A Supporting Tool for Learning to Improve Thinking Skill through Reading Activities

Wasan Na Chai Taneth Ruangrajitpakorn Thepchai Supnithi

Language and Semantic Technology Laboratory,
Intelligent Informatics Research Unit
National Electronic and Computer Technology Center, Thailand
{wasan.na_chai, taneth.ruangrajitpakorn, thepchai.supnithi}@nectec.or.th

***Abstract*— Thinking skill is an important skill required in most of person's activities, especially in academic level. This paper proposes a tool to support in learning thinking skills from learning by example of good published articles. The focused concept of the tool is to analyze content expression and relations of the contents as a representation of thinking process. The tool is designed to assist on assigning pre-defined content type-related tags and relation among the chosen types on each clause from the selected articles. From experiments, the results showed that the tool helps to increase learning performance. The average precision and recall scores from tagging of the participants using the tool were higher than the participant not using the tool for 0.15 and 0.22, respectively. Moreover, the participants showed significant growth in thinking skills in terms of more correct analysis and critical thinking after using the tool.**

Keywords-component; Thinking skill; supporting tool for learning; Reading analysis; Independent learning; Learning by example

I. INTRODUCTION

Learning is an important process to acquire knowledge and skills. Independent learning is another way of learning in which refers to a method of learner to acquire knowledge or skills by his/her efforts and to develop for inquiry and critical evaluation [1]. Independent learning suits for developing oneself in a free time and has benefits on enabling learners to improve their thinking process and analysis through activity. With this learning, learners have the freedom to research in their specific interest of knowledge and skills. However, extreme freedom in learning may bring some troubles such as misunderstanding, acquiring incorrect knowledge or outdated theory, etc. Therefore, interventions such as guidance or scoping are needed to keep learner on the right track of improvement [2].

Between learning for knowledge and skills, methods are different. In obtaining new knowledge, reading and listening to knowledge for memorizing and understanding are a usual method. However, acquiring skills requires continuous practice and guidance from experienced skill holders. Among skills, thinking is the most complex and dubious skill to acquire since ones' cognitive is differentiated. Thinking skills, which thought are in cognition and abstract, can manifest in ones' doing such as decision making, argument making, and logics in speaking and writing. Among those exemplified manifestations, writing is the most explicit act from tangible written pieces, especially an academic article which is made with clear logic and complicate but related thinking process.

While there are many techniques to master a skill, learning by example (LBE) is often applied with high regards used in many applications with acceptable success rate [3]. Examples play a role of an existing item which holds good characteristics waiting for analyzing and imitating or even further overcoming. Learners could learn by realizing extracted characteristics from an exemplary item. Thus, learning a thinking skill in terms of academic logic and systematical thought should be learned from an example of good and clear published academic articles. Although academic articles contain both technical and logical expression, this work focuses on only logical relation in thinking expression.

To help learners to acquire thinking skills by learning on logical relations from good academic articles as examples, we aim to create a tool providing a support on analyzing expression in articles for logical content and relations among them. We expect the tool to help improving thinking process by analyzing characteristics from good example and developing a thinking skill. The tool though is designed for independent learning, but an expert team is also involved in the process to provide guidance in scoping and monitoring the improvement of learners. The remaining of this paper is as following. Section II explains a design and process of the proposed tool. Section III describes experiments including settings, results and discussion of the obtained results. Lastly, Section IV gives a conclusion of this paper and provides ideas on how to improve the tool in the future.

II. THOUGHT TAGGER

Thought is reflected on what one expresses. In writing, thought is expressed through words in sentences in which are related by logic and intention. Therefore, reading articles from good writing can help readers learn and develop their thinking process. This tool is focused on the learners. A tool in this work is designed for users to analyze ones' thoughts via

