COGNITIVE INQUIRY: IS ENGLISH REALLY DIFFICULT FOR SCIENCE STUDENTS?

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Abstract

Science students are known miserable in coping very well with language, especially English. This study searched for the truth of this proposition by evaluating the formative test items for senior high-school level used in a science-based school in Aceh, Indonesia. The sources of this study were 150 questions and 35 students' answers on the pertaining tests for three different grades. The objective of this study was to find out the item facility and distractors' efficiency of each test item used for science students in their formative test. Methodology deployed was qualitative approach using content analysis in the scope of finding the item facility and distractors' efficiency for the test items. The result depicted that 84% of the items are in the 'easy' index, and 11% in 'moderate' index, and 4% 'difficult' index. Then, the data show that only 17% of the distractors' are efficient. The conclusion is that the formative test items are, indeed, easy for science students but with one condition: most of the distractors do not work properly for their cognitive level.

Keywords: *Cognitive domain, science students, language tests, language assessments, item analysis*.

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INTRODUCTION

Teaching instructors across disciplines have long been aware of their responsibilities in assessments and evaluations, yet very few make the follow-ups on this. Assessments and evaluation then fall into the charge of educational authority only—briefly speaking, government. As the result, teachers merely assume that whatever the mistakes and errors contained in the teaching and learning process, along with the evaluation process and its implications, are all to be shoved onto the charge of the authority. This is the most probable error in the teaching process itself as government is not the one who directly participate in the teaching process, they are just policy makers deciding based on research and empirical claims. Then a contemplative question gently emerges to be addressed to the practitioners, in this case, English teachers.

To be more specific, the wonder that appeared during the problem grounding of this study was the constant Acehnese students' proficiency in English in most high-schools in Aceh, Indonesia—which, unfortunately, is mostly poor. Samad & Fitriani's (2016) conducted a study on Acehnese students' TOEFL score and the result is dreadfully astonishing. The survey showed that from approximately 2000 students in Aceh, only 8 students reached the average TOEFL score. Almost all students strongly believe they would never outperform those who are good at English, and those who are good at it remain at a certain level for quite some time instead of inclining to be better users of English without realizing that their proficiency only ports on the mediocre proficiency. Inasmuch, at school, Indonesian students get English for four hours a week for six years, which in sum is approximately 5200 hours for English in formal setting only, but the majority of the students still fails English.

Some issues have been stated by a number of research findings that students these days are stressed out and undergoing academic burnouts (Zhang, et al., 2013); students also have low motivation in learning (Syahputri, 2016); the curriculum changes leading to chaotic teaching-learning environment is also one of the prevalences. Furthermore, numerous ELT researchers have found that most teachers only use simple conventional approaches in transferring knowledge which resulted in low achievement as confirmed by Gow, Kember, & Chow (1999) that students who are taught using surface approach would develop instrumental motives in learning—only to get good scores—and this leads to low language proficiency. And this makes sense for Acehnese students who have learned English for years and years but are still low-proficient.

Further presumed, there is something hidden beyond these and teachers, apparently, have control all over it—which is: those students are satisfied with their ability, already. This indeed sounds horrific but also somewhat comical at the same time. This is possible because they have the access to every knowledge on their finger tips. They just need to effortlessly type and what they are looking for is there on the screen only in micro-seconds. In addition, they believe that they

have coped with whatsoever constructed under the National Curriculum because, in majority, most of formative and summative tests at Acehnese highschools have been struggled to meet the curriculum demands (Syahputri & Ismail, 2017). Then we—teachers—find ourselves beaten up by the technologies which will still enrage to the certainless point of advancement. It is not the end of the story, though. There is one thing to do which has always been there in the teachers' control. Teachers are encouraged to move-up the students' thinking level into the higher level(s) so that the students become aware of the fact that there are a lot left to learn and they can focus more on expanding their knowledge regulation, in this case English. Since the regard is in language context, they should be taught how to use the language to its social and literary extent which is more useful in real life situation rather than to memorize syntactic patterns and textbook dialogues. Shortly, teachers should give students the thinking models they have never attempted before from which the students will re-grow their curiosity and motivation during the teaching and learning process. That is what they cannot get from technologies and mankind always wins when it comes to thinking and thoughts.

