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The impact of ICT utilization to improve the learning outcome: A meta-analysis

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ABSTRACT

This study aimed to describe the impact of the utilization of technology on learning outcomes through a meta-analysis. Data was collected by documenting research that is resulted from various sources collected through internet. These articles were published from 2006 to 2019, in United Nations Language. The article discusses the influence of information and communication technology (ICT) on learning achievement, analyzed qualitatively, describing the data in the form of sample size, standard deviation, and average, and published in journals indexed in Google Scholar. The analysis design employed a contrast group with the random effect model that the effect size is corrected. The analysis was used JASP software for calculating the average aggregate difference, drawing a forest plot, and publication bias. The results of the analysis show that there is a significant difference between groups using ICT and non-ICT in the learning process (SE=1.13), groups of students who utilizing ICT in the learning have better learning outcomes than those who do not use ICT. Based on the results of the analysis, it is very clear the urgency of implementing ICT in supporting the learning process. Schools should conduct an assessment of the condition of the school and students and then choose the appropriate ICT implementation. Thus, the quality of the learning process and students' technological literacy improve.

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1. INTRODUCTION

Technology is developing so rapidly in the last 20 years, especially information technology. All segments are exposed to technology and those who are unable to adapt will be constrained in various cases. For example, during the COVID-19 pandemic, schools that are not used to using technology will find it difficult to carry out learning [1]–[3]. Schools as educational institutions must also adapt to development [4]. According to Burke, Mariow, and Lento [5], the world of education has changed extremely. Past students were very dependent on teacher information and books in the library but students in the 21st century have grown up in a digital world that is able to access information widely [6]. On the other hand, Arlinwibowo *et al*. [7] found a product based on technology that can assistive visually impaired learning easier.

Utilizing technology in the learning process is a single choice amidst the strong flow of development. There are two big advantages gained by utilizing technology, the first is to improve the quality of learning [8]. By utilizing technology, the teachers have an opportunity to improve their creativity in the teaching and learning process [9]. Moreover, using technology in class can certainly increase students'

enthusiasm because creative teaching makes students are not bored [10]. The second is to provide habituation to students so that they are ready to enter the world of social or work closely with technology.

Fu [11] explained that many schools use information technologies in the learning process or are generally known as ICT-based education (information and communication technology). According to Lowther *et al*. [12], ICT is considered a device that can provide educational reform (improvement). Various studies have shown that the proper use of ICT can improve the quality of education and make it easier for teachers to link learning to contextual cases and real-life situations. Clearly, Boholano [13] mentioned that in the current era schools must have a curriculum that is integrated with information technology.

Every educational policy has its advantages and challenges [14]. If the benefits are greater and urgent, various challenges will be assessed to be resolved. First, we will analyze the benefit of using ICT in teaching and learning. Fu [11] stated that the integration of ICT in the teaching and learning process makes students have the potential to gain many insights, increase students' activity in the teaching and learning process (out a class or in class), provide various alternative strategies to demonstrate a content that has not been possible to demonstrate in the past (for electricity, atomic phenomenon, metabolism, and so on), and cut down on space and time limitations. In addition, the more developing science, the more complex the problems that are increasingly difficult to reason or traditionally solve [9]. Technology interventions are needed to solve current problems.

The second aspect, in the implementation of ICT-based learning, there are several challenges. There are two serious challenges in the field. The first is the ability to use ICT for teaching and learning [15]–[17]. The utilization of ICT is associated with a variety of technologies (hardware and software) that are developed so quickly that teachers must be able to adapt to technological change [2]. This is not easy because it means the teacher must always learn and fight against these developments. The second challenge is finance and facilities [18]. Not all schools have enough financial capacity to provide equipment and provide training facilities to their citizens related to the use of technology [14].

The second challenge is a problem that must be answered by two parties, namely schools and students. The funding is used for the procurement of goods so that schools have various facilities [19] to support the implementation of ICT in the learning process [20]. Then, the problem of facilities also requires support from students. Students also have a role in the availability of various learning facilities to support the implementation of ICT learning, at least devices or the internet. It is the synergy of both parties that will make the learning process run well [21].

