlMua High School	-1.2239	-0.0322

Number	School	Dimensions	
		1	2
11	SMABatik	-0.0551	-0.1805
12	SMABat_1	-1.0788	-0.3716
13	Islamic High School	-0.7547	-0.7056
14	SMAIsl_1	-1.9434	1.1409
15	SMAKrist	0.2068	-0.5584
16	SMACri_1	-3.4892	-0.0642
17	Widya High School	-0.7166	2.0045
18	MTA	0.3354	-0.2867
19	SMAMuh1	0.1156	0.0245
20	SMAMuh2	-0.7945	-0.1591
21	SMAMuh3	-2.3268	0.7647
22	Pangu High School	0.1213	0.0496
23	SMARegin	1.6032	0.0889
24	Citizen High School	0.0833	-0.7515
25	SMACri_2	1,987	0.8528
26	AlAbi High School	0.7892	-0.0972
27	SMAMuhPK	1,404	-0.3837
28	BinaW High School	-0.6279	0.4402
29	MAN1	0.4426	0.1251
30	MAN2	-0.4908	-0.3011
31	MAAlKahf	-1.4165	-0.9642
32	MAAlISla	-0.3517	0.0464
33	MAAlMuay	-0.9647	-0.6548

Based on the results of the stimulus coordinates, a SMA/MA mapping graph can be created in the city of Surakarta. Figure 1 is the graphic display.
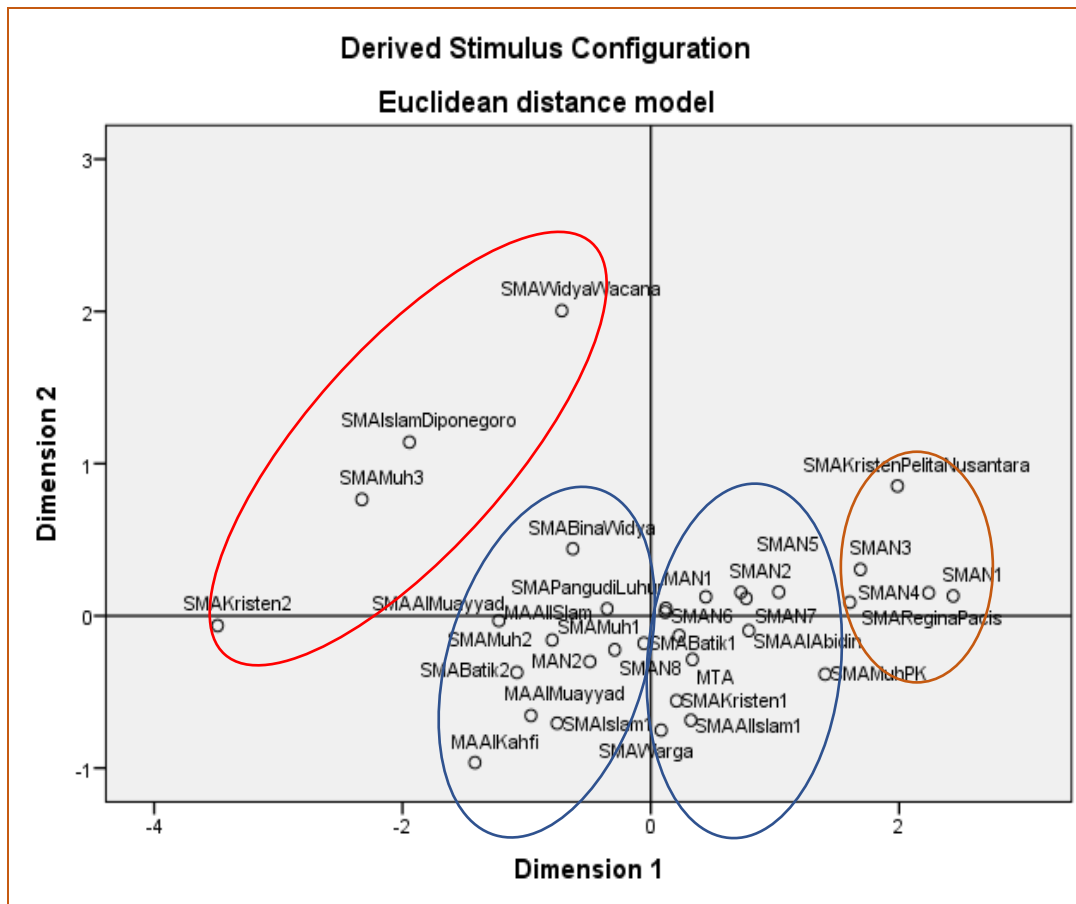
Figure 1. Mapping graph of SMA/MA in Surakarta City

