American Journal of Educational Research, 2020, Vol. 8, No. 3, 155-161
Available online at http://pubs.sciepub.com/education/8/3/5
Published by Science and Education Publishing
DOI:10.12691/education-8-3-5

Using DEA to Evaluate the Efficiency of Public High Schools for STEM Offering

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Received February 04, 2020; Revised March 06, 2020; Accepted March 14, 2020

Abstract The study examines the readiness of public senior high school for STEM track offering using Data Envelopment Analysis [DEA]. Efficiency of the schools were determined using input data such as student population, number of science teachers, teaching experience, educational qualification, number of classrooms, class size, teacher educational qualification, teaching experience, student-teacher ratio, science laboratory facilities, ICT laboratory, drop-out rate and budget for the school's operation and output data used was number of graduates. A total of 60 senior high schools were considered in the study and their school heads or principals and science teachers served as respondents. Findings indicated that a good number of public senior high schools are efficient based on the availability of science laboratory. Recommendations on how to improve less efficient schools are reflected in this paper. A program to motivate science teachers to pursue graduate studies in science and mathematics is recommended to be institutionalized as well as budget to provide adequate laboratory facilities may be provided to make the STEM strand offering a reality.

Keywords: *science education, data envelopment analysis, efficiency, STEM offering, science teacher*

Cite This Article: Christine C. Royo, and Maria Teresa M. Fajardo, "Using DEA to Evaluate the Efficiency of Public High Schools for STEM Offering." *American Journal of Educational Research*, vol. 8, no. 3 (2020): 155-161. doi: 10.12691/education-8-3-5.

1. Introduction

The rapid technological and scientific advancement that is happening all throughout the world demands that every individual is scientifically literate in order to respond properly. The new brand of education calls for educating the students is teaching them how to think, learn, solve problems and make informed decisions. Moreover, a country needs to enhance its capability in research and technology for global competitiveness through an effective and efficient science instruction or education. First world countries like the United States re-highlighted in 2010 the goal to provide STEM preparation for students by expanding the number of STEM schools from elementary to high school to ensure innovations in the 21st century. STEM excellence for the country is through preparation and inspiration of students for careers in STEM to develop STEM literate citizenry and STEM proficient workforce [1]. Various studies had looked into factors contributory to students' motivation to enter into STEM track. Among those identified to be associated with readiness for college and subsequent interest to pursue STEM are earlier exposure to science and mathematics content and efficacy in math [2], and rigorous curriculum with strong emphasis on real world problem solving and specialized research opportunities [1], and high quality STEM teaching [3].

The Philippine government recognizes the importance of developing its science and technology capability as a means of addressing the call for industrialization and globalization. The Philippines before was one of only three countries in the world and the only one in Asia that still had only 10 years in basic education. This has always been seen as a disadvantage for our students who are competing in an increasingly global job market. Thus, the K to 12 program was implemented last 2012 and was able to produce its first batch of graduates in 2018. The K to 12 program covers 13 years of basic education with the following key stages: Kindergarten to Grade 3, Grades 4 to 6, Grades 7 to 10 (Junior High School) and Grades 11 and 12 (Senior High School). Since the contents of the subjects that students will take in Grades 11 and 12 depend on their chosen career track, they must take extra care in making their choice. Tracks are categorized as academic and non-academic tracks. The academic track prepares students who plan to pursue college education and comprises four strands. These are:

a) ABM - Accountancy, Business, and Management
b) STEM - Science, Technology, Engineering, and Mathematics
c) HUMMS - Humanities and Social Science
d) General Academic

The next three tracks equip students with the skills needed to secure jobs in the field they want right after graduation from senior high school. These include:

a) Arts and Design- This track covers nine subjects, eight of which require 80 hours each per semester.

b)Sports - This track has nine subjects, which include Safety and First Aid, Human Movement, Coaching, Sports Officiating, and Sports Leadership.

c) TVL- This track contains nine subjects (known as the TVL track subjects) and TESDA specialized subjects. These are Home Economics, Agri-Fishery, Industrial Arts and Information and Communications Technology or ICT.