However, the problem is that not all schools have the same abilities and student situations are very heterogeneous [14], [20]. Based on this, commitment and careful planning are needed for the implementation of ICT in the learning process. Assessment of school ability and student situation must be carried out as the initial foundation for implementing policymaking. ICT-based learning is also very diverse so that possible and relevant strategies can be designed to be implemented.

It must be admitted that the implementation of ICT requires a lot of effort. Thus, there must be a calculation of the benefits of the policy. The significance of ICT implementation in improving the quality of education must be shown as a reference to show its urgency. Comparing the situation in various locations and countries is one of the important things to answer the urgency of implementing ICT in education. The conclusions of various study results will be the basis for various parties in deciding something.

Thus, this study aimed to determine the effectiveness of ICT-based learning when compared with conventional learning in various countries. It is hoped that the results of this meta-analysis research can be used as a general description of the effects of ICT learning in improving students' learning outcomes so that it can be used as a basis for policymaking, integration of ICT in education is urgent or not.

2. RESEARCH METHOD

This research was a meta-analysis that summarized the results of similar studies and conclude with a global conclusion. The theme of this research was the impact of using ICT in supporting the learning process. Thus, the data population in this article is a study of all studies that compare the results of a learning process by utilizing or integrating ICT and conventional (in this case translated as learning without utilizing ICT). The articles analyzed are those published in the journal from 2006 to 2019 in English. The article collection technique uses Google Scholar as a search engine that is linked to various journal portals and indexing agencies. This strategy is used to collect data as widely as possible in order to obtain a lot of data so that it can represent global conditions comprehensively and keep away from bias.

The inclusion criteria in this study based on articles published from 2006 to 2019 were: i) Articles published in the United Nations Language; ii) The article discusses the influence of ICT on learning achievement; iii) Articles are analyzed quantitatively; iv) The article describes the data in the form of sample size, standard deviation, and average; v) Articles are published in journals indexed in Google Scholar.

Articles that did not meet the six inclusion criteria would be included in the set of articles that fall under the exclusion criteria. Articles that fall within the exclusion criteria would not be included in the meta-analysis process. Finally, the researchers collected a total of 161 articles with relevant themes to the research focus. However, only 52 articles were found that writing data on the number of samples, the standard deviation of the data, and the mean of the research results. These three data are basic in finding global conclusions. If the three data were not written completely, a search would be carried out on the final page to find the raw data from the research results which could then be used to identify data on the number of samples, the standard deviation of the data, and the mean of the research results. If these data were not available, the article would be eliminated from the set of samples to be analyzed. In these 52 articles, there were several that contain more than one research result so that from the final collection of research results there were 60 research results that would be analyzed using meta-analysis techniques.

This study used a random effect model with the aim that the results of the research could be generalized to the population (not only applies to inferring data findings). The requirement to choose a random effect model was heterogeneity information I^2>25%. The type of meta-analysis in this study is a contrast group that will show whether or not there is a difference between ICT-based and conventional learning. The data obtained had a variation interval (difference in the minimum and maximum value), so the data must be standardized. Estimating of sample mean/effect size (d) are standardized by (1):

$$d = \frac{\bar{X}_1 - \bar{X}_2}{S_{within}}, S_{within} = \sqrt{\frac{(n_1-1)S_1^2+(n_2-1)S_2^2}{(n_1-1)(n_2-1)}} \quad (1)$$

The formula that used for find the standard error of d (SEd) is (2):

$$SE_d = \sqrt{V_d}, with\ V_d = \frac{n_1+n_2}{n_1 n_2} + \frac{d^2}{2(n_1+n_2)} \quad (2)$$

Hedges [22] showed that d that resulted has a slight bias. To minimize the bias, Herges changed to g with the (3) and (4).

$$g = J \times d, with\ J = 1 - \frac{3}{4df-1} \quad (3)$$

$$df = degree\ of\ freedom\ (n_1 + n_2 - 2)$$

$$SE_g = \sqrt{V_g}, with\ V_g = J \times V_d \quad (4)$$

Then, the analysis process is carried out using JASP software. The data entered were g as the effect size and SE_g to produce a forest plot in which there were a value interval and standard error for each study and its conclusions. In addition, JASP also helped in the calculation of heterogeneity and publication bias (funnel plot). Thus, it could be concluded the effect of ICT learning in the learning process.