Figure 1 shows the mapping of SMA/MA in Surakarta City based on CBNE scores, namely Indonesian, English, Mathematics, Physics, Chemistry, and Biology subjects. There are four quadrants in school mapping with a central point (0,0), namely quadrant I located at the top left, quadrant II located at the top right, quadrant III at the bottom right, and quadrant IV at the bottom left.

School mapping is carried out using the shortest distance between objects (without looking at the quadrant location). Proximity can be said to mean that these objects have similar CBNE values. Mapping is carried out subjectively, including:

1. Group I includes: Widya Wacana High School, Diponegoro Islamic High School, Muhammadiyah 3 High School, and Christian 2 High School.
2. Group II, includes: SMA Bina Widya, SMA Pangudi Luhur, SMA Al Muayyad, MA Al Islam, SMA Muhammadiyah 1, SMA Muhammadiyah 2, SMA Batik 2, MAN 2, SMAN 8, SMA Batik 1, MA Al Muayyad, SMA Islam 1 , and MA Al Kahfi.

3. Group III, includes: SMAN 2, SMAN 5, SMAN 6, SMAN 7, MAN 1, SMA Al Abidin, MTA, SMA Kristen 1, SMA Al Islam 1, SMA Muhammadiyah Special Program, and SMA Warga.

4. Group IV, includes: SMAN 1, SMAN 3, SMAN 4, SMA Regina Pacis, and SMA Kristen Pelita Nusantara.

They were mapped based on the level of similarity of CBNE scores with the characteristics in each exam. CBNE score consists of English, Mathematics, Physics, Chemistry, and Biology. The fiveth score is sought on average to determine the closest distance. There are four groups formed, namely gorup I, group II, group III, and group IV. Group IV has a higher CBNE score than the other groups. Meanwhile, the group that had the lowest CBNE score was Group I. Group III obtained a higher CBNE score than Group II, but not better than Group IV.

The next step is to calculate the stress value and RSQ value. Calculation of Stress (Standardized Residual Sum of Square) and RSQ (Residual Sum of Square) values was carried out using SPSS software. The resulting stress value was 0.05818 or 5.818%, classified as good. The RSQ value is 0.99192. It can be seen at Tabel 3.

Tabel 3. Result Stress and RSQ

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                    For   matrix
      Stress  =   ,05818      RSQ =   ,99192
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The model can explain the mapping characteristics by 99.19%. The mapping model can be used if the RSQ value is at least 0.6 (Chawla & Sondhi, 2011). This means that this model can be used to describe the mapping of SMA/MA in Surakarta City according to CBNE scores, namely Mathematics, Chemistry, Physics, Biology, Indonesian, and English exam subjects.

Education is the right of all Indonesian citizens. School clustering means that there is educational inequality in the context of learning outcomes. This is influenced by a wide variety of factors. This pre-elementary research study is expected to be the first step for further research in improving student learning outcomes. Mapping schools as basic research to find out the clustering of CBNE score gaps, so that subsequent research can be used as a basis for sample selection to see the quality of education. Mapping schools as basic research to find out the clustering of UTBK score gaps, so that subsequent research

can be used as a basis for sample selection to see the quality of education. It will help parents in determining school selection based on CBNE scores.

Educational success is not only influenced by the quality of the school but is also influenced by the role of family and school partnerships (Novita et al., 2023). Teachers can encourage all families to achieve parents' goals related to the quality of education (Rodríguez-Bravo & Murga-Menoyo, 2023). Apart from that, school leadership influences student academic achievement which will affect school quality (Ahmed et al., 2022). Teachers' causal beliefs about the quality of education influence school characteristics. Teacher causal beliefs mean believing that income satisfaction and decision-making power are the most important relational factors. Apart from that, careful planning is the most important factor in improving the quality of learning (Olivos & Yuan, 2023). Inductive reasoning must be involved in developing science competencies (Wicaksono & Korom, 2023). Thus, educational strategies can be implemented to develop science competencies. Interesting teaching methods, good teacher explanations, and teachers being able to motivate students are part of success in improving the quality of teaching (Šťastný & Chvál, 2023). The quality of teaching and learning experiences can be seen from the teacher's ability to build relationships with students and the teacher's ability to maintain communication with colleagues (Jaekel et al., 2023). This will have an impact on school quality.

