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The Effects of Deductive and Inductive Instructions on Medical University Undergraduates' Improvement of Medical Research Articles Writing Performance

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ABSTRACT

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This study attempted to compare the effectiveness of the explicitly deductive (ED) and the explicitly inductive (EI) instructions in teaching particular structure that marks causal relations in medical research articles (MRAs) among Chinese medical university undergraduates of elementary and intermediate levels of English proficiency. The effects on short- and long-term learning were also investigated. Research proves that the causal relations are essential for MRAs and the verbs + that-clauses are commonly adopted as the causal markers in published English MRAs. Thus, they were taught as the target knowledge in the present study. A total of 64 medical university undergraduates were recruited and randomly divided into two instructional conditions. Performances in both conditions were measured by immediate and delayed posttests. The Mann-Whitney U test, repeated measured ANOVA and the two-way ANOVA were conducted to analyze the data. Results revealed a statistically significant difference between these two instructional approaches, with the EI instruction having a greater effect on participants' short-term and long-term learning of the target knowledge. English proficiency had no significant influence. The results shed light on the impact of the deductive and the inductive approaches on English for specific purposes (ESP)/ MRAs writing teaching, and some implications for teaching as well as future studies were provided and discussed.

I. INTRODUCTION

Publishing medical research articles (MRAs) written in English has been becoming one of the most essential and important tools for professionals to communicate within medical academic communities and to convey novel research findings to a wider world (Reimerink, 2006; Swales, 1990). It is well recognized that teaching English for specific/medical purpose (ESP/EMP) writing should not merely control linguistic errors, but also make it become a suitable genre to correspond to specific contexts and practices. Besides, distinctive differences in linguistic rhetorical choices can be found in English academic writings for particular purposes and readers (Paltridge & Starfield, 2013). Thus, teaching ESP/EMP to improve MRAs writing performance should aid students in skilfully employing particular writing styles with specific rhetorical choices. Among them, ways of expressing causal relations are essential, due to the

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characteristics and goals of MRAs, namely discussing and explaining mechanisms, rationale, and principles behind medical research, pharmacological effects, disease healing, and prevention, etc. (Hudzik, 2016; The Lancet, 2013). Cao, Sun and Zhuge (2018) proposed that causal relations cover about 65% on average of medical-related articles. Thus, assisting medical university undergraduates to express causal relations by using MRAs' particular rhetorical choices is indispensable for helping them improve their MRAs writing competence to produce adequate articles that correspond to the medical contexts.

Much research on language teaching has focussed on teaching instructions, and studies on deductive and inductive instructional approaches have attracted much attention (e.g., Trendak, 2009; Vogel, Herron, Cole, & York, 2011). Şik (2014) proposed that young language learners preferred an inductive approach while higher efficacy could be observed when employing a deductive approach to teaching English to adults, but opposing research findings were obtained by other researchers (e.g., Glaser, 2016; Takimoto, 2008; Vogel et al., 2011). Besides, Mallia (2014) proposed that some socio-culturally contextual factors as well as the learners' language levels could also influence the effectiveness of the instructional approaches. In other words, which instructional approach works more effectively remains unclear, and no research finding can be generalized for all.

Furthermore, according to Decoo (1996) and DeKeyser (2008), the simple delimitation that the deductive approach is explicit while the inductive approach is implicit should be negated. Therefore, although there is a universal agreement on the effectiveness of the explicitly deductive (ED) instruction in language teaching among adult learners, whether the explicitly inductive (EI) instructional approach works more effectively among adult EFL learners remains unclear and controversial (Qi & Lai, 2017), as such an issue has been insufficiently studied based on empirical classroom research (Vogel et al., 2011). Moreover, little research on this issue, especially when regarding the improvement of MRAs writing performance by teaching the usage of particular rhetorical structures to mark causal relations in MRAs and the impact on short-term and long-term learning of the target knowledge, has been conducted among Chinese medical universities undergraduates with different levels of English proficiency. Therefore, the purpose of the current study was to fill the gap by comparing the effectiveness of the ED to the EI instruction in teaching the particular structure that marks causal relations in MRAs among Chinese medical university undergraduates of different English proficiency levels. Their effects on learners' short- and long-term learning were also compared. To achieve this purpose, the following research questions were addressed:

1) What is the effect on the short-term learning of the particular rhetorical choices to make causal relations in MRAs by Chinese medical university undergraduates when being taught with the explicitly-deductive (ED) instruction versus the explicitly-inductive (EI) instruction?
2) Can the same findings of the first research question be applied to learners of different English proficiency levels?
3) Is the effect on the long-term learning different from the short-term learning of the target MRAs causal markers by the students when being taught with ED instructional approach versus the EI instructional approach?

II. LITERATURE REVIEW

1. The Importance of Causal Relations in MRAs

The medical research article is a formal, rigorous, and scientific texts, which requires logical structure, coherence and structural integrity. Such requirements can be fulfilled by adopting cohesive devices to connect essential parts in articles to express various relations in articles (S. A. Kim, 2017). Among them, causal relations play an essential role in cohering and representing the core of medical research articles (Cao, Sun, & Zhuge, 2018). Furthermore, causal relations are essential and fundamental since they explain the functioning as well as mechanisms explored by researchers after observing phenomena or conducting experiments, treatments, and diagnosis. Furthermore, causal relations allow research peers, professionals and other related personnel to distil essential information and novel knowledge from those articles (Mihăilă & Ananiadou, 2014). This is very helpful for readers to increase reading speed, recall content and identify events with higher importance, which significantly reduces the research peers' workload in cohering and understanding the core information of MRAs (Cao, Sun, & Zhuge, 2018). Thus, causal relations play an essential role in constructing MRAs to convey their core information.

2. *Verbs + That-Clauses* as the Marker of Causal Relation in MRAs

Causal relations can be conveyed in many ways, and "causal markers are both highly ambiguous and highly variable" in MRAs (Mihăilă & Ananiadou, 2014, p. 24). The words with causal meanings such as conjunctives (e.g., because, since), adverbs (e.g., therefore, hence) and prepositions (e.g., because of, due to) (Mo, 2015) can be adopted to mark causal relation (see (1)).