3. RESULTS AND DISCUSSION

3.1. Result

This study analyzed 60 research results taken from 52 articles. There are several studies that produce several research results. Several studies [23], [24] shared the impact of ICT utilization to improve learning outcomes among female and male students. Thabet and Kalyankar [25] shared the fact of achievements (memory, understanding, and application) affected by ICT utilization. Bester and Brand [26] divided achievement, namely mathematics, geography, and English that was improved by ICT utilization in learning. Tareef [27] divided two studies of the influence of ICT on achievement and problem-solving abilities.

In general, the research selected is research that found the influence of the use of ICT in improving learning outcomes. In this research, what is meant by learning outcomes are student achievements in various domains, subjects, and levels of education. The results of the study compared the control group with the experimental group (ICT-based). Based on the data sample size, mean, deviation standard, researchers can produce the effect size and standard error as presented in Table 1. Based on the data in Table 1, a heterogeneity test will be performed to show the suitability of the model with the data. The results of the heterogeneity test are shown in Table 2.

Table 1. Summary of research data, effect size, and standard error

ID	Researcher code	Based on ICT			Conventional			ESg	SEg
		n	SD	M	n	SD	M		
Study 1	[28]	26	18.68	70.81	26	15.68	59.69	0.64	0.28
Study 2	[29]	80	7.29	72.15	76	7.39	56.92	2.07	0.20
Study 3	[30]	16	9.41	68.94	15	13.63	61.93	0.59	0.36
Study 4	[31]	20	1.50	29.60	20	1.96	25.20	2.47	0.42
Study 5	[32]	18	11.02	67.22	19	10.03	56.42	1.00	0.35
Study 6	[33]	35	5.05	20.46	35	5.15	16.03	0.86	0.25
Study 7	[34]	50	4.15	17.58	50	3.82	14.85	0.68	0.20
Study 8	[35]	25	3.38	88.29	25	3.49	72.36	4.56	0.54
Study 9	[23]	132	17.50	75.20	110	21.80	64.10	0.57	0.13
Study 10	[23]	100	18.00	71.60	100	20.10	68.00	0.19	0.14
Study 11	[36]	15	0.41	4.80	15	1.66	3.80	0.81	0.38
Study 12	[37]	20	2.89	22.07	22	4.21	20.37	0.46	0.31
Study 13	[38]	58	3.06	25.34	53	2.48	26.47	-0.40	0.19
Study 14	[39]	100	2.33	17.04	100	2.69	16.45	0.23	0.14
Study 15	[40]	26	10.19	66.46	26	8.63	58.31	0.85	0.29
Study 16	[41]	38	4.78	13.90	39	3.75	4.46	2.18	0.29
Study 17	[42]	93	5.51	37.04	91	5.58	36.66	0.07	0.15
Study 18	[25]	30	1.59	5.27	30	1.32	4.27	0.68	0.26
Study 19	[25]	30	1.50	7.40	30	1.68	5.47	1.20	0.28
Study 20	[25]	30	1.21	6.90	30	1.52	5.37	1.10	0.28
Study 21	[24]	25	3.10	14.48	25	3.01	10.12	1.40	0.31
Study 22	[24]	25	3.28	14.04	25	3.66	9.68	1.23	0.31
Study 23	[43]	30	5.47	20.17	30	3.35	15.53	1.01	0.27
Study 24	[44]	38	3.66	17.50	34	3.21	18.41	-0.26	0.24
Study 25	[45]	48	7.19	82.83	40	4.08	68.55	2.37	0.28
Study 26	[46]	50	20.23	77.20	50	13.51	51.30	1.49	0.23
Study 27	[26]	23	0.99	7.52	22	2.26	5.50	1.15	0.32
Study 28	[26]	23	1.49	6.87	22	1.84	4.32	1.50	0.34
Study 29	[26]	23	0.72	9.39	22	1.76	6.32	2.26	0.38
Study 30	[47]	87	13.88	71.29	78	15.68	36.26	2.36	0.20
Study 31	[48]	50	6.43	50.66	50	4.73	23.92	4.70	0.39
Study 32	[41]	40	3.91	4.70	40	1.56	1.25	1.15	0.24
Study 33	[49]	40	3.75	84.52	40	9.56	81.61	0.40	0.22
Study 34	[50]	33	16.05	73.82	33	14.44	40.79	2.14	0.31
Study 35	[51]	34	3.19	16.68	32	2.08	12.75	1.43	0.28
Study 36	[52]	48	5.43	14.67	48	2.74	12.13	0.59	0.21
Study 37	[52]	67	6.54	15.11	67	3.47	12.74	0.45	0.17
Study 38	[52]	66	5.23	14.15	66	3.37	12.04	0.48	0.18
Study 39	[53]	30	0.39	3.77	30	0.35	3.08	1.84	0.31
Study 40	[54]	28	2.15	6.96	25	2.71	7.88	-0.37	0.28
Study 41	[55]	35	1.46	28.83	35	6.79	11.94	3.40	0.37
Study 42	[56]	62	4.62	32.19	47	6.2	23.02	1.70	0.22
Study 43	[57]	76	12.8	44.78	71	11.96	49.59	-0.39	0.17
Study 44	[58]	67	19.02	88.17	59	17.89	84.38	0.20	0.18
Study 45	[27]	45	8.766	31.2	45	8.9	28.9	0.26	0.21
Study 46	[27]	45	7.3	42.1	45	6.9	44.3	-0.31	0.21
Study 47	[59]	37	5.79	53.7	36	8.17	31.11	3.16	0.35
Study 48	[60]	116	4.25	94.84	103	7.65	73.56	3.48	0.21
Study 49	[61]	33	2.38	16.94	33	3.39	15.09	0.62	0.25
Study 50	[62]	35	4.35	9.59	33	4.35	7.36	0.51	0.25
Study 51	[63]	30	1.91	15.50	30	0.95	18.55	-2.00	0.32
Study 52	[64]	41	1.23	6.51	31	1.06	6.55	-0.03	0.24
Study 53	[65]	30	2.18	12.43	30	1.82	10.73	0.84	0.27
Study 54	[66]	20	8.26	70.50	20	13.57	45.00	2.22	0.40
Study 55	[67]	31	9.37	80.33	30	7.63	67.67	1.46	0.29
Study 56	[68]	32	2.52	62.20	28	2.61	61.34	0.33	0.26
Study 57	[69]	40	4.75	15.98	40	4.26	12.73	0.71	0.23
Study 58	[70]	36	1.46	39.23	34	1.18	33.96	3.91	0.41
Study 59	[71]	33	5.97	19.65	32	6.78	13.08	1.02	0.26
Study 60	[72]	40	16.50	59.80	39	13.44	55.45	0.29	0.23