Increasing school efficiency is based on the number of students, the competence of teachers and teaching staff (Lin & Yu, 2023). The quality of schools is influenced by several factors, such as teacher performance (Dina et al., 2022), learning process, curriculum, human resources, facilities and infrastructure, academic atmosphere, finance, and governance (Sy, 2022). Quality education can be seen from good planning system, governance system, good teacher with quality components (Elvira, 2021). School quality is related to school characteristics, student characteristics, and families (Dimiski, 2023).

CONCLUSION

Based on the results of mapping with MDS, there are four SMA/MA groups in Surakarta City based on similarities in CBNE scores, namely Mathematics, Chemistry, Physics, Biology, Indonesian and English. The division of groups includes: group I contains four schools (Widya Wacana High School, Diponegoro Islamic High School, Muhammadiyah 3 High School, and Christian 2 High School); Group II consists of 13 schools (SMA Bina Widya, SMA Pangudi Luhur, SMA Al Muayyad, MA Al Islam, SMA

Muhammadiyah 1, SMA Muhammadiyah 2, SMA Batik 2, MAN 2, SMAN 8, SMA Batik 1, MA Al Muayyad, SMA Islam 1, and MA Al Kahfi); group III includes 11 schools (SMAN 2, SMAN 5, SMAN 6, SMAN 7, MAN 1, SMA Al Abidin, MTA, SMA Kristen 1, SMA Al Islam 1, SMA Muhammadiyah Special Program, and SMA Warga); and group IV consists of 5 schools (SMAN 1, SMAN 3, SMAN 4, SMA Regina Pacis, SMA Kristen Pelita Nusantara).

SMA/MA mapping is expected to help the community in choosing schools based on the competencies to be developed by students. School clustering means that there is educational inequality in the context of learning outcomes. This is influenced by a wide variety of factors. This research is expected to be the first step for further research in improving student learning outcomes.

REFERENCES

Ahmmed, S., Saha, J., & Tamal, M. A. (2022). An Empirical Study For Determining The Quality Indicators For The Primary And Secondary School Of Bangladesh: A Structural Equation Modeling Approach. *Heliyon*, *8*(10), e10870. https://doi.org/10.1016/J.HELIYON.2022.E10870

Azwar, S. (2021). *Penyusunan Skala Psikologi* (Ke-tiga). Pustaka Pelajar.

Chawla, D., & Sondhi, N. (2011). *Research Methodology: Concepts and Cases - Deepak Chawla &*. Vikas Publishing House Pvt Ltd.

Chicco, D., Warrens, M. J., & Jurman, G. (2021). The Coefficient Of Determination R-Squared Is More Informative Than SMAPE, MAE, MAPE, MSE And RMSE In Regression Analysis Evaluation. *PeerJ Computer Science*, *7*, 1–24. https://doi.org/10.7717/PEERJ-CS.623/SUPP-1

Dimiski, A. (2023). How Does Pre-School Attendance Affect School Performance? An Application Of Gini-BMA Methodology On PISA 2018 Dataset. *The Journal of Economic Asymmetries*, *28*, e00321. https://doi.org/10.1016/J.JECA.2023.E00321

Dina, A., Yohanda, D., Fitri, J., Hakiki, M., & Sukatin (2022). Teori Kinerja Guru Dalam Meningkatkan Mutu Pendidikan. *Jurnal Edukasi Nonformal*, *1*(1), 149–158. https://ummaspul.e-journal.id/JENFOL/article/view/4009.

Elvira, E. (2021). Faktor Penyebab Rendahnya Kualitas Pendidikan dan Cara Mengatasinya (Studi pada : Sekolah Dasar di Desa Tonggolobibi). *Iqra: Jurnal Ilmu Kependidikan Dan Keislaman*, *16*(2), 93–98. https://doi.org/10.56338/iqra.v16i2.1602

F Cox, T., & Cox, M. (2000). Monographs On Statistics And Applied Probability. *Hand The* (Vol. 101). Chapman & Hall/CRC.