Only to mention, most of students in Aceh can only perform to the level of *"Comprehension"* which is the second level of Bloom's cognitive taxonomy. In this level, one understands the object/number/formula/idea/etc into the real time condition by confirming and connecting the information with his/her prior knowledge. When posed to the more complex rute, i.e: evaluate, and create, s/he would likely find obstacles because of the novelty that his/her mind cannot recognize; whereas he/she does possess this ability as explained in the ZPD (Zone Proximal Development). This is the fissure in which teachers can fill up with 'skill' to help the students' cognitive growth.

One of the most possible area to intervene is test item, especially to its distractors when it comes to multiple choice items. Teachers design test items and they can decide whether to train the students' thinking skills or to spoil the students with easy task items. Doing the first assuredly demands the teachers to possess the thinking skills, too.

In conclusion, this study examined how far English teachers at the science-based school in Aceh, Indonesia have involved cognitive domain in the distractors content of their English grammar test items. Based on the rationale elaborated above, there were two problems formulated in this study:

1) What is the item facility index of each item? And what is its cognitive level?
2) How efficient were the distractors?

Therefore, the objective of this study was to find out the item facility index of the formative test items for grade X, XI, and XII along with ithe cognitive level; and the distractors' efficiency of the formative test items.

LITERATURE REVIEW

1. Item analysis

Item anaysis is important to the revision of the question items. From this stance, a teacher or test-designer can see how

effective is the test they have designed for their students. In case there are too many easy or difficult items, then the item should be revised or thrown out (Brown, 2004). Although it is only for the low-sake use of foramtive test, the test items should be constructed very carefully because test items are not merely score identifiers (Fulcher & Davidson, 2007), they also act as the motivation booster for students and evaluation opportunity for teachers whether to use the same teaching method(s) or shift it to another one. The effect of evaluation is indeed relatively huge (Bachman, 1990).

There are three steps in doing item analysis as suggested by Brown (2004) and Heaton (1989); the first is item facility or to see the difficulty level of each item. Heaton (1989) has proposed the index as shown in the following section. If an item is too difficult or too easy, then the validity and reliability of the item remain doubted (Deyger & Gorp, 2015). The second is item discrimination index which is the ability of each item to differentiate between upper level students and lower level students. This step was skipped in this study, however, since the items taken from the school are the one designed purposively for the upper level students at the school, while lower level students had another set of items which are not discussed in this study. The last one is the distractor efficiency. A distractor is considered effective if at least chosen by 2% of the whole test-takers (Fulcher & Davidson, 2007)—in this case, 1 test-taker.

2. Cognitive Domain

There have been a lot cognitive taxonomy levels with various labels proposed by experts in learning, however, many language teaching reseacrhers pose on Bloom's cognitive taxonomy as certain language instructions have been derived from this taxonomic level as cited from Kramer, Lundgren, & Mabbot (2010) below. Number 6 is the one added to the conformity of the revision of the taxonomy.

1. Knowing – define, list, table.
2. Comprehending – describe, report, paraphrase, explain.
3. Applying – interpret, generalize.
4. Analyzing – compare, contrast, differentiate.
5. Synthesizing/Evaluating – synthesize, evaluate, decide, predict.
6. Vreating – make, write, design.

There are six levels which are dychotomized into two levels, which are LOT (Lower-Order levels) and HOT (Higher-Order levels). LOT includes the lowest three levels—knowing, comprehending, and applying—and HOT involves the other higher three levels which are analyzing, evaluating/synthesizing, and creating (Assaly & Smadi, 2015). In 'knowing' level, the students are able to recall and recognize information; in 'comprehending' level, they are able to understand what the information means; in 'applying' level, they can apply the concepts to the real life situation; in 'analyzing', they can compare, contrast, and breakdown the information into its elements; in 'evaluatin' the students are able to judge the value of the

information; and in the highest level 'creating', they can combine the parts of information to make a new form.