Note: i) M=the mean of each data presented in the research sample; ii) n=amount of data displayed in the research sample; iii) SD=standard deviation shown in the research sample; iv) ESg=Effect size as a quantitative index used to summarize study results in a meta-analysis. That is, the effect size reflects the magnitude of the relationship between variables in each study which in this study represents differences in learning involving ICT and without involving ICT; v) SEg=Standard Error as a value that is used as a basis for determining the true effect size interval.

Table 2. Residual heterogeneity estimates

	Estimate
I^2 (%)	96.062

The study takes a random effect model so that the data must meet the assumption of heterogeneity. I^2 is one method that can be used to test heterogeneity. I^2 illustrates the proportion of the size variation of the summary effect on a scale of 0% to 100%. The data collected in this study shown in Table 2 produces I^2=96.062%>25%, so it is said that there is heterogeneity so that the selection of a random effect model is appropriate with the criterion. Then, to infer the overall effect, it can be seen in the forest plot in Figure 1.

The data in the forest plot shows that the summary effect is 1.13. It can be interpreted that there are differences in learning outcome by 113% among groups or the student that learn with ICT have a learning outcome 113% higher than students who use conventional learning models. Besides, with a confidence interval of 0.95%, it is known that the range of summary effect is 0.83 to 1.44 so that it does not contain zero. It indicates a significant difference between students learning with ICT and conventional. Then, there will be the analysis of the publication of bias in the meta-analysis. This analysis is very important to show the validity of conclusions in research because meta-analysis can be considered biased if only taking research with the desired results and not displaying research results that accept null hypotheses or provide negative conclusions (against the theory/not as expected).