> (1) The virus trans-activators are potentially oncogenic, because they could induce the expression of cellular genes through a mechanism similar to that through which they act on their regulatory regions, LTRs.
> (Katoh, Yoshinaka, & Ikawa, 1989)

The words which "are used much less than the number of non-causal instances" in most of other contexts can also be employed to convey causal relations in MRAs (Mihăilă & Ananiadou, 2014, p. 4). For instance, in the sentence (2),

the causal relation that SPI-2 genes can be activated for transcription because "SsrB binds within SPI-2" is triggered by the word "and" which possesses non-causal meaning in most other texts.

(2) SsrB binds within SPI-2 and activates SPI-2 genes for transcription.
(Yoon, McDermott, Porwollik, McClelland, & Heffron, 2009, p. 9)

Apart from those two categories of words that belong to the group of close-class words, syntactic markers with words which belong to the group of open-class words, such as *verbs + that-clauses*, are "more commonly used as causal [markers]" (Mihăilă & Ananiadou, 2014, p. 2), as evidenced by the results provided by Mihăilă and Ananiadou (2014) by analyzing the frequency of the syntactic markers and *verbs + that-clauses* in the *BioCause* corpus. As causality is at the heart of medical knowledge, the *BioCause* corpus annotated with approximately 850 causal relations from open-access full-text medical-related journal articles published in the years ranging from 2012 to 2018. According to their findings, such syntactic causal markers occupied more than 70% of the total causal relations annotated.

Take sentences (3) and (4), where *"suggesting that…"* and *"suggested that…"* indicate the causal relations, as the examples. Although the syntactic markers *"suggesting that"* and *"suggested that"* do not bear causal meaning (Mihăilă & Ananiadou, 2014), the causal relations are conveyed, and sentences (3) and (4) can be rephrased as (3') and (4') respectively.

(3) … rv3614c was expressed much lower in H37Ra compared to H37Rv by qRT-PCR, whereas expression of rv3614c in H37Ra::phoP was restored to wild-type levels, suggesting that the rv3612c-rv3616c gene cluster is regulated by PhoP.
(3') …because the rv3612c-rv3616c gene cluster is regulated by PhoP, rv3614c was expressed much lower in H37Ra compared to H37Rv by qRT-PCR, whereas expression of rv3614c in H37Ra::phoP was restored to wild-type levels.
(Frigui, Bottai, Majlessi, Monot, Josselin, Brodin, & Cole, 2008)

(4) …DNA disrupted the integrity of the cell envelope causing cell lysis suggested that DNA was acting as a cation chelator.
(4'): …because DNA could disrupt the integrity of the cell envelope which caused cell lysis, DNA could act as a cation chelator.
(Mulcahy, Charron-Mazenod, & Lewenza, 2008)

It can be discovered that *verbs + that-clauses* can act either as the object, or *-ing* adjuncts in sentences when conveying causal relations in MRAs (Mihăilă & Ananiadou, 2014). Since such relation is commonly and largely demanding while explaining hidden principles or mechanisms in results and discussion sections of MRAs, the sentences which employed *verbs + that-clauses* to convey causal relations in all result and discussion sections annotated in the *BioCause* corpus were analyzed in the present study. Words used and their frequency are shown in Figure 1.

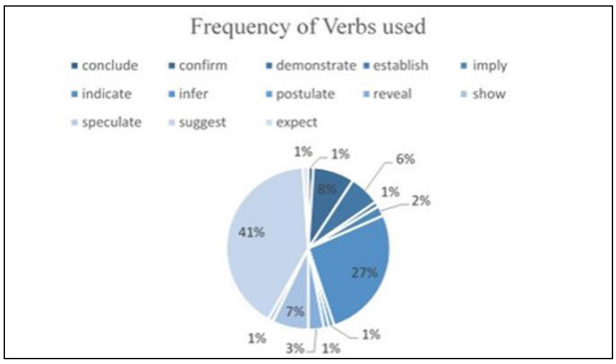

FIGURE 1 Frequency of Verbs Used

It can be observed from the Figure 1 that the verbs "*suggest*" and "*indicate*" were most commonly used, and other verbs with similar meanings and functions were also employed. Researchers (e.g., Liu & Braine, 2005; Mo, 2015) asserted that compared with articles written by English native speakers, Chinese EFL learners tended to misuse and overuse causal markers. When being able to adopt commonly-used rhetorical strategies to express causal relations, which is essential in MRAs, Chinese EFL learners can improve their English articles writing performance (Mo, 2015). Furthermore, using *verbs + that-clauses* by Chinese medical university undergraduates to convey causal relation was scarcely found (Mo, 2015). Hence, teaching medical university students who desire to join the professional community by publishing sound research articles in English on international medical-related journals to be proficient in adopting specific rhetorical choices, such as *verbs + that-clauses,* to express causal relations in MRAs is necessitated. However, research on this issue has been rarely conducted among Chinese medical university undergraduates with different levels of English proficiency. Thus, the current study set studying such rhetorical choice as the learning goal.

3. Inductive Instruction and Deductive Instruction

English as well as ESP/EMP teaching has various categories for pedagogical approaches. Among the various pedagogical approaches, the inductive and the deductive instructional approaches have attracted a good deal of attention.

Decoo (1996) asserts that "deduction is understood as the process that goes from the general to the specific, from consciously formulated rules to the application in language use" (p. 96). Based on this perspective, metalinguistic knowledge is provided or explained explicitly by teachers. In other words, grammatical rules and other language knowledge, which illustrates how and why the target structures are formed and function to achieve specific purposes in the contexts where they are adopted, are offered (Al-Kharrat, 2000). Terminology referring target language knowledge is therefore normally used and imparted firstly

in a systematic and logical manner. Successively, language learners access to instances which demonstrate the way how target linguistic structures or items are used, and then are guided to produce their own sentences to test whether they grasp the target knowledge (Vogel et al., 2011). Harmer (2007) named such teaching instruction and process as PPP-like method. PPP refers to *present, practice* and *produce.* The previous research on the deductive instruction mainly followed such steps.