In order for the students to choose their senior high school specialization; they will undergo assessments to determine their strengths and interests. This will include an aptitude test, a career assessment exam, and an occupational interest inventory for high schools. According to DepEd, career advocacy activities will also be conducted to help guide students in choosing their specialization or track.

The offering of the STEM strand is a good strategy for the attainment of more than enough scientists, engineers and technologist in the country. This need was partly answered by the establishment of the 13 campuses of the Philippine Science High School (PSHS) throughout the country. The students of PSHS are required to take a science/math-related course in college, as specified under the Manpower Development Program of the Department of Science and Technology. The school system is supervised by the Department of Science and Technology (DOST), and is offering a curriculum with a focus on the sciences and mathematics to deserving Filipino children from any background. They are expected to take up a science & mathematics course in college and, hopefully, go for a career in science. One of the expected outcomes of DOST is the fostering highly capable and world competitive human resources in the fields of science and technology through national science and technology programs making PSHS [Philippines Science High School] a top level science high school in the ASEAN region by 2015 and assigning at least one DOST scholar to each town by 2016. Unfortunately, the total number of students in the 13 campuses of PSHS is only a small percentage when compared to the total high school students enrolled in public high schools throughout the country. One way to augment the number of students who are trained in science, math and technology is to increase the number of senior high schools offering STEM strand.

The government's updated Philippine Development Plan (PDP) 2011-2016, indicated the need for science and technology and higher education to play an important role in the effort to captivate high-quality and high productivity activities, such as the greater value-added parts of business process outsourcing, tourism, and some branches of industry. PDP also added that through a rationalization of the roles of higher education institutions and a finer delineation of their roles, the turnout of a critical mass of scientists, engineers, and other technical personnel shall be pursued to allow the country to climb the value-added ladder in sectors where it possesses global competitive potential. Research and development investments as well as policies on science and technology will boost factor productivity contribution to Philippine gross domestic product growth [4]. The National Academy of Science and Technology Philippines (2016) further cited that science, technology and innovation (STI) are also central elements in the elevation of a country which is an indispensable response to the country's challenges. It entails sufficient investment infrastructure to resources in science and technology (S&T) human resource development, research and development (R&D), and physical infrastructure in which the minimum number of scientists and technologists can be targeted and wanted for innovation-driven development. If such needs are addressed, industrial and agricultural productivity, overall efficiency, and abundant outputs of knowledge products such as scientific publications, patents, and innovations are results of the presence of highly-trained scientists and technologists. Thus, it able to provide the highly-trained professionals with material reward, productive working conditions, and social recognition.

The demands and challenges in Science Education do not revolve only on technological advancement. It has a great social importance especially from rural, urban, modern, and complex industrialized societies. Educators and researchers work hard to achieve in the holistic development of students as well as the delivering host (the teacher). We need citizens who can propel technological advances without sacrificing the environment.

The students' performance in the National Career Assessment Examination (NCAE) significantly correlates to the students' academic performance. The positive correlations of the students' performance plus the proper career assessment conducted can serve as guide for the learners in choosing the academic track provided that there are available schools nearby that can cater to the influx of STEM inclined students [5]. In assessing the readiness of STEM strand in the Division, the yardstick will be the DepEd issued memo containing the requirements for a STEM strand offering.