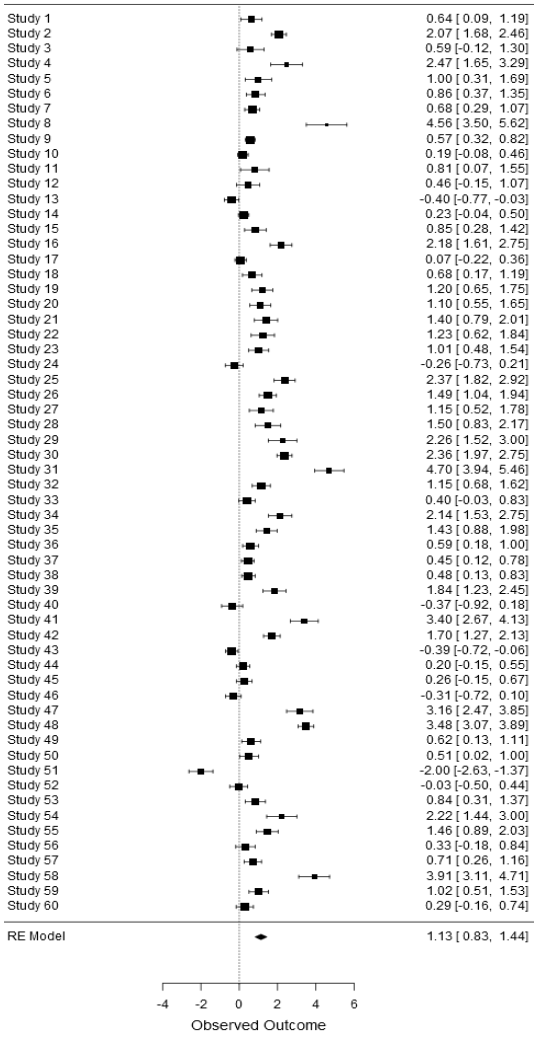

Figure 1. Initial forest plot

In this meta-analysis, detection of publication bias can use the Trim and Fill method. According to previous research [73], the Trim and Fill method uses an iterative procedure to remove the most extreme small research from the positive side of the funnel plot and then recalculates the adjusted effect size, reduces the effect variance, and produces a narrower confidence interval. Thus, researchers can see a shift in effect size when unpublished research is included in the analysis [73]. The Trim and Fill data results with the help of JASP software are shown in Figure 2.

Figure 2 shows that there are no open points in the funnel plot with random effect models. The display shows that there is no or no missing (unpublished) research found. Therefore, the conclusion that ICT learning has a positive effect compared to conventional learning is free from potential biases. To strengthen this argument, the results of the initial forest plot Figure 1 will be compared with the forest plot using the Trim and Fill method.

The results of the forest plot analysis using the trim and fill method show an image that is exactly the same as Figure 1. There is no difference in each selected sample data interval between the initial forest plot image and the forest plot image using the trim and fill method. The comparison thus strengthens the previous argument that there is no indication of bias in the meta-analysis. Thus, the conclusion that ICT-based learning improves learning outcomes effectively compared to conventional learning is valid.

Various studies have been carried out separately in space and time. Thus, it is not strong enough to justify the results of their research to be applicable in a wide scope. This study produces findings with a broad scope because it concludes various studies. The conclusion of this meta-analysis is a finding that has general. In another sense, it is also a finding that under normal circumstances, ICT can improve the quality of the learning process which has an impact on the ability of graduates. This finding can be used as a consideration of the urgency of ICT implementation in various parts of the world, of course with normal circumstances and situations.