Unlike the deductive approach by which language knowledge is taught in a linear and sequence manner, the inductive instructional approach allows a wider-range way (Vogel et al., 2011). Decoo (1996) defined induction as "the process that goes from the specific to the general, namely first the real language use, from which will 'emerge' patterns and generalizations. It evokes natural language learning and direct method" (p. 96) which refrains the use of learners' native language, encouraging students to use the target language, and differs from the grammar–translation method (Krause, 1916). In this respect, the inductive teaching approach focuses on aiding learners in working out the language rules from the real language usages (Vogel et al., 2011). Language knowledge, rules, and principles are normally not provided or explained directly. Instead, instances or related materials which can illustrate the ways in which the target language knowledge is used in the corresponding context are supplied. Then, learners are aided in "inducing" the target language knowledge, rules or principles in language use by exposing to successive practice gradually (Gollin, 1998). Harmer (2007) asserted that language learners tried to hypothesize how the target language knowledge is put together and function in particular context based on the instances, texts and other teaching materials with authentic and natural language usage. Compared to the deductive instruction, the operations of research on the inductive instruction to language teaching varied. For example, Robinson (1996) assisted students' to induce the language rules by themselves without providing any teacher's explanations on the target language knowledge. Rosa and O'Neil (1999) required participants to seek the rules during the presentation whilst Herron and Tomasello (1992) provided corresponding practice (i.e., sentencing completing) and students were assisted to "induce" the grammatical rules by doing such practice after the oral activities.

However, when many researchers investigated the deductive approach, following the traditional steps, and the inductive approach with no explicit explanation of language rules or principles inserted, Decoo (1996) and DeKeyser (2008) suggested that such traditional classification was insufficient for dynamic changing and various modalities of induction and deduction in language teaching. They support the position that the inductive approach does not reject explicit teaching of rules. The language rules can also be explicitly exposed to learners after they are assisted to discover them by engaging in language use. Decoo (1996), therefore, refined the inductive and deductive approaches to five subcategories (see Table 1 and Appendix 3). DeKeyser (2008) also suggested that "both deductive and inductive could be either explicit or implicit" (Qi & Lai, 2017, p. 27) (see Table 2). DeKeyser (2008) further asserted that meta-linguistic rules were surely involved in both of the explicit deductive and the explicit inductive learning, and the difference between these two approaches was that whether the rules were learned through teaching or learner's self-discovery.

TABLE 1
Five Subcategories of Modalities
(adapted based on Qi & Lai, 2017, p. 27)

	Deductive		Inductive		
	Modality A	**Modality B**	**Modality C**	**Modality D**	**Modality E**
Instruction	Explicit	Explicit/ Implicit	Explicit	Implicit	Implicit
Guided rule discovery/ summary	Absence	Presence	Presence	Absence	Absence
Materials un/ structured	N/A	N/A	N/A	structured	unstructured

TABLE 2
Dekeyser's (2008) Inductive/Deductive-Implicit/Explicit Dimensions (p. 315)

	Deductive	**Inductive**
Implicit	Traditional teaching	Rule discovery
Explicit	Using parameters	Learning L1 from input

Adair-Hauck, Donato, and Cumo-Johanssen (2005) provided the PACE model which was designed based on the principles of the explicitly inductive instructional approach. To be more precise, P refers to the presentation of the target linguistic knowledge through contextualized materials with natural English usage. After that, students' attentions (A) are guided to focus on particular language patterns through practices. Instructors then ask some guiding questions to lead students to collaboratively understand or explain the rules that govern the target structure, which is named co-construction phase (C). Extended (E) practices are successively given to enhance their understandings of the target language knowledge.

Some studies were therefore conducted to compare the effectiveness of the deductive instruction to the explicitly inductive instruction on English teaching, mainly focusing on English grammar and pragmatics teaching. However, the findings are inconsistent, as while Glaser (2016), Haight, Herron, and Cole (2007), Rose and Ng (2001) and Vogel et al. (2011) found significant differences, others' (e.g., Trosborg and Shaw, 1998) findings did not show any. Researchers who found significant differences provided inconclusive findings either. For instance, Rose and Ng (2001) proposed that the deductive instruction worked with higher efficacy, whilst Vogel et al. (2011) showed that participants in the explicitly inductive condition performed better in terms of short-term learning, although the results on post-test regarding long-term learning did not differ. Glaser (2016) also demonstrated that participants in the explicitly inductive group surpassed their peers in the deductive group, which suggested that the explicitly inductive instruction enjoyed

higher efficacy in the pragmatic competence teaching. Qi and Lai (2017) explained that the inconsistent findings might be due to the differences in participants' proficiency levels in the target language as well as features and types of target language knowledge. Also, different operations of the deductive and the explicitly inductive instructions influenced. Therefore, their research findings cannot be generalized to all English/language teaching and more research is necessitated to shed further light on this issue.

4. Inductive Instruction or Deductive Instruction?

Apart from the inconsistent research findings, Mallia (2014) proposed that socio-cultural factors which also impacted the effect of any English teaching approach should be considered. Although English teachers commonly have the assumption that one sound teaching approach that has been demonstrated by research can work equally effective worldwide, regardless of differences in terms of local socio-cultural factors (Küçük, 2011), socio-cultural factors, such as learners' needs, preferences, and appropriateness of implementing classroom practices within particular educational contexts, etc. should also be considered (Mallia, 2014). Küçük (2011) asserts that while the inductive instruction are universally presumed to be more effective in English teaching, the deductive approach might be more proper in some countries, such as China where large-size classes and "exam-culture mentality that values accuracy and tests learners' competence through written English tests" (Mallia, 2014, p. 223) exist. This is because the deductive instruction is less time-consuming and can provide learners with holist metalinguistic information which helps students to gain higher tests scores (Mallia, 2014). Besides, Vogel et al. (2011) asserted that contradictory results might be yielded when having participants with different language proficiency levels to examine the effectiveness of the deductive and the inductive approaches on English learning.

However, there is a lack of empirical classroom research on the issue, considering those influential factors within the context of Chinese medical universities. Thus, the current study attempted to fill in the research gap by achieving the above-mentioned research purpose.

III. METHOD

1. Participants

Third-academic-year undergraduates studying at a medical university in China were recruited via research advertisement. A CET-4[1] English simulation test was given before grouping actual participants from all students who were willing to participate to test their English proficiency levels. Elementary and intermediate-level students, decided in accordance with the CET testing rubric and scoring system, were finally recruited as they were able to process the target English structure, but they were still developing their MRAs writing competence. The actual participants in the current study were 64 undergraduates, including 31 female and 33 male students, between the ages of 20-23. A translation exam (Appendix 1) was employed as the pre-test to test whether the participants already had the related background knowledge about using the target rhetorical structures as causal markers after randomly and equally dividing them into two groups with two sub-categories: ED groups: ED-elementary (EDe), ED-intermediate (Edi), and EI groups : EI-elementary (EIe), EI-intermediate (EIi). Consent forms were obtained from all participants.

