Journal of Engineering and Applied Sciences 12 (10): 2710-2714, 2017
ISSN: 1816-949X

Educational Effectiveness Evaluation using Hybridization of Input-Output Model and Clustering Analysis Method: Indonesian Data

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Abstract: In system-level educational monitoring, Indonesian Ministry of Education and Culture publishes statistical data of education every year. The data are used to evaluate the educational development in Indonesia. But when it comes to educational effectiveness, the topic is not yet an issue. Some publications had been discussed about educational effectiveness by focusing on observing the educational substances. Moving from recent effectiveness issue condition, this research is trying to give a different point of view by using educational data from the government to evaluate the educational effectiveness. The hybridization of input-output model and clustering analysis is introduced in this study as a new approach to evaluate the educational effectiveness. As the result of the method's usage even though it could not explicitly measure the effectiveness rate, the method may estimate the effectiveness relative to all members. Based on the data, it could be inferred that the effectiveness of educational development is 85, 88 and 76% for elementary school, junior and senior high school, respectively.

Key words: Educational effectiveness, hybridization method, clustering, input-output model, monitoring

INTRODUCTION

Educational effectiveness is part of education research area which is need to be paid a more attention because of its role of monitoring. Based on (Scheerens, 2016) there are several level of effectiveness which are system-level, school-level and classroom-level. Based on those effectiveness domain level, there are many researches have been conducted in order to observe, evaluate or developing concept and method related to each level of effectiveness domain. Classroom level effectiveness is the level which have many researchers work on. This level basically related to teaching method effectiveness. Kao *et al.* (2015), Lin and Wei (2011) observed the impact and effectiveness of the usage of technology in education. While Van Damme and Ellet observing effectiveness in school level. Damme investigates the educational effectiveness in secondary schools in flanders (Damme *et al*., 2002) while Ellet investigates school effectiveness in USA (Ellett and Teddlie, 2003). Whilst in system-level, Suryadarma tried to explain about the impact of corruption to education (Suryadarma, 2012) and Van Der Werf explained the usage of effectiveness model to evaluate the school improvement.

When it comes to system-level monitoring educational effectiveness, Scheerens works a lot on it by conceptualizing and designing the effectiveness model (Scheerens, 2001a, b; Scheerens *et al*., 2011) based on input-process-output model. Input-output model actually a generic monitoring model which is stressing on the correlation between input and output by skipping out the process in-between them. Recently, the educational monitoring and evaluation in Indonesia is using the statistical data from the Ministry of Education and Culture by evaluating per indicators while effectiveness is not yet an issue.

Clustering is a method which is focusing on grouping a set of unlabelled data (Soni, 2012). Clustering has the ability to put the similar objects into a certain group and put the dissimilar objects into another group. In case that the standard specification of an object existed, the groups which are formed on the clustering process could be ranked by comparing to each other. When the rank refers to effectiveness and the standard of educational effectiveness occurs then the effectiveness could be evaluated by comparing groups to each other.

Based on the previous publications, there are many researches which are discussing about effectiveness measurement results and methods. But all of this researches are exclusively conducted for particular cases (e.g., the school effectiveness in developing countries (Scheerens, 2001a, b), effectiveness of school types (Bedi and Garg, 2000), etc. The existence of educational data which is annually published by Ministry Education and Culture could be used as an educational effectiveness measurement material. In essence this research is focusing on how the educational effectiveness evaluation could be

utilizing the data which is provided by the government. And for that purpose, the hybridization method of input-output model and clustering analysis is introduced here.

MATERIALS AND METHODS

In this research, hybridization may refer to combining two or more technologies/techniques to solve problems. Technologies here refer to the input-output model and the clustering analysis. The input-output model is often used to evaluate system performance. Black box evaluation technique uses the model to observe whether a certain input corresponds to the desired output or not while clustering analysis is generally used to separate a dataset into several groups based on the similarity of their members. By combining those two, hopefully it could give a new perspective of educational effectiveness evaluation. In general, the hybridization methodology could be separated into three activities which are model preparation, clustering analysis preparation and the hybridization (implementation and observation).

Input-output model preparation: The model which are going to be used is adapted from the basic system model which are proposed by Scheerens *et al.* (2011) and could be seen in Fig. 1. Formerly, to measure the effectiveness, Scheerens use the OECD education indicators which are positioned in each of component (context, inputs, process and outputs).

Because the hybridization has to use indicator's values to do the clustering and due to limitation of the existing data, the basic system model need to be adjusted (Wijayanto, 2016). The adjusted model is as it shown in Fig. 2. The adjusted model has been already equipped by indicators which is provided by Ministry of Education and Culture and the placement is assumed to be correct based on the consideration of each role to the model component. The adjustment to the model is being done because of the consideration the indicators on each component may not compatible to the original model. The context component is deciphered into educational support which is confined to have influence only to the process. Input component is defined as anything which related to educational input (e.g., student's or their family's passion towards education). The process is assumed to be similar in all of provinces (because Indonesia has a standard curriculum) so it will be a constant factor in this research. And the output is defined to be something which are related to educational output (e.g., completion, result of study). The educational effectiveness evaluation does not take the educational substance evaluation into account, because there are no data provided yet by the government.