For a school to offer the STEM Track. The following are the requirements:

A. Teacher

- Teachers for the STEM Track are required to possess the following qualifications:
- Bachelor's Degree Holder with at least 15 units of specialization in the subject/s to handle (under the Teacher Preparation for Subject Matter: TOR and Certificates)
- Knowledgeable in using software that may aid in teaching specialization (under Special Training Required/Desired Training: Certificate/License/ Demonstration)
- Licensure Examination for Teachers (LET) passer (if not, should pass the LET within 5 years of teaching in the SHS (under LET/Professional License or Professional Education Training (CPE)
- Preferably 2 years of teaching experience (Teaching Experience: Certification)
- "Industry" /Work Place Experience: Certification/ Recommendation Preferably with 2 years of workplace experience (may be gained during the first five years of teaching in SHS)

B. Facilities and Infrastructure

Comprehensive floor plan (by storey if building/s is/are high rise) indicating the following with their size in sq. m. and maximum student capacity

- Instructional rooms for core subjects (including applied subjects if lab is not necessary)

- Laboratories computer lab (for applied and/or specialized subjects per curriculum offering)
- STEM laboratories (bio lab, chem lab, physics lab)
- Workshop room/ studios (for applied and/or specialized subjects per curriculum offering)
- Learning Resource Center or library Internet facilities
- Ancillary services (List laboratory/workshop equipment, apparatuses, tools, etc. by curriculum offering (refer to DepED's list of materials requirement per curricular offering)
- Certificate of Occupancy to ensure safety of classrooms/shop rooms

The present study determines the efficiency of public high schools for the offering of the STEM strand using Data Envelopment Analysis (DEA). The findings of the assessment can be a guide on the preparation for the offering of the STEM Strand to cater the interest of the students and for the future preparation of the needed manpower to run the various industries and enterprises in the province.

2. Material and Methods

The study's locale is the one of the Schools Divisions of the Department of Education. There are two (2) cities, and twenty (20) municipalities with five hundred forty five (545) public elementary schools and sixty one (61) public high schools. The study only include the randomly selected public high schools in the province. There are 60 senior high schools in the Division.

For the year 2019, there is no STEM strand offering among the 60 public high schools that offer senior high school. The respondents of the study were the secondary public high school science teachers and principals from randomly selected schools to represent the North and South geographic location in the Province. Other data that served as inputs for DEA (e.g. budget, drop-out rate) were be taken from the Division Office.

The data collected were processed using Data Envelopment Analysis (DEA). DEA is an objective method for comparing the relative efficiency of decision making units (DMUs) with the same multiple inputs and outputs. This method was originated by Charnes, Cooper and Rhodes (CCR) [6]. DEA is an efficiency estimation technique, but it can be used for solving many problems of management such as ranking of DMUs [7]. DEA divides DMUs into two groups—efficient and inefficient—while in practice, there is often a need to fully rank them. DEA may not provide enough information for ranking the efficient DMUs, in particular when there are insufficient DMUs or the number of inputs and outputs is too high relative to the number of DMUs [8]. DEA is a powerful benchmarking technique since it compares service units viewing all resources used and services provided as well as identify the most efficient units or best practice units and the inefficient units in which improvements are possible. DEA also calculates the amount and type of cost and resource savings by making each inefficient unit as efficient as the moist efficient or best practice units [9].

Input data for DEA includes student population, number of science teachers, teaching experience, educational qualification, number of classrooms, class size, teacher educational qualification, teaching experience, student-teacher ratio laboratory facilities, ICT Laboratory, drop-out rate and budget for the school's operation. Output data for DEA is the number of graduates.

3. Results & Discussion

The study profiled the science teachers in terms of educational qualification, years of experience and specialized training and seminars. Figure 1 reveals that majority of the science teachers are bachelors degree holder with more than half in the field of education and a quarter in non-education fields.