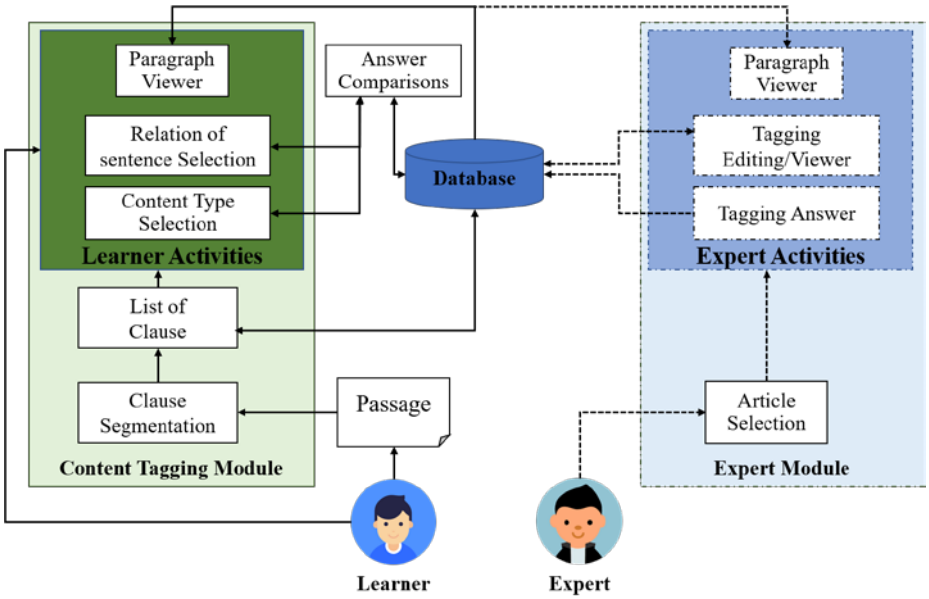


Fig.1 An overview process of the proposed Thought Tagger tool.

completed texts reading as a good example. The tool asks users to analyze the texts for content type of each sentence and relations among sentences. The example of the good logical and sound expression is expected for users to realize the gap of their thinking process and the use of correct expression. The tool is separated into three parts. The first part is a user-interface designed to get list of clause input along with tagging. Second, the answers are compared to the correct answers through the answer comparison module. Last, the storage is designed to record the list of clauses and tagging information. The tool is designed as illustrated in Fig.1.

A. Clause Boundary Segmentation

Clauses are a solid expression as a complete bound of a single thought since it can hold only one action expressing through a verb. Since this work focuses on expressed thought cryptic within the expression, the text input should be separated into a clause. A type of an English sentence basically falls into four types: a simple sentence, a compound sentence, a complex sentence and a compound-complex sentence. A difference from four kinds is based on a combination of clauses as shown in Table I.

TABLE I. Types of clause in English used in the proposed tool.

Type of an English Sentence	Clause Component	
	Independent Clause (IC)	Dependent Clause (DC)
simple sentence	1	None
compound sentence	2 or more	None
complex sentence	1	1 or more
compound complex sentence	2 or more	1 or more

In this tool, although users are asked to provide only text from academic articles as a whole as input passage, clauses are automatically segmented without removing punctuation or conjunction to be worked on. The clause segmentation is applied from the existing tool [4]. The tool generates clause-ID as index referring to each clause from appearance order. Clauses with clause-ID are stored into the database, and the tool provides two blank fields for collecting a tag of relation of clause and content type.

B. Content Type Tag

Each clause comes with an idea and it is expressed into the articles with reasons. Thus, a clause itself is a summary of intended content from a writer. This tool asks a user to analyze the clause for a type of content and to annotate the clause with a pre-defined tag. A list of *Content type* is designed from the analysis of the expert. It also includes the experience from writing articles of experts and feedback from experienced publication reviews. The pre-defined content types are carefully designed to cover all the ideal concepts in logical expression for academic articles. For example, tags for annotation of *content type* are show in Table II.

TABLE II. Examples of selectable content types provided in the proposed tool.

ID	Content type	ID	Content type
1	Assumption	11	Explain the result
2	Causal relation	12	Give an Example
3	Clear Evidence	13	Give an opinion
4	Compare	14	Infer
5	Convince	15	Interpretation
6	Criticize	16	Originality
7	Examined	17	Scope
8	Explain in the other way	18	Show Difficulty
9	Explain The cause	…	…

10	Explain the necessity	40	Support

Each clause should be assigned with one of pre-defined content types. Though, users are allowed to blank out of the tag if they cannot decide which tag to assign. The assignment is to be conducted via an UI of the tool (explained in Section 2.D).

C. Relation Tagging

Relation of clause indicates the link of thoughts from author's ideas in their work. From observing the published articles from renowned sources, we found that most of the clauses were related to form a logical network to convince reader. Thus, we expect learners to learn the relational expression from the example.

Once users assign a content type to each clause, they are also asked to assign relation between them. The assignment of clause relation is to fill the clause ID of the previous clause regardless of assigned content types. In case of a new concept unrelated to any previous concepts, uses are allowed to assign 'none' to the clause.

D. Usage and User Interface

The tool is designed as a web-based application which can be used via a web-browser since it is a tool for independent learning and should be used regardless of location. We separate design of user-interface (UI) of the tool based on users' role. Learners are those who are novice and aim to study think processes of writer from their published articles while writer who are experienced in publishing articles.

The learners are asked to annotate each clause for both content type and relation of clause via a UI shown in Fig.2. The annotated clause is stored in a database and checking the answer with the correct answer data. The review is then displayed to learners to re-organize their understanding while honing their skills.