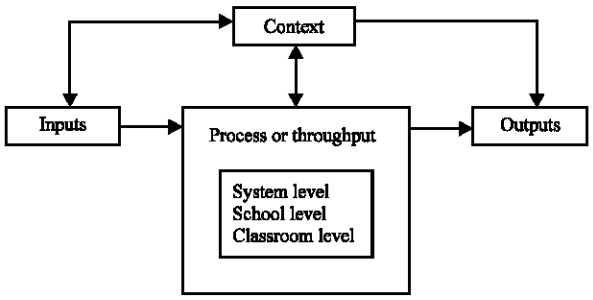

Fig. 1: Scheeren's basic system model (Scheerens *et al.*, 2011)

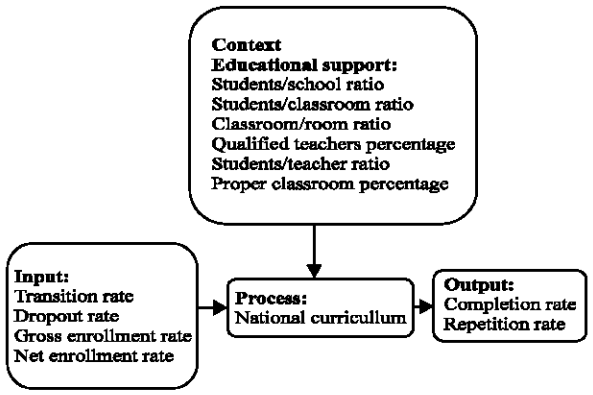

Fig. 2: The adjusted systems model for Indonesian education (Wijayanto, 2016)

Clustering analysis preparation: This effectiveness analysis has its limitation related to clustering analysis due to its behaviour which is merely focusing on grouping a set of unlabelled data (Soni, 2012). Because it is only focussing on grouping, the only possible thing to do is comparing those groups based on the within sum of square result. The analysis will use hierarchical method, specifically using complete link method because it is distance based clustering method so the process of grouping is trackable and could be visualize using a dendrogram. Moreover, by using complete link method, it could avoid the chaining effect and focus on the outlier. Focusing on the outlier may be useful to detect the unusual behaviour.

From school statistical data which is provided by Ministry of Education and Culture (Pendidikan, 2012), the dataset is then extracted, structured and normalized before it could be used in clustering analysis. The clustering will be implemented to three components of the model in Fig. 2 (excluding the process component). Each model's component will be considered as a separate.dataset which will be clustered. So, the number of clusters are also estimated for each component's dataset.

Table 1: Standard value per indicator

Indicators	Unit	Elementary school	Junior high school	Senior high school
Students/school ratio	Students	168	288	384
Students/class ratio	Students	28	32	32
Class/classroom ratio	Class	1	1	1
Qualified teachers	Percentage	100	100	100
Completion rate	Percentage	100	100	100
Students/teachers ratio	Students	18	18	19
Repetition rate	Percentage	0	0	0
Dropout rate	Percentage	0	0	0
Proper classroom	Percentage	100	100	100
Enrollment rate	Percentage	100	100	100
Gross enrollment rate	Percentage	-	100	100
Transition rate	Percentage	100	100	100

The hybridization: The hybridization is performed by observing the results of the clustering which is implemented on each of component model. The observation follows linear function of the model. The observational function is defined using proportionality as follows:

$$O \propto I + pS = O \propto I + S$$

Where:

O = The output
I = The input
P = The process which is defined as constant due to standard condition with and assume to have value 1
S = The educational support

The observational function is not to be computed but just for observing the relation among model's components. When the clustering algorithm is implemented on each component dataset (input support output) which is resulting clusters for every dataset, the observation is conducted to look at the rank of province's cluster on each component model. For example, a certain province which is grouped in the best cluster of input component and also grouped in the best cluster of support component is also projected to be in the best cluster of output component. It is because of proportionality assumption of model's components according to the function. When I and S both are the highest number possible and p is constant multiplier then O is also resulted the highest number possible.