3. Science Students' Language Ability

Our daily surveys show that science students are not good at language, in this case English, but their score in test are frequently excellent. To look closer, these kind of students are not good at performing language, ecpecially face-to-face interaction because they understand language in certain symbolization of meanings instead of meanings themselves.

Verily, the science students know what a meaning conceives but they do not know how to narrate it in a good sequential procedure in a systematic language. Their ability in processing language is more to 'decoding' rather than 'encoding', and oftentimes labelled as passive language ability. Starfield (1990) supports that as soon as one is involved with scientific academic domain and are accustomed to using precise and implicit meanings, he/she would likely to comply with 'context-reduced' communication which is the propensity to depend on the keyword meaning; on the other hand, those who are trained very well with public speaking—namely Social science students—tend to employ 'context-embedded' communication which is the negotiation of meanings.

METHODOLOGY

The methodology used in this study was qualitative content analysis which promotes the in-depth elaboration of the quantitative data to be more meaningful in the qualitative interpretation (Mayring, 2000). Content analysis' objects can be transcripts of speeches, interviews, protocols, or documents. Through its procedure, this study employed deductive category application as Mayring (2000) suggests to be used in a content analysis which is based on a theoritical framework or criteria.

The data collection process was carried out using two instruments, namely the researcher herself as the qualitative inquirer (Patton, 2002), and 150 formative test-items and 35 students' answers from grade X, XI, and XII at a science-based school in Aceh, Indonesia as the objects of this study. The objects were purposively taken from the school for the reason that the school is an internationally-standardized-science-based school.

In attempt of analyzing the data obtained, the following formula for determining the item facility as addressed in the first research question was used as suggested by Heaton (1989).

$$FV = \frac{R}{N}$$

The formula is represented by FV as the facility value, R as the number of correct answers, and N as the whole number of test-takers. For its interpretation, the following indices were used as the parameter (Heaton, 1989):

Table 1. Index of item facility

Index	*Facility level*
0.00-0.30	Difficult
0.31-0.70	Moderate
0.71-1.00	Easy

Regarding the second question, the researcher looked into each distractor's efficiency in the whole item sets. A distractor is considered effective if it is chosen by at least 2% of the test-takers, since in this case there were 35 students, so it should be chosen by at least 1 student.

RESULT AND DISCUSSION

This section narrates three points which resulted from the data collection and data analysis process. The first sub-section explains the result of the grade X, XI, and XII formative test at the school. And the second sub-section elaborates the distractors' efficiency and the cognitive level employed.

a. Result of Item Facility

In the following graph is presented the result of item facility from the test formative item of grade X, XI, and XII.

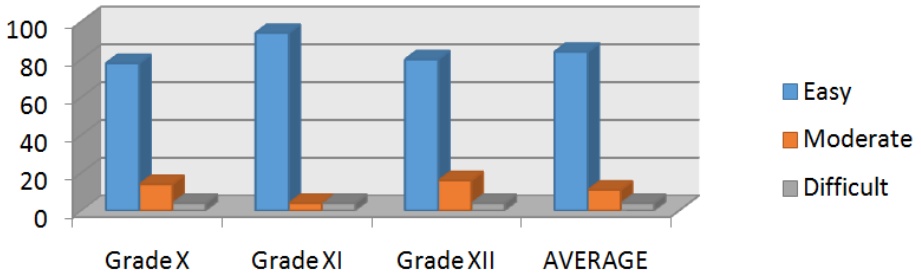

Figure 1. Percentage of item facility index

The figure above shows us that almost all items have 'easy' index. In grade X's items, 94% of the questions on grammar are in the 'easy' index, none is in the 'moderate' index, and 6% in the 'difficult' index. Then in grade XI's items, 85% is easy, 10% is moderate, and 5% is difficult. Lastly, for grade XII's items, 94% of the questions is easy, 6% is moderate, and none is difficult. Conclusively, in average, there is 91% easy items, 6% is moderate items, and 3% is difficult items.