For this tool, we focus on user-interface design to ensure consistent use in all parts. Segmented clauses and their ID (as marked as #2 and #1 in Fig.2 respectively) are listed in appearance order from top to bottom. In a row of clause information, a user is to select a content type (shown as #3 in the figure) and to assign an ID of related clause (located under clause ID and marked with #4 in the figure). Lastly, the rightmost part (marked as #5) is a group of miscellaneous functions such as function to manually edit a clause boundary and function to delete a clause in case of a noisy text.

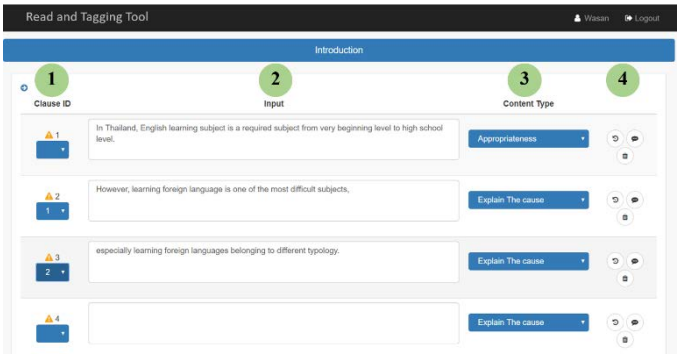


Fig.2. A UI of learner part for tagging content type and relation of clauses to each segmented clause.

III. Evaluation and Discussion

A. Experiment Setting

For evaluating usefulness of the proposed tool, an experiment in usage was set up. The main focus is to compare learner's thinking processes from independent learning without a help of a tool and with the proposed tool.

The participants in this experiment were 12 Thai graduate students in Thailand. They all studied in a department of computer science and information technology. The participants were randomly separated into three groups as 4 participants per group. The first group was a group that did not use the tool. The second group was a group to be provided with the tool. The third group was a group to work on a task without the tool and then worked with the tool in a second endeavor. All groups were asked to select academic articles from an article pool gathering by expert team. The article materials were from IEEE Xplore 2015-2016, and they were determined by the expert for their readability and good presentation regarding logical expression and relation. The remained articles in the pool must be consentaneous by all three expert and in a domain of computer science and information technology. As a result, the article pool contained 43 papers in total.

In the experiment, participants were asked to freely select 3 articles from the pool. Then, they analyzed an introduction part of the articles for content type of each clause and relation among the clauses according to aforementioned tool set up. In analyzing and tagging, one of the expert was to provide the guidance on how to understand logical content of a clause and to give a comment on tag selection. Once one article was done, participants were on break for at least one hour to recover from fatigue and to prevent from overload.

In evaluation, the assigned tag to each clause in both content type and relation of clause were counted and compared to the gold standard answer consenting from all experts. The measurement in this experiment was precision, recall and F-measure. The precision in this experiment was a proportion of correct answers from all given answers of the participant. The recall was a proportion of correct answers from all clauses in the article. The F-measure was a score calculate from two multiplies with precision and recall and

divided by a summation of precision and recall score. F-measure value is calculated by (1).

$$F1 = 2 * \frac{precision * recall}{precision + recall} \quad (1)$$

B. *Experimental Result and Discussion*

The results of precision and recall in average of the first group and the second group in content type tagging, relation assignment and overall are given in Fig. 3. Fig. 4 shows the results of all groups but the third group in both when they conducted experiment before using the tool and on the tool for their improvement from the first article to the last article.

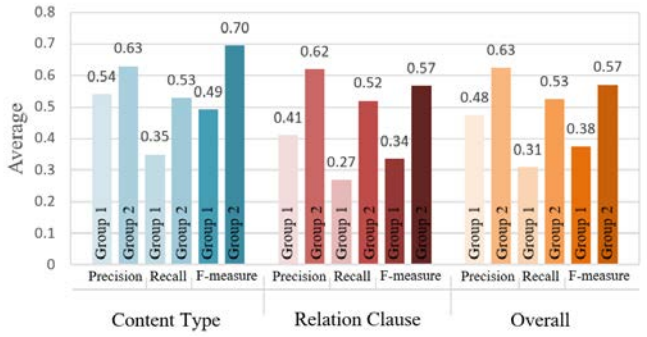
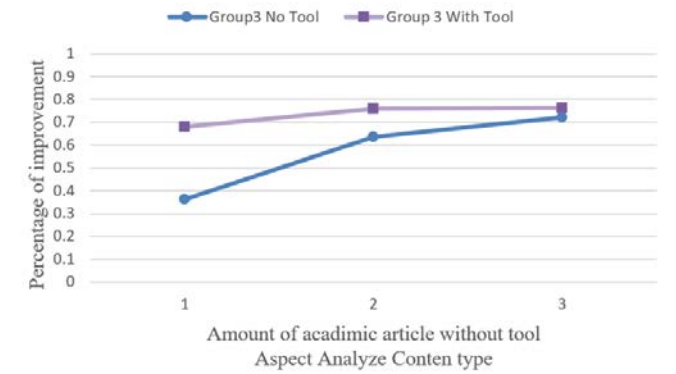


Fig.3. Comparison of average results in precision and recall between participants with tool and without tool.