2. Research Design and Materials

Considering the purpose of the current study, this study followed the steps: 1. pre-test; 2. teaching (treatments); 3. testing tasks (Appendix 2), including immediate-post-test and eight-week-delayed-post-test. *The learning task* was designed with the aim that participants were trained to understand and learn the usage of the target structure to convey causal relations in MRAs, while the testing tasks were devised to measure the learning outcomes. Treatments were administered by the same English teacher through the 75-minute MRAs writing training section. All ED participants and all EI participants took the training together in ED and EI conditions respectively, regardless of language proficiency levels.

As different purposes make writers to employ distinctive rhetorical structures when creating academic writings in English, specific professional articles should be utilized to gain a deeper and better understanding of how professionals communicate and represent their research findings effectively and strategically (Paltridge & Starfield, 2013). Furthermore, many researchers (e.g., Lei, 2012; Liu & Braine, 2005) suggested that using sample articles written by English-speaking authors could provide better guidance and assistance for students with respect to the improvement of their writing skills in terms of authentic usage of causal connectives. Besides, the ESP/EMP articles are always the responses to particular readers in particular academic settings, which requires the particular linguistic choices and forms serve specific purposes (Paltridge & Starfield, 2013). The published MRAs therefore become sound teaching materials, containing commonly used and particular linguistic items as well as rhetorical choices. Thus, the teaching materials that were used for the present study were obtained from the *BioCause* corpus. The example of discourse causality analysis from *BioCause,* "marking the causal trigger" (Mihăilă & Ananiadou, 2014, p. 4), is shown in Figure 2.

[1] CET: College English Test, examines the English proficiency of non-English-specialized undergraduate and postgraduate students in China. It consists of band 4 and band 6.

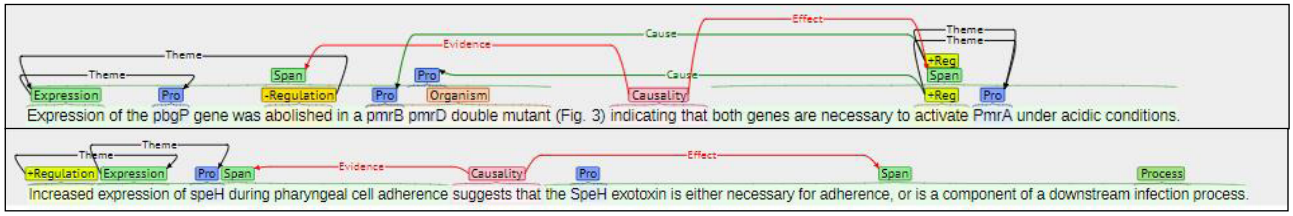

FIGURE 2 Example of Discourse Causality From the *BioCause*

3. Teaching Procedures

The study adopted Modality A and the integration of Modality B (Appendix 3) and PACE from Decoo's (1996) framework and the model proposed by Adair-Hauck, Donato, and Cumo-Johanssen (2005) to design the deductive and inductive instructional approaches for the two treatment groups respectively. Fifteen sentences that were selected from the *BioCause* corpus were adopted as the teaching materials and presented in the same sequence in both conditions during the teaching process, which made sure that participants in both conditions were exposed to the same amount of sample sentences and practices with the same level of difficulty. Because the participants might not learn the medical-related knowledge which was described by the given sentences, the medical terminologies in the sentences were translated into Chinese and the related medical knowledge were briefly explained by the teacher to avoid the influences of non-English knowledge, such as the professional medical knowledge.

1) Explicitly Deductive

In the ED condition, the teaching task began by explaining the grammatical rule of the target structures and their function in MRAs orally in Chinese. The above-mentioned verbs that are commonly used were also imparted. Then five sentences were presented to illustrate the rules and functions of the target pattern, and students were guided to understand their meanings, mainly focusing on how *verbs* + *that-clauses* worked as the causal relation markers. After that, the teacher analyzed the other five sentences one by one to enhance students' understandings of the target knowledge. Successively, participants were instructed to rewrite another 5 reworded sentences (the original *verbs* + *that-clauses* were replaced by conjunctives including "since", "because" and "as") by using the target structures previously explained as the practice. After that, the teacher offered the original sentences and guided students to check whether they got correct answers (verbs could be used interchangeably).

2) Explicitly Inductive

In the EI treatment condition, during the first phase of the teaching, 10 sentences, consisting of original five sentences from the *BioCause* corpus and their five reworded counterparts in which other causal markers (e.g., because, since, as) were used to replace *verbs* + *that-clauses,* were presented to the participants. The participants were guided to read and get the meanings of those sentences. Following this step, participants' attentions were called to the target pattern (*verbs* + *that-clauses*) and their function in MRAs, by working in groups to compare the similarities and differences among those presented sentences (i.e., same causal relations could be found in each pair of sentences, but the markers were different). Then, they were required to observe the other five sentences on hand-outs. Same sentence analyzing activity was repeated but without the teacher's guidance inserted in this phase. Participants were required to compare the differences and similarities between the original and reworded sentences by compiling Venn diagrams and listing the causes and effects described as well as verbs in each pair of sentences. Later, the teachers asked guiding questions to cue participants to discover the rules of using the target pattern, their function and verbs that could be used in such causal-relation-marking structure. After that, the target knowledge as well as the list of verbs were explained and provided explicitly by the teacher. Successively, participants were provided with the rephrased version (the original *verbs* + *that-clauses* were replaced by conjunctives including "since", "because" and "as") of another five sentences. Then they were instructed to rewrite those sentences using *verbs* + *that-clauses* as the extended practice. After that, they were offered the original sentences and required to work in groups to discuss whether they got the correct answers (verbs could be used interchangeably).