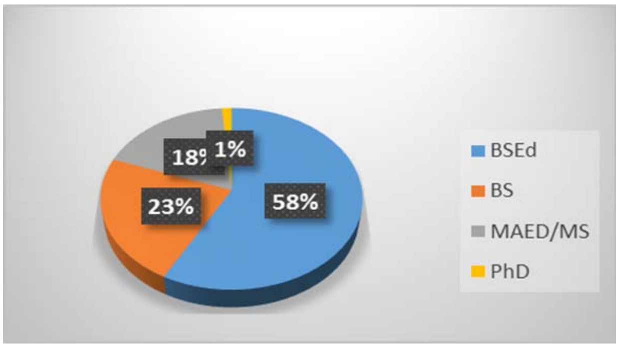

Figure 1. Education Qualification of Science Teachers

Figure 1 shows that of the 245 science teachers, 142 (58%) are BSEd (Bachelor of Secondary Education) with major in science (General Science, Biology, Chemistry, Physics) and math. However, 56 (23%) hold BS (Bachelor of Science) degree like Biology, Physics, Chemistry, Electrical Engineering, Nursing, Forestry, Environmental Science, and Physical Science. The table also reveals that 44 (18%) teachers are MAEd or MS holders and 3 (1%) PhD (Doctor of Philosophy) holders. As a whole, 198 (81%) are bachelor's degree holders and 47 (19%) earned master's and doctoral degree. There is a need to encourage the pursuit of graduate programs in the relevant field in order to improve the profile of teachers and make the offering of STEM strand more possible in a number of schools. The educational qualification of a teacher in their field of specialization will have a positive impact to the students learning. It will enhance the students' knowledge and increase the grasp of the content as the teacher has built in knowledge that he or she can impart to the learners. Science teachers with graduate education will improve teacher effectiveness [10]. A study also indicated that achievement in science were higher among students whose teachers had a master's degree, which reveal a significant positive association [11].

Figure 2 shows the teaching experience of science teachers in selected public high schools.

More than a quarter of the science teachers are new to the job and another 31% had handled science subjects for more than 5 years but less than 10 years. This data indicated that in terms of required teaching experience, most teachers will be eligible to teach in the STEM track.

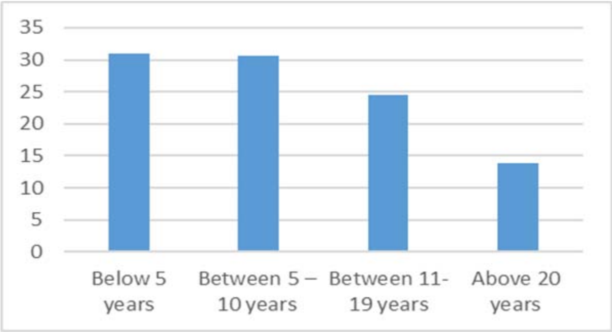

Figure 2. Teachers' Years of Experience in Teaching Science of the Selected Senior High School

Teaching experience is positively associated with student achievement gains throughout a teacher's career [12]. Gains in teacher effectiveness associated with experience are most steep in teachers' initial years, but continue to be significant as teachers reach the second, and often third, decades of their careers. Furthermore, as teachers gain experience, their students not only learn more, as measured by standardized tests, they are also more likely to do better on other measures of success, such as school attendance. It is observed that during the entire length of years rendered by a teacher in teaching science, effectiveness is strongest during the first few years of teaching [13]. Teachers with early experience in teaching showed favorable results with high impact in teacher effectiveness. There is also a gain in high productivity of teachers during the first few years of teaching, and then a decrease on the performance experience can follow [14]. Hence, supporting the teachers through well-designed professional development is an excellent strategy to make the teaching experience count.

Table 1 shows the most common professional development training provided to science teachers handling the senior high school.