In order to define the group's level, the within cluster sum of square (Within SS) is utilized. Within SS ranks the groups order by the results of the sum of square computation in each cluster correspond to standard value which is presented on Table 1. The Within SS is derived as:

$$\text{Within SS} = \sum_{i \in S_k} \sum_{x \in C_i} \text{dist}^2 (m_i, x)$$

Where:

S_k = The observation set in the kth cluster
m_i = The standard data point
x = A data point in cluster C_i

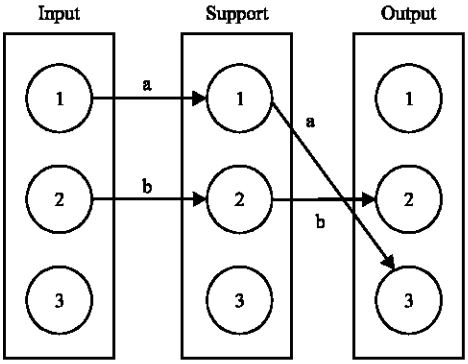

Fig. 3: The observation of cluster result: a) Ineffective relation and b) Effective relation

The observation is shown on Fig. 3. For example, after every component dataset in the model is clustered, it is assumed to obtain three groups of clusters off all component. The cluster's number in each component model indicates its quality, the lower the number the higher quality it has. Based on the proportionality concept, if a certain province has highest level of input and then supported by the highest quality of educational support then it should be resulted the highest quality of output. Because the relation resulted a lowest quality of output then it may conclude if there are an ineffectiveness in process. While relation could be derived as an effective relation.

RESULTS AND DISCUSSION

On the previous researches (Wijayanto, 2016), the method have been experimented on educational datasets from elementary school, junior and senior high school. The datasets are using the educational data on the year 2011-2012 (Pendidikan, 2012). After passing through the hybridization, the datasets are then presented in Table 2. Based on Table 2, it could be observed some unexpected results from certain provinces related to their educational performance. The green shading indicated over effective phenomenon and red shading is representing ineffective relation and the rests are effective relation. For example, West Sumatera, in elementary school level, it is considered ineffective because although, it is supported by the best support the output is only considered as a second level. That phenomenon also happens on its junior high school but on contrary the senior high school level is considered over effective because although it is supported by the second worst support but the output is the best.

The labelling whether it is ineffective or over effective is provisionally done by manual

Table 2: Hybridization experimental results (Wijayanto, 2016)

	Elementary school			Junior high school			Senior high school		
Provinces	Input	Support	Output	Input	Support	Output	Input	Support	Output
Special district of Jakarta	1	2	1	1	1	1	1	2	1
West Java	2	2	1	3	3	1	2	3	1
Banten	2	2	1	4	1	1	2	3	1
Central Java	2	1	1	3	1	1	2	1	1
Special district of Yogyakarta	1	1	1	1	1	1	1	3	1
East Java	2	1	1	2	1	1	2	2	1
Special district of Aceh	1	1	1	2	2	1	1	1	2
North Sumatera	2	1	1	2	1	1	2	2	1
West Sumatera	2	1	2	1	1	2	2	4	1
Riau	2	1	1	2	1	1	1	1	1
Riau Islands	1	3	1	1	1	2	2	1	2
Jambi	2	1	1	2	1	1	2	1	1
South Sumatera	2	1	1	3	1	1	2	1	1
Bangka Belitung	1	1	2	2	2	2	2	1	2
Bengkulu	2	1	1	3	1	1	1	1	1
Lampung	2	1	1	3	1	1	3	1	1
West Kalimantan	2	4	2	6	2	2	3	2	3
Central Kalimantan	2	4	1	5	2	1	2	4	3
South Kalimantan	2	4	2	4	2	1	3	1	1
East Kalimantan	1	1	1	2	2	1	2	2	1
North Sulawesi	1	4	1	2	2	2	1	1	1
Gorontalo	2	1	2	4	2	1	2	1	5
Central Sulawesi	2	4	2	4	3	1	3	1	3
South Sulawesi	2	1	1	2	1	1	2	1	1
West Sulawesi	2	1	2	4	3	1	2	5	1
Southeast Sulawesi	2	4	1	2	1	1	1	2	2
Maluku	2	1	1	2	2	1	1	2	2
North Maluku	2	4	1	2	3	1	1	4	2
Bali	1	1	1	1	3	1	1	2	1
NTB	2	1	1	2	1	1	2	5	1
NTT	2	1	2	5	2	2	3	1	6
Papua	1	5	2	6	2	2	3	1	4
West Papua	1	5	2	5	2	3	3	4	3

observation. Sometimes, it is difficult to decide whether it is effective or ineffective due to discrepancy among clustering results in each component model especially related to the difference in number of cluster. Dissimilarity in number of cluster will influence the distribution impact of each cluster group.

Based on Table 2, it could also be inferred that the effectiveness of educational development in elementary school is 85%. While the effectiveness for junior and senior high school is 88 and 76%, respectively. Furthermore, by using this observation, it could be highlighted right away when some provinces become ineffective.

CONCLUSION

Due to the monitoring issues of educational effectiveness in Indonesia, this hybridization could be used as an alert system. Aside from all of its limitation, the method could analyze the input-output relation which is influenced by the educational support. Even though it could not explicitly measure the effectiveness value, the method may estimate the effectiveness relative to all members.

Basically, this hybridization method is a general method which could be developed and adjusted due to difference circumstances (e.g., the component's indicators, component model adjustment, etc.). Due to the several assumptions which have been used in this research, several research enhancements opportunities open in the future (e.g., enhancement on the model, enhancement to the observational function or even taking account the presence of substantial indicators).

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