To see how difficult the item is, provided below the easy facility value which reached the highest 'easy' value, 1.00. This is an item from grade X, in the topic of grammar. Item 30. *I come from Wrafter, a small town in Australian countryside. The town was____in 1789.*

A. Found
B. Ruins
C. Rural
D. Founded
E. Clerk

The item above might appear correct, but with closer investigation, there are two major flaws in it. In its stem, there are two sentences which might seem coherent; but if we look at the item's objective—which is to make the test-takers find a correct verb form after the auxiliary verb in passive voice, the first and the second sentence in the stem are irrelevant. This is what Brown (2004) argues about multiple choice, that both stem and options should be stated simply and directly without ay stem-lengthening. Probably, the first sentence would be coherent to the second one if the word *'old'* was added so the sentence becomes *'...a small old town in Australian countryside.'* So it is related to the context *'...found in 1789'*.

Secondly, concerning to its distractor—option B, option C, option D, and option D, none of these were efficient. This is not in regard of the high intlligence of science students but more to the misleading word class used in the distractors. It is as simply as employing the 'comprehension' level to find the correct answer. As soon as we read the item, we would understand that passive voice sentence construction always needs auxiliary 'be' and a past participle verb. The verbs that we can find in the options are stated only in option A and option D; then we just need to choose one out of two instead of out of five, and the other three are useless.

In the 'moderate' value, below is an example taken from grade XII formative item on the topic grammar. The index of the following item is 0.50.

Item 40. *I don't want to give up_____piano lessons, but my work schedule has changed, and I can't find the piano in any longer.*

A. To have
B. Have
C. Had
D. Have had
E. Having

If the 'easy' indexed facility employs mostly 'comprehension' taxonomic level, in the 'moderate' index, a higher order was found. First, we can see that there is only one sentence eventhough with one sub-ordinate and one co-ordinate, we find the ideas are united. So that the stem becomes tied-up and direct. From the options, we see all options employ one word-class, which is verbs. This forces the test-takers to think harder, ultimately to the level of 'analysis' in where they have to compare and contrast the constituent elements to decide a verb form to use after verb *'give up'*.

Students with the ability to analyze would find that after a base verb, another base verb cannot just pop-in. The base verb is found in option B. Further, they had three to drop. Again they employed their analyzing ability in where they found that a base verb has never been followed by past or past participle verb. So they dropped option C and option D. Now they had two to decide and in such circumstance, they needed to utilize the first taxonomic level—knowing. So they recalled that the verb *'give up'* should followed up by a gerund so that they dropped option A and chose option E. This is, of course, not a definite process, but it is the most likely

process to happen based on the cognitive taxonomic construction. The chain of thinking that happened during the decision making select those who definitely understood the case and some who failed the case. Then this item was answered by 6 students out of 12 students in grade XII. In addition, option D, option C, and option A did play their role as efficient distractors since 3 students chose option D, two students choose option C, and one chose option A. No body chose option B as it is suspected that all test-takers indeed utilized their first-step of analysis but not all prevailed. This undeveloped thinking-structure should be encouraged again during the teaching-learning process, especially in the improvement of the instruction (Hughes, 2014).

Last to provide in this section, below is the item with 'difficulty' index 0.25. This item is taken from grade XI test items, also on grammar topic.

Item 42. *Beginning in the mid-1970s, milk sales____down in the United States, and the CMAB____to do something to increase the sales.*

A. Went; was deciding
B. Were going; was deciding
C. Go; decides
D. Went; decided
E. Were going down; decided

This item was only answered correctly by 3 students out of 12 students in grade XI; and interestingly, distractor E and distractor B were highly effective—six chose E and three chose B, but no one chose option A nor option C. The author found that the item is very-well constructed: first, the stem is clear and direct; second, identical word-class is used in the options. The purpose of this item is simple, which is to enable the test-takers to recall the use of *Simple Past Tense* and *Present Continous tense*, but most students arrayed. Despite its simple objective, this item employs higher thinking level, which is 'evaluating', in where the test-takers should be able to judge the case by developing the criteria of the item element(s). The thinking chain is most likely to be as follows. The first key word found by employing two lowest taxonomic levels, 'knowing' and 'comprehending', is *1970*, which is an abssolute dejection for option C representing *Simple Present Tense.* Then no one chose option C. But those who did not utilize the 'applying' level, mistakenly in rush saw the plural mark in *'sales'* and chose option B as they presumed that there are two actions, one action took place during the other action was happening. The same thing might also have happened to thoce who choose option B that they see plurality in *'sales'* so it must match *'were'* and singularity in *'CMAB'* so it must match *'was'*, then the decision was option B.