Table 1. Teachers' Specialized Trainings and Seminars in Science of the Selected Senior High School in the Division of Bukidnon

	District A	District B	District C
	f (%)	f (%)	f (%)
Computer Literacy	56 (56.5)	24 (64.8)	78 (71.5)
How to Conduct Investigatory Projects	37 (37.3)	19 (51.3)	57 (52.3)
Science Content	87 (87.8)	35 (94.5)	88 (80.7)
Total Number of Teachers	99 (40.4)	37 (15.1)	109 (44.4)

Specialized trainings for teachers includes workshops, peer coaching and science conferences focus on science theories. Science teachers trained in science content give more information and learning to the students. The students are well equipped with the theories especially if knowledge is provided in hands-on learning. This is achieved if students are more on doing things that will give profound effect on learning in schools, particularly on science teaching [15]. As pointed out by National Science Education Standards [16], science content increases and changes thus, teacher's knowledge in science must keep pace. Training and seminars given to teachers offer efficient, quick, and practical knowledge of the subject matter as well as the teacher must be able to answer how, what, ifs and buts, as "science" is always equipped with curiosities. Aside from the basic qualities, the teacher must have vast experience and knowledge on issues to teach 21st century skills in science. It was argued that the three content standards related to the 21st century skills (information and communication skills, thinking and reasoning skills, and personal and workplace productivity skills), made students engaged in the process of learning science, to use scientific evidence to make decisions, and to apply science in everyday life through innovative science instruction [17].

Table 2 shows the variables considered in determining the efficiency of the school and the potential readiness for the offering of STEM track.

Table 2. Variables Used in the DEA efficiency Measurement

Inputs	Output
Student Population	Number of graduates
Number of Dropouts	
Number of Science Teachers	
Number of Classrooms	
Class size	
Available budget/allocation (MOEE)	
Laboratory & Equipment	
Teacher Education Qualification	
Teaching Experience in Science	
Teacher Student Ratio	

The efficiency is on the use of available resources (inputs) to produce the number of graduates (output). In the list of inputs, only laboratory, teacher educational qualification, and teaching experience are indicated in the requirement to offer a STEM track. The challenge faced by most schools is the availability of science laboratory and ICT laboratory which are major requirements in the offering of STEM track.

Table 3 shows the scores of efficient and less efficient selected senior high schools with science laboratory in the Division. As shown, senior high schools with efficiency scores of 1 are the efficient schools with science laboratory. However, efficiency scores of less than 1 are considered less efficient senior high schools.

The efficiency evaluation of schools with science laboratory shown in Table 3, and the succeeding Table 4-7 showed the results of the evaluated schools for potential improvements. These includes all the variables arranged in order from the viewed output number of graduates (NG) followed by all inputs: student population (SP); number of dropouts (ND); number of science teachers (NST); number of classrooms (NC); class size (CS); MOOE; lab equipment (LE); TEQ; number of teaching experience (NTE); and teacher-student ratio (TSR). In the efficiency reference sets (ERS) table, it showed Schools (DMUs) with science laboratory on the first column, the numerical order of the number of schools, followed by columns 3-6 for schools being evaluated or assessed.

The assessed school, SHS-1 was benchmarked with SHS-8, SHS-9, and SHS-3 using the three schools' output and input parameters in getting the efficiency percentage value as well as the percentage value for improvement of SHS-1. As shown, senior high schools with efficiency scores of 1 are the efficient schools with science laboratory. However, efficiency scores of less than 1 are considered less efficient senior high schools.

Table 3. Efficiency Scores and Less Efficiency Scores of SHS with Science Laboratory

Efficiency Scores of Schools with Science Laboratory			Less Efficiency Scores of Schools with Science Laboratory		
NAME of SCHOOLS	DMU	Efficiency	NAME of SCHOOLS	DMU	Efficiency
DMUs	No.	Score	DMUs	No.	Score
SHS-3	**2**	1	SHS-1	**1**	0.963132367
SHS-7	**3**	1	SHS-13	**5**	0.733625024
SHS-11	**4**	1	SHS-19	**10**	0.939568344
SHS-14	**6**	1	SHS-29	**16**	0.652959001
SHS-15	**7**	1			
SHS-16	**8**	1			
SHS-17	**9**	1			
SHS-20	**11**	1			
SHS-22	**12**	1			
SHS-23	**13**	1			
SHS-27	**14**	1			
SHS-28	**15**	1			
SHS-30	**17**	1			
SHS-31	**18**	1			
SHS-32	**19**	1			
SHS-37	**20**	1			

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The efficiency scores of each evaluated SHS shown in Table 4 column 3 showing the weights of each SHS with science laboratory which in turn vary as the evaluated SHS changed. For each calculation, other cells in the set changed to identify the SHS being benchmarked (SHS-1, SHS-18, SHS-29, and SHS-13).