4. The Testing Task

An immediate post-test was administered following the teaching in both conditions. The tests consisted of Yes-No (YN) judgment and translation task which were devised to test learning outcomes. In the YN task, the participants were required to judge whether *verbs* + *that-clauses* in the ten given sentences, which consisted of original sentences from *BioCause* corpus and rephrased ones, functioned as causal markers following the judgment task steps proposed by Schütze and Sprouse (2014). This test was aimed at measuring whether these participants established the awareness of using *verbs* + *that-clauses* to mark causal relations in MRAs. In the translation task, ten sentences were required to be translated from Chinese to English by using the taught *verbs* + *that-clauses* (verbs could be used interchangeably). Translation testing task can function as an effective tool to measure learners' productive skills (Saricoban, 2012). It was therefore designed to test the partic-

ipants' productive skills, namely using *verbs + that-clauses* to express causal relations in MRAs.

5. Data Collection and Data Analysis

The current study adopted the pre-translation test, immediate-post-test, and eight-week-delayed-post-test, in the format of the YN judgment and translation task, to collect data. The pre-test was given one week prior to the treatments after grouping actual participants into the ED and the EI groups. The immediate-post-test, which tested the short-term learning, was conducted immediately after the treatments. The eight-week-delayed-post-test, which tested the long-term learning, with similar test types but different sentences, was given eight weeks after the treatments had been administered. The full score of the pre-test and both post-tests was 20 (YN judgment: 10, translation test: 10). All test questions and rating rubric were developed based on studies conducted by Schütze and Sprouse (2014), and Saricoban (2012). The differences among groups and the effects of the ED and EI treatments on learners' learning outcomes were compared by using the Mann-Whitney U test. The two-way ANOVA analysis, which was proven to be suitable for the current study (Blanca, Alarcón, Arnau, Bono, & Bendayan, 2017), was conducted to test whether different levels of English proficiency influence the learning outcomes in different instructional conditions. The repeated measured ANOVA was implemented to test the impact of the ED and the EI instructional approaches on the short-term and the long-term learning of the target knowledge. All analyses were conducted by employing IBM SPSS Statistics 24. Two English teachers who were working at the same university were trained to rate the tests. They rated tests separately and yielded an inter-rater reliability of .913, indicating the high degree of rating consistency.

IV. RESULTS

1. Preliminary Results

Results showed that no significant differences in terms of pre-test scores were observed between participants of the ED and the EI groups (U = 464, p > .05, η^2 = .003) and different English proficiency levels (U = 476, p > .05, η^2 = .004) before the treatments were administered, and they achieved comparatively low scores (see Table 3 and 4) on pre-translation test. The results indicated that all participants were equivalent in terms of their initial MRAs writing competence with regard to the use of *verbs + that-clauses* as the causal relation marker in MRAs.

TABLE 3
Preliminary Descriptive Statistics

Instructions	Proficiency	*n*	*M*	*SD*
ED	elementary	15	2.53	2.669
	intermediate	17	2.47	2.294
	Total	32	2.50	2.436
EI	elementary	16	1.75	2.049
	intermediate	16	2.25	1.612
	Total	32	2.00	1.832
Total	elementary	31	2.13	2.363
	intermediate	33	2.36	1.966

TABLE 4
Mann-Whitney U Test Results of Gain Scores Difference Between Two Groups — Before The Treatments

Pre-test	Groups	Mann-Whitney U	*p*	η^2
	ED	464	.488	.003
	EI			
	Elementary	476	.608	.004
	Intermediate			

2. Effects of the ED and EI Instructional Approaches

To assess the effects of the ED and the EI instructional approaches on participants' short-term learning outcomes for the *verbs + that-clauses* MRAs causal marker, the Mann-Whitney U test was conducted to measure the difference between pre-test and immediate-post-test scores that were gained by participants of each group respectively, and the immediate-post-test scores obtained by participants of two groups. There was a statistically significant difference at the .05 level between scores gained by both groups' participants before and after the treatments (ED: Z = -6.937, p < .05, η^2 = .763; EI: Z = -6.942, p < .05, η^2 = .764), suggesting that both of the ED and the EI instructional approaches worked effectively in teaching the target knowledge.

However, Table 5 and 6, which display the test results of the comparisons with the immediate-post-test scores gained by the participants of two groups, demonstrate that the EI approach worked more effectively: although positive gain scores in immediate-post-test illustrated that the participants of the ED and the EI groups made some progress after the treatments, participants in the EI condition (M = 18.25, SD = 1.25) performed better than did those in the ED condition (M = 15.42, SD = 1.76), with the difference being statistically significant (Z = -5.389, p < .05, η^2 = .46).

TABLE 5
Descriptive Statistics After the Treatments

Test	Instruction	*n*	*M*	*SD*
Immediate-post-test	ED	32	15.422	1.7603
	EI	32	18.125	1.2508

TABLE 6
Mann-Whitney U Test Results of Gain Score Difference Between Two Groups — After the Treatments

Test	Group	*Mann-Whitney U*	*p*	η^2
Immediate-post-test	ED EI	112	.00	.46

To further investigate the effectiveness of the ED and the EI among participants of different levels of English proficiency, the two-way ANOVA was conducted (see Table 7, 8, and Figure 3). A significant main effect was obtained for instructional approaches ($F(1, 60) = 50.831$, $p < .05$, $\eta^2 = .459$), indicating that the participants in the EI condition performed better than those of the ED group did in general, which was in line with the previous Mann-Whitney U test results. The English level has no effect on all participants' learning outcomes in general ($F(1, 60) = .001$, $p > .05$, $\eta^2 = .000$), suggesting that all participants made meaningful progress in the learning of the target causal markers in MRAs, regardless of the English proficiency levels. However, the significant main effect was obtained for the instructional approaches by proficiency interaction effects ($F(1, 60) = 4.115$, $p < .05$), although this was a small difference ($\eta^2 = .064$) (Cohen, 1973). Such a result indicated that the effectiveness of the ED and the EI instructional approaches to verbs + that-clauses causal markers' teaching could yield different results between the elementary and intermediate participants: participants in elementary English level category had comparatively lower immediate-post-test scores ($M = 17.75$, $SD = 1.0646$) than did participants in the intermediate English level category ($M = 18.5$, $SD = 1.3416$) in EI condition, while elementary participants had slightly higher scores ($M = 15.833$, $SD = 1.7182$) than did intermediate participants ($M = 15.059$, $SD = 1.7667$) in ED group.