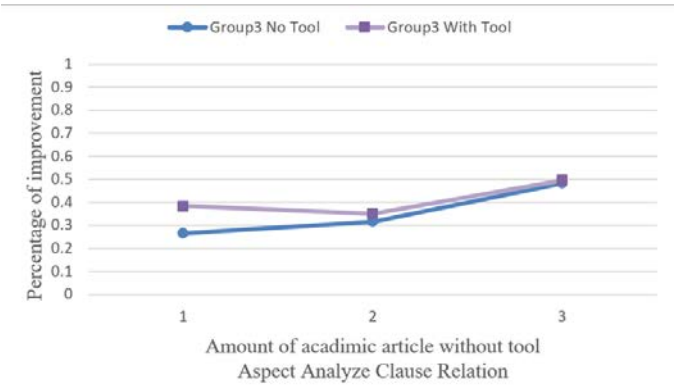


Fig.4. Improving results of the third group comparing with tool and no tool.

From Fig.3, it is clear that precision, recall and F-measure from the second group are higher than the first group both assigning content type and relation of clauses. For an overall, the average precision, recall and F-measure from tagging of the participants using the tool were higher than the participant not using the tool for 0.15 and 0.22, respectively. The results reveal that relations of clause were prone to be incorrect more than content type assignment. This is because the relation of clauses requires understanding in overview of all expressions to assign while content type is for individual clause. In addition, the tool was able to greatly boost scores of recall since the tool provides the automatic clause segmentation function and results in more awareness and preventing on missing clauses.

The results from Fig.4 are to show a growth of participants' ability from the first article to the last article. The rising graphs indicate that participants with the tool had stable rising scores in F-measure. Moreover, the third group which initially did not use the tool and then was asked to use the tool obtained a noticeably steep rising after using the tool. The score on the F-measure value in the first article is 0.36. After using the tool, the score increases to 0.68. The percentage difference is 47.06% in the content type feature. In the second article, we found that the participants have improved thinking process although not using the tool. The gap has narrowed to only 15.79%. Furthermore, the results from third article of the third group despite not working on the tool were slightly lower than the participants with tool. The difference value is 5.26%. This indicates that the tool has an effect on learners even they had used it once. Thus, we applied two-factor ANOVA test to see the difference between the F-measure results of each participant from all article. Apparently, the result was given that the scores were significantly different for 7.89 scores in average with α (significant level) = 0.05 and f-critical = 2.82. From calculate ANOVA test, the results can be concluded that this tool statically significant affects learners use the tool.

Based on the statistics, it can be seen that the number of answers to the clauses were increased from the second paper without using the tool onwards. This can be inferred that the tool made the participants realized on how to separate clause and importance of logical content implicitly hidden in a clause. Moreover, the amount of correct answers was also increased.

From interviews with participant after test. They commented this tool is useful for novice learner and those who want to know the process of analysis. The tool is also an area for practicing the thought process. They can also study the writing style from good article samples through analysis by tagging. This thinking skill can be applied to writing.

For interviewing from the experts in the experiment, they were impressed by sudden growth of skills from participants of the group with the tool. They also mentioned that the time spent in tagging the content type and relation of clauses for each clause was continuously shorten, and participants shows a sign of more confident as the experiment went on. Additionally, they suggested on visualization of a graph relation among clauses from the tag data since it could

explicitly display a network of thoughts in logical expression. The visualized network of thought may help learners to realize and imitate the process of thinking more empirically with visualization.

IV. Conclusion and Future Work

This paper proposes a tool supporting on learning thinking process by analyzing the good example. The tool is designed to provide a strict environment for analyzing thinking process imprinted in academic articles which are full of related logical expression. The tool asks users to annotate each clause in an article with types of content (such as fact declaration, reason provision and conditional statement) and indication of relation between clauses. The aim in tagging is for learners to realize the thinking process from an exemplar and training of analysis skill. From experiments, the tool was proved to increase the number of correct tagging results in both precision and recall for both content type selection and assigning relation of clauses. The improvement in terms of correctness was significantly different between using the tool and without the tool. Moreover, the use of the tool could increase participants' understanding on importance of thinking skill in both analysis and critical thinking.

In the future, we plan to visualize the annotated content type and relation of clauses from a good article collected in the tool into a network of thoughts to empirically display though relation. Furthermore, we plan to add more function to use the tagged data in suggesting logical expression in writing an academic paper. For the part of expert, it will be a task to develop in the future work. The expert will be choosing the article to tagging or editing answer the article.

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