Table 4. Efficiency Reference Sets of Input-Oriented CRS DEA Model for Less Efficient SHS with Science Laboratory

EFFICIENCY REFERENCE SETS (ERS)					
		SHS 1	SHS 19	SHS 29	SHS 13
DMUs	**No.**	**Weights**	**Weights**	**Weights**	**Weights**
SHS-1	**1**	0	0	0	0
SHS-3	**2**	0	0	0	0
SHS-7	**3**	0	0	0	0
SHS-11	**4**	0	0	0	0
SHS-13	**5**	0	0	0	0
SHS-14	**6**	0	0	0	0
SHS-15	**7**	0	0	0	0
SHS-16	**8**	0.033332	0.17868	0.26196	0.1632487
SHS-17	**9**	0.839979	0	0.12879	0
SHS-18	**10**	0	0	0	0
SHS-20	**11**	0	0	0	0
SHS-22	**12**	0	0	0	0
SHS-23	**13**	0.118066	0	0	0
SHS-27	**14**	0	0.20054	0	0.0262558
SHS-28	**15**	0	0	0	0
SHS-29	**16**	0	0	0	0
SHS-30	**17**	0	0	0	0
SHS-31	**18**	0	0.02261	0	0.0001693
SHS-32	**19**	0	0	0	0
SHS-37	**20**	0	0.58222	0.29441	0.4071275

Table 5 shows the evaluation of a less efficient public high school and its potential for improvement. The assessed school, SHS-1 was benchmarked with SHS-8, SHS-9, and SHS-13 using the three schools' output and input parameters in getting the efficiency percentage value as well as the percentage value for improvement of SHS-1.

With SHS-1 as the assessed school, results had demonstrated a negligible decrease of the NG with percentage value of .00002%. The inputs for improvements include a decrease value of 9.89% SP from the actual 1212; 5.01% of ND from the actual value of 47; 12.94% of NST from the actual 10; 52.71% NC; 3.69% CS and MOOE from the actual values of 56 and 1213354 respectively; 25.94% LE; 61.91% TEQ; 4.74% NTE; and 3.69% TSR.

Table 5. Assessment of SHS-1 for potential improvement

	8			9			13		Com posite	Act ual	-	Com posite	=	Excess
	377			255			290		**261**	261		**261**		**0.00005**
	1706			991			1718		**1092.12**	1212		**1092.1**		**119.879**
	20			48			31		**44.6457**	47		**44.646**		**2.354322**
	10			8			14		**8.70608**	10		**8.7061**		**1.293924**
	30			15			29		**17.0236**	36		**17.024**		**18.97644**
0.033	55	+	**0.84**	55	+	**0.1181**	50	=	**53.9354**	56		**53.935**		**2.064595**
	2E+06			1E+06			2E+06		**1213354**	1259800		**1E+06**		**46446.22**
	896			547			855		**590.28**	797		**590.28**		**206.7196**
	2			1			2		**1.14278**	3		**1.1428**		**1.857225**
	11.46			8.9			12.11		**9.28758**	9.75		**9.2876**		**0.462423**
	0.04			0.03			0.02		**0.02889**	0.03		**0.0289**		**0.001106**