TABLE 7
Descriptive Statistics

Instructions	Proficiency	*n*	*M*	*SD*
ED	elementary	15	15.833	1.7182
	intermediate	17	15.059	1.7667
	Total	32	15.422	1.7603
EI	elementary	16	17.750	1.0646
	intermediate	16	18.500	1.3416
	Total	32	18.125	1.2508
Total	elementary	31	16.823	1.7007
	intermediate	33	16.727	2.3355
	Total	64	16.773	2.0372

Note. Dependent Variable: Immediate-post-test-scores

TABLE 8
Two-Way ANOVA Results Instruction*Proficiency

Source	*df*	*MS*	*F*	*p*	η^2
Instructions	1	114.601	50.831	.000	.459
Proficiency	1	.002	.001	.974	.000
Instructions * proficiency	1	9.278	4.115	.047	.064
Error	60	2.255			
Total	64				
Corrected Total	63				

Note. Dependent Variable: Immediate-post-test-scores

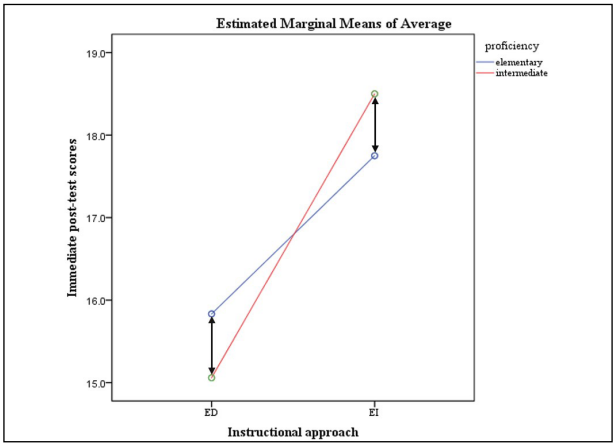

FIGURE 3 Interaction Effects of Instructional Approach and Proficiency on Immediate Learning Outcomes (Immediate Post-test)

To examine the sustainable effect of different instructional approaches on the long-term learning of the target causal marker among learners of different English levels in two instructional conditions, the Mann-Whitney U test, repeated measured ANOVA and two-way ANOVA were conducted. The Mann-Whitney U test results revealed that the EI instructional approach also had more positive effects on participants' long-term learning of the target knowledge than did the ED instruction, and English proficiency level had no significant influence on the long-term learning of the target knowledge (instructions: $Z = -5.253$, $p < .05$, $\eta^2 = .438$; proficiency: $Z = -.047$, $p > .05$, $\eta^2 = .000$, see Table 9). The results of repeated measured ANOVA indicated that there was no significant main effect for time ($F(1, 62) = .002$, $p > .05$, $\eta^2 = .000$, Wilks' lambda = .997,) and no time by instructions effect, $F(1, 62) = .543$, $p > .05$, $\eta^2 = .009$, Wilks' lambda = .991 (see Table 10 and 11), indicating that the effects of two instructional approaches on the learning outcomes remained stable over time.

TABLE 9
Mann-Whitney U Test Results of Gain Score Difference Between Two Groups —After the Treatments

Test	Group	*n*	*M*	*SD*	Mann-Whitney U	*p*	η^2
8-week-delayed-post-test	ED	32	15.51	1.67	123	.00	.438
	EI	32	18..00	1.27			
	Elementary	31	16.80	1.73	508	.962	.000
	Intermediate	33	16.71	2.13			

TABLE 10
Descriptive Statistics

	Instructions	*n*	*M*	*SD*
Immediate-post-test	ED	32	15.422	1.7603
	EI	32	18.125	1.2508
	Total	64	16.773	2.0372
EI8-week-delayed-post-test	ED	32	15.516	1.6776
	EI	32	18.000	1.2763
	Total	64	16.758	1.9375

TABLE 11
Repeated Measured ANOVA Results

Source	*df*	*MS*	*F*	*p*	η^2	Λ
Time	1	.002	.002	.961	.000	.997
Time × instructions	1	.439	.543	.464	.009	.991
Error(time)	62	.809				

Interestingly, the result of the two-way ANOVA showed some different results from the previous two-way ANOVA analysis results on immediate-post-test scores (see Table 12, 13 and Figure 4). A significant main effect was still obtained for instructional approaches, $F(1, 60) = 42.863$, $p < .05$, $\eta^2 = .436$, and proficiency also had no significant effect on participants' learning outcomes that was tested by the eight-week-delay-post-test. However, unlike the previous two-way ANOVA results, no significant main effect was obtained for the instructions by proficiency interaction effects ($F(1, 60) = .14$, $p > .05$, $\eta^2 = .002$). Although the elementary participants still did better in ED conditions and worse in EI condition, and the participants of intermediate English level had higher scores in EI condition than did in ED condition, this was an extremely small difference ($\eta^2 = .002$) (Cohen, 1973).

TABLE 12
Descriptive Statistics

Instructions	Proficiency	*n*	*M*	*SD*
ED	elementary	15	15.600	1.5260
	intermediate	17	15.441	1.8446
	Total	32	15.516	1.6776
EI	elementary	16	17.938	.9979
	intermediate	16	18.063	1.5370
	Total	32	18.000	1.2763
Total	elementary	31	16.806	1.7305
	intermediate	33	16.712	2.1398
	Total	64	16.758	1.9375

Note. Dependent Variable: 8-week-delayed-post-test scores

TABLE 13
Two-Way ANOVA Results Instruction*Proficiency

Source	*df*	*MS*	*F*	*p*	η^2
Instructions	1	98.167	42.863	.000	.436
Proficiency	1	.005	.002	.965	.000
Instructions * proficiency	1	.322	.140	.709	.002
Error	60	2.290			
Total	64				
Corrected Total	63				

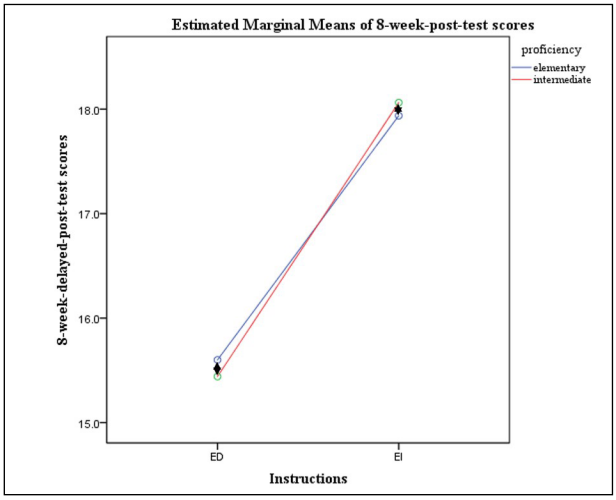

FIGURE 4 Interaction Effects of Instructional Approaches and Proficiency on Delayed Learning Outcomes (8-week-delayed-post-test)