Those who applied 'analyzing' level, came up further that the action in the co-ordinate sentence happened as a result from the main ordinate sentence so they sought the cause-effect conjunction and found none, all they found there was *'and'*, which is not a cause-effect conjunction. This shows that they were able to compare and contrast the element of each action through the semantic utilization and decided that these two actions—in this sentence—are not necessarily appear as main-

ordinate and sub-ordinate sentence, but main-ordinate and co-ordinate sentence so that it is a compound sentence instead of a complex one. When making decision, they then employed 'evaluating' level in order to judge the correct verb form used in *Simple Past Tense* compound sentence. They came to the point of recalling *Parallelism*; and in *Parallelism* the verbs appear in the same form. Now they had option B and option D; but they dropped option B as they repeated the analysis that in the context, both action *'go'* and *'decide'* do not take time so they chose option D.

b. Result of Distractor Efficiency

Regarding the distractors' efficiency, the result is drawn in the figure below.

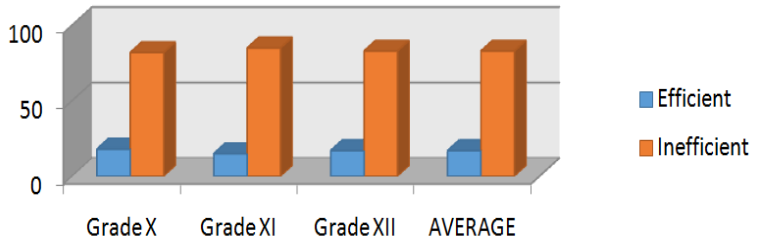

Figure 2. Distractors' efficiency

From the table above, it is learned that most of the distractors do not play their role to distract, only very few do. In grade X distractors, we can see that from 250 distractors, only 45 distractors that distracted, which is 18%. Then in grade XI's item distractors, only 15%, or 38 distractors out of 250, did distract the students. Finally in grade XII, 17% of the distractors are effective. As the result in the average, from 750 distractors, only 128 distractors are efficient.

The example of effective distractors are as provided in the following.

Item 26 grade X. *In which sports or activity do we use **CLUB** to hit the ball?*

A. Billiard
B. Badminton
C. Golf
D. Ice hockey
E. Baseball

There were 3 out of 11 students in grade X chose D, one chose, A, three chose option E, and one chose option B. This mainly concerns with the use of 'knowing' taxonomic level, however the index is 'difficult' due to the test-takers being uninformed about such sports information. The facility index of the item is 0.27, which is 'difficult'. However, this item is considered good, as we see that all of the distractors are nouns, kinds of sports, and all sports using balls.

Item 49 grade XI. *A healthy diet____a lot of fresh fruit and vegetables. Vegetables____especially low in calories and high in nutrients such as vitamins and minerals.*

A. include; is
B. includes; are
C. include; are
D. includes; is
E. includes; -

The answer is option B which was apparently chosen by 8 students out of 12 students in grade XI. However, other distractors are efficient since each distractor was chosen by one test-taker, so one chose option A, one chose option C, one chose option D, one chose option E. The facility value of the item above is 'easy' with the index of 0.67.

The example of inefficient distractors:

Item 3 grade X. *Last month, I____skiing for the first time.*

A. go
B. going
C. went
D. didn't went
E. did going

The item above has a perfect 'easy' index, 1.00. The asnwer is option C, *went,* and the other options did not function well as distractors. None of the test-takers chose them. The objective of the item, indeed, is simple which is to make the test-takers find the correct verb form of the past verb. As soon as the clue *'Last month...'* is comprehended in our mind, the form that appear is a positive form of past verb, which is in option C. The distractors are suggested to be revised.