Table 6. Assessment of SHS-29 for Potential Improvement

	8			9			20		Compo site	Act ual	-	Compo site	=	Excess
	377			255			161		**179.000102**	179		**179.000102**		**-0.000102**
	1706			991			370		**683.467015**	1062		**683.467015**		**378.532985**
	20			48			10		**14.365096**	22		**14.365096**		**7.634904**
	10			8			3		**4.533144**	12		**4.533144**		**7.466856**
	30			15			11		**13.029161**	23		**13.029161**		**9.970839**
0.26196	55	+	**0.1288**	55	+	**0.2944**	45	=	**34.73952**	54		**34.73952**		**19.26048**
	1946200			1125600			499000		**801703.6318**	1227800		**801703.6318**		**426096.3682**
	896			547			220		**369.934657**	1195		**369.934657**		**825.065343**
	2			1			1		**0.947119**	3		**0.947119**		**2.052881**
	11.46			8.9			6.5		**6.06193928**	11.1		**6.06193928**		**5.03806072**
	0.04			0.03			0.04		**0.02611837**	0.04		**0.02611837**		**0.01388163**

Table 7. Assessment of SHS-13 for Potential Improvement

	8			14			18			20		Compo site	Act ual	-	Com posite	=	Excess
	377			147			284			161		**131**	131		**131**		**-2.8E-05**
	1706			401			1645			370		**439.9466**	668		**439.9466**		**228.0534**
	20			35			22			10		**8.258933**	33		**8.258933**		**24.74107**
	10			3			11			3		**2.9345**	4		**2.9345**		**1.065501**
	30			11			37			11		**9.670942**	18		**9.670942**		**8.329059**
0.163	55	+	**0.03**	44	+	**0**	58	+	**0.41**	45	=	**28.4645**	52		**28.4645**		**23.5355**
	1946200			553200			2E+06			499000		**535693**	730200		**535693**		**194507**
	896			503			1406			220		**249.2835**	407		**249.2835**		**157.7165**
	2			0			0			1		**0.733626**	1		**0.733626**		**0.266375**
	11.46			14.27			8.56			6.5		**4.893282**	6.67		**4.893282**		**1.776718**
	0.04			0.03			0.05			0.04		**0.023611**	0.04		**0.023611**		**0.016389**

Another school (SHS-29) illustrated in Table 6 benchmarked with SHS-16, SHS-17, and SHS-37 using the three schools' output and input parameters in getting the efficiency percentage value and the percentage value for improvement of SHS-29. Results demonstrated a negligible increase of the NG with percentage value of .00006%. The inputs for improvements include a decrease value of 35.64% SP from the actual 11062; 34.70% of ND from the actual value of 22; 62.22% of NST from the actual 12; 43.35% NC; 35.67% CS; 34.70% MOOE from the actual amount of 426096; 69.04% LE; 68.43% TEQ; 45.38% NTE; and 34.70% TSR. These results of SHS-19 also showed a more decreased percentage value as compared to SHS-1 and SHS-19.

The last school SHS-13 with science laboratory being assessed is shown in Table 7. This school was benchmarked with SHS-16, SHS-27, SHS-31, and SHS-37 using the four schools' output and inputs parameters in getting the efficiency percentage value as well as the percentage value for improvement of SHS-13. Results demonstrated a slight increase of the NG with percentage value of .000021%. The inputs for improvements include a decrease value of 34.14% SP from the actual 668; 74.97% of ND from the actual value of 33; 26.64% of NST from the actual 4; 46.27% NC; 45.26% CS; 26.64% MOOE from the actual amount of 730200; 38.75% LE; 26.64% TEQ and NTE from the actual value of 1 and 6.67 respectively; and 40.97% TSR.

4. Conclusions and Recommendations

The study was able to determine efficient and less efficient public high schools in the context of readiness for STEM offering. A number of these public high schools can be made to offer the STEM track as they already qualify in terms of requirements. What needs to be institutionalized is the motivation for the science teachers to pursue graduate programs in specialized fields of science and mathematics that may be in the form of scholarship grants and other agency support. In addition, the maximum utilization of science and ICT laboratories may be pursued to support experiential learning anchored on real world problem solving and allow the conduct of relevant researches and science inquiry by students.