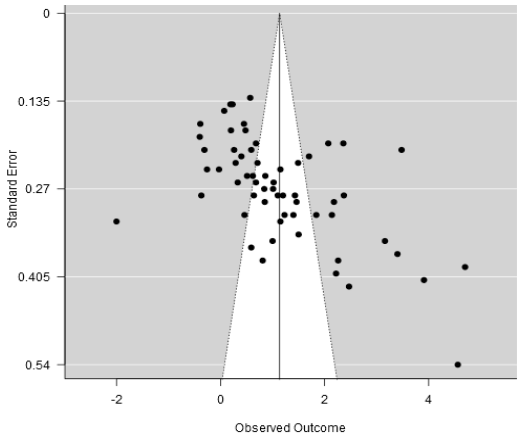

Figure 2. Funnel plot of Trim and Fill method

3.2. Discussion

Technological developments occur so rapidly and target all groups. Technology develops to facilitate many things so that someone is able to do various things effectively and efficiently [74], [75]. Technology integration is widely applied in schools by taking information and communication technology-based learning terminology (ICT). Fu [11] said that ICT such as computers, the internet, and electronic delivery systems (radio, television, and projectors, and others) are widely used in education today. According to Easingwood and Williams [76], ICT learning can appropriately provide information convenience so that the learning process becomes more interesting and varied [10], [34]. Thus, it is logical that if research show learning based on ICT is carried out with good planning it will improve learning performance.

The content of education is very complex. Many materials are very difficult to illustrate [9]. Whereas contextual learning is proven to improve the quality of learning [10], [77]–[79]. However, contextual education contains a variety of real cases that have high complexity, especially in high-class material [9]. For example, abstract mathematics, anatomy, electromagnetic, and various other materials are difficult to observe [80]. In such a situation, a tool is needed that is able to closer the material to contextual cases through samples and simulations [78], and technology is an appropriate solution. ICT can be a solution in facilitating the learning process through simulation [48], [81]. Many substances that are not easy to understand then become easier with the help of ICT such as chemistry subjects [56], [77], [82], physics [81], [83], and biology [82]. Thus, the theory becomes easier to understand [77], [81].

ICT-based learning makes the learning process more flexible in describing various things and strongly supports the contextualization of the material than conventional learning because there are many things that can be virtualized [84]. In language subjects, technology can present as an example. Various learning support information such as native speakers or cultural illustrations can make linguistic nuances appear in the learning environment [67], [74] and make language learning more attractive [50]. Furthermore,

ICT can assist in interpreting and doing calculations in the complex calculation (very difficult or impossible conventionally) in mathematical cases [85], even technology can make it easier for students to understand mathematics in various representations, mathematical models, and images [53], [54], [70], [72], [80]. Thus, the learning process becomes more effective and efficient [9]. Various problems that provide obstacles in the technical aspects (not in the realm of concepts) can be solved by ICT.

One of the advantages of ICT is its ability to show the material in a variety of information bases (audio, video, audio-video) to match its audience [86]. There are two advantages of having it: being able to meet the needs of students according to the character of their learning, more likely to like learning based on audio, visual, or audiovisual. The second advantage is being able to accommodate students with special needs. Arlinwibowo and Retnawati [87] mentioned that information base conversion is needed, so teaching materials accessible for them easily, especially the people with special needs. According to Arlinwibowo *et al*. [19] student with a special need is currently not very well facilitated. Thus, ICT as a solution can help teachers develop learning processes that are oriented to student needs.

4. CONCLUSION

The analysis shows that there is a significant difference between the learning outcomes of groups who use ICT and non-ICT in the learning process, groups of students who learn by utilizing ICT have better learning outcomes than those who do not utilize ICT. Forrest plot data shows there is a summary effect of 1.13 so that it can be interpreted that learning outcomes using ICT are 113% higher than students who use conventional learning models. In addition, with the confidence of 0.95%, there is a summary effect interval ranging from 0.83 to 1.44 so that it does not contain zero. It shows a significant difference between students who study with ICT and conventional. To test publication bias can be done using the Trim and Fill method which shows that there is no publication bias in the meta-analysis conducted. Thus, the conclusion that ICT-based learning is more effective compared to conventional learning is free from bias. Based on the results of the analysis, it is very clear the urgency of implementing ICT in supporting the learning process. Schools should conduct an assessment of the condition of the school and students and then choose the appropriate ICT implementation. Thus, the quality of the learning process and students' technological literacy increases

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