Item 47 grade XI. *When my grandmother was in high school, she ... a lot of rules and regulations, and she ... very hard.*

A.have to follow; had to work
B.had to follow; have work
C.had to followed; had to worked
D.have to follow; have to work
E.had to follow; had to work

The index of facility value of the item above is 1.00. It is 'easy'. The item aims at enabling the test-takers to use the correct form of past model of *'have to'* so the test-takers needed to employ their 'analyzing' level. All students chose B, which is the correct answer and the other option failed to play their role as the item distractors.

c. Discussion

From the findings above, English is then considered easy to science students. But let us look further into this fact. From 150 questions, 91% of the questions are in the 'easy' index, and most have perfect 'easy' index which is 1.00. The easy items are presented in the level of 'knowing' and 'comprehending' taxonomic level, which in fact employs the recalling and remembering of most information. This kind of items do not need more complex thinking process and presumably, students who are not-science-based would most possibly to be able to answer this kind of question, too. Higher order thinking application in multiple choice items are encouraged since most teachers only use the two lowest levels of te taxonomy, and this does not give any significant impact on the students' achievement. The order suggested are in the two higher levels which are 'analyzing' and 'evaluating'—the level of 'creating' might seem limited to multiple choice items. So, instead of designing grammar multiple choice items with one-word option, the teachers should design distractors—or stems—wrapped in both in compound and complex sentences. This is predicted to promote students to think in

higher level such as in Item 42 and Item 49 displayed above.

Further, 83% of the distractors did not work well. Shedding the light on the multiple choice items, distractors play the main role. The stem-distractor items should be objective, simple, direct; and item analysis indices are vital in the process of the items' evaluation whether they are to be accepted, discarded, or revised (Brown, 2004). Unfortunately, very few teachers are familiar with the item analysis of the test(s) they have designed.

The rationale built-up in the formest section about the fact that science students are bad at English appears to be confronted in this study. Beside the first factor that shows most of the items employed only 'knowing' and 'comprehending' level, additionally, a finding from Rimfield, et.al (2015) concerning to gene roles in educational achievement showed that there is no classification between science and non-science genes. Naturally, same genes are responsible for all academic achievements whether it is language, math, science, humanities, and even art. On the contrary, Hadzazy (2011) cited SAT scores from Karl Tate College Board showing that out of 1.5 millions of SAT test-takers in 2010, 5 students score 700-800 in critical reading (language) but 200-300 in math, and 154 students score 700-800 in math but scored 200-300 in language. This confirms that science-based students are not necessarily good at English, *per se* the majority copes better with math. And the rest are presumably highly intelligent testees who can do well in both math and language, and the number of course much larger than 154 students. Those 154 and 5 students are only the minority who excel in language and miserably fail in math, or vice-versa.

In conclusion, regardless of the natural ability and IQ levels between science and non-science students, environment poses the most prominent roles that can enhance curiosity, determination, and memory in both science and language (Rimfield, et.al., 2015). In this pertinent science-based school, teachers and students do use full English in teaching-learning activities for all subjects. All science-based subjects are delivered in English, so they are accustomed to the use of English of scientific terminologies, then the students are conformed with both 'context-embedded' and 'context-reduced' communications. So this is a science-based school running its activities in bilingual model; the integration of both science and language is worth applying in other schools. This is a good model for other non-science based school to also run such policy og integration. Indeed, it was carried out in some high-schools in Aceh a couple of years ago which was known as *RSBI (Rintisan Sekolah Berbasis International)* but the program was unfortunately cut off.

CONCLUSIONS

As the conclusion, this study verifies that although numerous issues have affirm science students are weak at language and language students are weak at science can no longer preserve in language learning context. From the formative items analyzed in this study, it was found that there are several factors influencing this condition. Firstly, the

cognitive level of items and secondly, the distractors' efficiency. In addition, the genetic and neuroscience issues also pose their propoitions. To any extents, somehow, the solution emerges in environment such as science-language-based environment created in Teuku Nyak Arief Fatih Bilingual School. However, concerning to the test item, it is strongly suggested that teachers use higher order cognitive level when constructing test items so students can incline in both science and language domains as they have been supported by such sophisticatedly nurturing environment.

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