Gudono. (2017). *Analisis Data Multivariat* (Keempat). BPFE-Yogyakarta.

Jaekel, A. K., Fütterer, T., & Göllner, R. (2023). Teaching Characteristics In Distance Education—Associations With Teaching Quality And Students' Learning Experiences. *Teaching and Teacher Education*, *132*, 104174. https://doi.org/10.1016/J.TATE.2023.104174

Khademi, A. (2023). Investigating Test Content Structure Using Multidimensional Scaling. *Research Methods in Applied Linguistics*, *2*(2), 100047. https://doi.org/10.1016/J.RMAL.2023.100047

Lichtenberg, S., & Tasissa, A. (2023). A Dual Basis Approach to MultidimensionalScaling. *Linear Algebra and Its Applications*, 682, 86-95. https://doi.org/10.1016/J.LAA.2023.11.004

Lin, Y. C., & Yu, M. M. (2023). Performance Evaluation Of Compulsory Education System In Taiwan: A Modified Dynamic Network Data Envelopment Analysis Approach. *Studies in Educational Evaluation*, *78*, 101280. https://doi.org/10.1016/J.STUEDUC.2023.101280

Mair, P., Borg, I., & Rusch, T. (2016). Goodness-of-Fit Assessment in Multidimensional Scaling and Unfolding. *Multivariate Behavioral Research*, *51*(6), 772–789. https://doi.org/10.1080/00273171.2016.1235966

NCSS Statistical Software. (n.d.). Multidimensional Scaling (Chapter 435). *Statistical Software*. National Council for the Social Studies.

Novita, S., Schönmoser, C., & Lipowska, M. (2023). Parent And Teacher Judgments About Children's Mathematics And Reading Competencies In Primary School: Do Parent Judgments Associate With Children's Educational Outcomes?. *Learning and Individual Differences*, *105*, 102302. https://doi.org/10.1016/J.LINDIF.2023.102302

Olivos, F., & Yuan, X. (2023). Teachers' beliefs about educational quality: Examining the power of school settings through survey experiments. *Teaching and Teacher Education*, *129*, 104140. https://doi.org/10.1016/J.TATE.2023.104140

Pernamawati, S., Kritiawan, M., & Fitria, H. (2021). Analisis SWOT Ujian Nasional Berbasis Komputer. *Jurnal Manajemen, Kepemimpinan, Dan Supervisi Pendidikan*, *6*(1), 112–123. https://jurnal.univpgri-palembang.ac.id/index.php/JMKSP/article/view/4038/3923

Rodríguez-Bravo, A. E., & Murga-Menoyo, M. Á. (2023). Analysis of parental goals according to family variables *In Implications for quality education in secondary education*. *Heliyon*, *9*(9), e19740. https://doi.org/10.1016/J.HELIYON.2023.E19740

Šťastný, V., & Chvál, M. (2023). Different Subjects, Different Incentives: Private Tutoring And Perceived Instructional Quality In Czech Lower-Secondary Schools. *International Journal of Educational Development*, *98*, 102737. https://doi.org/10.1016/J.IJEDUDEV.2023.102737

Sy, S. H. (2022). Urgensi Mutu pada Lembaga Pendidikan. *Ideas: Jurnal Pendidikan, Sosial, Dan Budaya*, *8*(3), 697. https://doi.org/10.32884/ideas.v8i3.841

Ula, S. M., & Nawangsari, E. R. (2018). Implementasi Ujian Nasional Berbasis Komputer (Computer Based Test, CBT) Di SMP Negeri 1 Sidoarjo Kabupaten Sidoarjo. *Dinamika Governance : Jurnal Ilmu Administrasi Negara*, *7*(1), 1–16. https://doi.org/10.33005/jdg.v7i1.1193

Wicaksono, A. G. C., & Korom, E. (2023). Role Of Inductive Reasoning, Gender, Learning Satisfaction, And Educational And Career Preference In Predicting Scientific Competency In High School. *Thinking Skills and Creativity*, *49*, 101376. https://doi.org/10.1016/J.TSC.2023.101376