V. DISCUSSION

The current study examined the effects of the explicitly deductive and the explicitly inductive instructional approaches on the teaching of *verbs + that-clauses* as the causal relation markers in MRAs among Chinese medical undergraduates of elementary and intermediate English proficiency levels. The immediate-post-test and eight-week-delayed-post-test demonstrated that both of the instructional approaches assisted participants to make meaningful progress, but the EI approach tended to be more effective in general. Participants' English levels did not have a significant influence. Although the two-way ANOVA analysis, having the immediate-post-test scores as the dependent variables, showed that participants of elementary English level had comparatively lower scores than the intermediate participants did in the EI condition, and slightly higher scores than the intermediate participants did in the ED group, the difference was small. By analyzing the effects on the long-term learning of the target knowledge, having the eight-week-delayed-post-test scores as the dependent variables, no significant difference was noted. Thus, it is fair to assert that when the target causal markers in MRAs were taught with the EI instructional approach, the participants of elementary and intermediate levels of English proficiency could achieve better and more favorable learning outcomes, indicating that the EI instructional approach possessed higher efficacy. This finding is opposite to the Mallia's (2014) position that the ED instructional approach works more effectively for English as well as ESP/EMP teaching in countries, such as China, due to the exam-culture mentality. However, this finding is consistent with previous investigations conducted by Haight et al. (2007) and Vogel et al. (2011), suggesting that the EI instructional approach surpassed the ED instruction in terms of teaching target grammatical structures to learners of elementary and intermediate English levels.

However, since the medical terms and related knowledge were explained briefly by the teacher in the current study, future studies could examine learners at advanced levels of English proficiency and with different amount of professional medical knowledge as these variables may also influence the effectiveness of the instructions (Paltridge & Starfield, 2013).

Concurring with Vogel et al. (2011)'s ideas, this finding is also consistent with cognitivism theory which focuses on the "complex, cognitive processes such as thinking, problem solving, language, concept formation and information processing" (Snelbecker, 1983, p. 11), requiring learners' active participation and engagement in the learning process to construct knowledge via hypothesis testing and problem-solving rather than being passive receivers (Leonard, 2002; Vogel et al., 2011). When the participants were taught with the EI approach, they were required to think about the linguistic structures and the functions in the context of MRAs. Then they could formulate the hypotheses about rules by analyzing the examples and answering the guiding questions with assistance from the teacher. In other words, during this process, participants were assisted to manipulate the input (instances from the *BioCause* corpus), form the hypotheses about the target knowledge (*verbs* + *that-clauses* serving as the causal markers), and then test their hypotheses by answering questions and practice. The teacher's explicit explanations about the target knowledge then were provided to assist participants to enhance and strengthen the understandings of the target knowledge. Moreover, Jean and Simard (2013) proposed that the effectiveness of the ED and the EI instructional approaches might rely on the nature of language rules and the complex of syntactic structures. Klauer and Phye (2008) suggested that the inductive reasoning could facilitate the complex problems solving. Compared to the mere learning of the grammatical structures, the learning of *verbs* + *that-clauses* that possesses non-causal meaning as the causal relation markers in MRAs became more complex and difficult, as not only did the structure need to be grasped, but also the cognition in developing the concept of using them to express causal relations should be activated. Therefore, this finding is also in line with their opinions, meaning that the EI instructional approach could be more effective for the construction of more complex and difficult knowledge. Future studies may systematically explore the interaction among the nature of other MRAs writing knowledge/skills and the effects of the ED and the EI instructional approaches on the learning of them.

Contrary to the research findings obtained by Vogel et al. (2011), the current study's findings of the long-term learning analysis still yielded a statistically significant difference with regard to the effect of the ED and the EI instructional approaches over time. Vogel et al. (2011) suggested that due to the teachers' teaching styles, additional exposure or practice of the target knowledge, and other untested extraneous variables that existed during the period between the immediate- and delayed-post-test, no significant difference in different instructional approaches was observed over time. However, the current study proved that the EI approach was more effective than the other on participants' long-term retention. Such a result might be attributed to the exclusion of influential variables (e.g., teacher teaching style, additional exposure and practice, etc.) suggested by Vogel et al. (2011) from the current study. Additionally, the result can indicate that the different process of constructing knowledge with the ED and the EI instructional approaches made students engage in different levels of cognitive processing of the target knowledge. The EI instructional condition required participants to engage more in cognitive processing when interacting with teachers and teaching materials, which made contributions to the long-term retention (Qi & Lai, 2017). However, due to the inconsistent findings, more studies should be conducted to examine the influences of other extraneous variables and the cognitive mechanism behind the cognitive processing when being taught with the ED and the EI approaches for more effective and appropriate choices of instructions.

Furthermore, the teaching materials which were used in the current study were obtained from the *BioCause* corpus that annotates published English MRAs. The materials, therefore, enabled participants to be exposed to the authentic and natural usage of particular rhetorical choices found in professional medical research articles. This also demonstrates that the corpus-based teaching materials need to be widely adopted to not only enhance the teaching effectiveness but also allow students to access to authentic and particular rhetorical choices of linguistic items for the success of ESP/EMP teaching.

VI. CONCLUSION

English has been acting as an essential tool for professionals to communicate in medical and other related fields globally. To successfully share information in these communities, producing adequate MRAs is one of the most important approaches. MRAs employ particular rhetorical linguistic items and structures to fulfil their specific goals. Therefore, learning the usage of the particular rhetorical choices is very essential for non-English medical students who desire to join the professional communities by publishing adequate MRAs in international leading journals. However, insufficient research on this issue has been conducted, especially in the context of Chinese medical universities.