Acknowledgements

The authors would like to express their gratitude to the Commission of Higher Education for the scholarship grant and support for the study.

References

[1] Bruce-Davis, M. N., Gubbins, E. J., Gilson, C. M., Villanueva, M., Foreman, J. L., & Rubenstein, L. D. “STEM high school administrators’, teachers’, and students’ perceptions of curricular and instructional strategies and practices”. J*ournal of Advanced Academics*, 25(3), 272-306. 2014.

[2] Wang, X. “Why students choose STEM majors: Motivation, high school learning, and postsecondary context of support”. *American Educational Research Journa*l, 50(5), 1081-1121.2013.

[3] Means, B., Wang, H., Young, V., Peters, V. L., & Lynch, S. J. “STEM‐focused high schools as a strategy for enhancing readiness for postsecondary STEM programs”. J*ournal of Research in Science Teaching*, 53(5), 709-736. 2016.

[4] Caraballo, M.U. “PH Economic Growth Needs Tech Boost Scientist”. *Manila Times,* Retrieved from pids.gov.ph/pids-in-the-news/821. 2014, July, 7

[5] Ferrer, F. P. & Dela Cruz, R.J. “Correlation of Stem Students’ Performance in the National Career Assessment Examination and Academic Subjects”. *International Journal of Social Sciences*. Vol. 3, No. 1. 2017.

[6] Charnes, A., Cooper, W.W. & Rhodes, E. “Measuring the Efficiency of DMUs”. *European Journal of Operational Research*, pp. 429-444, 1978.

[7] Adler, N., Friedman, & Sinvany-Stern, L. “Review of Ranking Methods in the Data Envelopment Analysis Context”. *European Journal of Operational Research*, 140, pp. 249-265, 2002

[8] Khodabakhshi, M. & Aryavash, K. “Ranking All Units in Data Envelopment Analysis”. *ELSEVIER*. Volume 25, Issue 12. Pages 2066-2070, 2012

[9] Sherman, H. D. & Zhu, J. “Service Productivity Management”. *Springer US*. 2006

[10] Harris, D. N. & Sass, T.R. “Teacher Training, Teacher Quality, and Student Achievement”. CALDER Working Paper 3. Washington, DC: *The Urban Institute*. 2007

[11] Henry, G. T., Bastian, K. C., Fortner, C. K., Kershaw, D. C., Purtell, K. M., Thompson, C. L., & Zulli, R. A. Teacher preparation policies and their effects on student achievement. *Education Finance and Policy*, *9*(3), 264-303, 2014.

[12] Kini, T., & Podolsky, A. “Does teaching experience increase teacher effectiveness’. *A Review of the Research*, 1-72, 2016

[13] Rice, J.K. “The Impact of Teacher Experience Examining the Evidence and Policy Implications”. Brief No. 11. *National Center for Analysis of Longitudinal Data in Education Research*. 2010

[14] Boyd, D. J., Lankford, H., Loeb, S. Jonah, Rockoff, E. & Wyckoff, J.H. “The Narrowing Gap in New York City Teacher Qualifications and Its Implications for Student Achievement in High-Poverty Schools”. CALDER Working Paper 10. Washington, DC: *The Urban Institute*. 2007

[15] National Academy of Science and Technology Philippines. Science for the People - DOST. 2016 DOST Performance Report. Retrieved from dost.gov.ph/phocadownload/Downloads/Annual_Reports/Performance_Reports/2016%20DOST%20Performance%20Report.pdf. 2016

[16] National Research Council. “Science Content Standards”. National Science Education Standards. Washington, DC: The National Academies Press 1996

[17] Rahayu, S. “Promoting the 21st century scientific literacy skills through innovative chemistry instruction”. In *AIP Conference Proceedings* (Vol. 1911, No. 1, p. 020025). AIP Publishing LLC. 2017, December.