The current study filled the research gap by examining the effectiveness of the ED instruction and the EI instruction in teaching medical university undergraduates with elementary and intermediate levels of English proficiency the *verbs* + *that-clauses* as the causal relation marker in MRAs in the Chinese educational context. A statistically significant difference between two instructional approaches was noted, with the EI having a greater effect on participants' learning outcomes. These findings align with some

previous research findings (e.g., Vogel et al. 2011) and the cognitivism theory, indicating that actively engaging in the learning process through formulating hypotheses about the target knowledge, solving problems that provide cues and testing hypotheses can facilitate ESP/EMP learners to achieve more favorable learning outcomes. In such the EI model, both the teacher and learners engaged and collaborated actively in the process of co-constructing the target knowledge, which is very essential for the construction of target knowledge (Herron & Tomasello, 1992).

Furthermore, this study made contributions to ESP/EMP instructions and, more specifically, to the unstudied aspect of the effectiveness of the ED and the EI instructional approaches in the improvement of MRAs writing competence among Chinese medical university undergraduates. Besides, this result demonstrated an important pattern across elementary and intermediate levels of Chinese medical university undergraduates, suggesting the positive effect of the EI approach to introduce the certain rhetorical structure in MRAs in the classroom's ESP/EMP teaching. Also, the present study demonstrated the effectiveness of the adaptation of the *BioCause* corpus-based teaching materials in the teaching ESP/EMP writing. In this respect, it also has pedagogical implications. ESP/EMP teachers should be aware of the importance of the instructional approaches and teaching materials while aiding medical university EFL learners to improve their research articles writing performance. Given the fact that both of the EI and the ED approach assisted students' to grasp the target knowledge and the EI was more effective than the ED in the learning of the target knowledge, ESP/EMP instructors might achieve more favorable teaching outcomes when continuously and increasingly adopt the EI instructional approach. Furthermore, selecting teaching materials which can provide students with authentic and natural usage of the particular rhetorical items that correspond to specific professional contexts is essential. Teaching materials, such as the ones obtained from the *BioCause* corpus as well as other corpora are highly recommended to replace the artificial textbooks. Considering the above-mentioned implications, future studies may systematically explore the effect of the ED and the EI instructional approaches on the learning of other particular MRAs' rhetorical strategies and among learners with different levels of English proficiency, i.e., advanced level.

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APPENDIX 1

Examples of the Pre-Test Questions

Scores were given when they express causality relations in the answers, regardless of other errors, such as the meaning of terms was translated incorrectly.
Translate the following sentences into Chinese.
1. The anticipated appearance of mice could be observed, suggesting that gene knockout was obtained.
2. PI staining was observed in cells exposed to DNA and EDTA, confirming that this treatment was lethal
3. All the convalescent sera tested had SeMac-specific antibody (Fig. 3B), indicating that SeMac is produced in vivo during infection
4. The CAP resistance phenotype of biofilms grown in limiting magnesium (20 microM) was similar to biofilms grown in DNA, confirming that DNA imposes a magnesium limitation stress
5. retS and ladS were also constitutively expressed, indicating that posttranslational modifications are essential for their activity

APPENDIX 2

Examples of the Testing Tasks

A. Translation (English terminology were provided)
1. 由于掩埋在二聚体界面处的总表面积为1258A2，所以SrcA可作为溶液中的二聚体存在
2. 在测定中包含SeMac不影响马链球菌的调理吞噬作用，所以SeMac不抑制马PMN的马链球菌的调理吞噬作用
3. Rv2623为提供结核分枝杆菌提供抗应激保护，所以RV2623缺陷突变体可能在体内减弱
4. 在生物膜或浮游生物培养中，lux没有明显的DNA诱导的CAP抗性，所以在细胞外DNA存在的情况下，这些基因对CAP抗性是必要的。

B. Yes-No Judgment -- whether do the following verbs+that-clauses serve as causality markers?
1. There was no significant difference in the percentages of PMNs associated with wild-type and DeltavicK bacteria at both time points and in both horse and rabbit blood (Fig. 3), indicating that the DeltavicK mutant retains the ability of S. equi to resist to phagocytosis by PMNs
2. These extracellular toxins target red blood cells to provide access to iron, but often show activity against immune cells, suggesting that they contributed to the bacterial response to the immune system of hosts, including phagocytosis by insect blood cells
3. … suggested that if P. luminescens and Y. enterocolitica that interact with the midgut of diverse hosts use the same adhesion and invasive factors
4. the PrtS (Plu1382) secreted by P. luminescens can induce melanization of the hemolymph, which suggests that it can probably circumvent the innate immune response of the insect
5. A strain deficient in the pmrA gene was approximately 100,000-fold more sensitive to polymyxin B than the wild-type strain when grown pH 5.8, which suggested that this resistance was PmrA-dependent.

APPENDIX 3

Decoo's Five Modalities (Decoo, 1996, pp. 96-98)

Modality	Description
Modality A Actual deduction	The grammatical rule or pattern is explicitly stated at the beginning of the learning process and the students move into the applications of this (examples and exercises).
Modality B Conscious induction as guided discovery	The students first encounter various examples, often sentences, sometimes embedded in a text. The "conscious discovery" of the grammar is then directed by the teachers: on the basis of the examples the teacher normally asks a few key questions and the students are led to discover and formulate the rule. The rationale usually given is that students who discover the rule on their own will profit from this.
Modality C Induction leading to an explicit "summary of behaviour"	The learner first practices a certain structure in an intense way. Through this practice the rule is "somehow" induced and internalized. Then, at the end of the learning segment, the teacher summarizes the rule explicitly. The methodologists advocating this approach avoid the impression that this explanation is important, by simply calling it "a summary of behaviour". It was the approach of early proponents of audio-lingualism and can be detected in a number of specific methodological recommendations of the past three decades.
Modality D Subconscious induction on structured material	In subconscious induction on structured material, the students are exposed to language material that has been structured in such a way to help the inductive process. The principle advocates that through the systematic repetition of the same pattern, through graded variations, through drill and practice, the student will come to an "integrated mastery" of the rule, without conscious analysis. This modality was the major technique advocated by many of the audio-lingual methods around 1960, and especially by the French audio-visual methods.
Modality E Subconscious induction on unstructured material	This is supposed to come as close as possible to "natural acquisition". Only intense language practice is given, on the basis of authentic input, without any linguistic structuring or manipulation. "Generalizations" will come naturally, comparable to first language acquisition.