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STOP USING LEARNING-BY-TEACHING. A SIMPLE REVISION COULD PROVIDE SIMILAR EFFICIENCY: A CASE STUDY ON METACOGNITIVE BENEFITS.

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Abstract

Earlier researches have shown that the learning-by-teaching pedagogy could be an effective pedagogy. As being a peer tutor, students might learn better than just sitting and listening in the classroom. Studies also reveal that there are two types of strategies which tutors would adopt, named as knowledge-building and knowledge-telling strategy. Although the former one could provide a greater learning outcome, tutors trend to use the later one more often. Metacognition is thus believed to be essential because it is a factor of such selection. This study contributes towards exploring the potential of the knowledge-telling strategy to promote college students' metacognitive skills. Results indicate that no significant metacognitive skills improvement could be founded in the tutors compared to their tutees. Knowledge-telling strategy does not help in promoting knowledge-building strategy. It implies that measurements have to be taken; otherwise, tutors will keep using the low efficient knowledge-telling strategy in LdL.

Keywords

Learning-by-Teaching, Metacognition, Metacognitive skills, Knowledge-Telling Strategy

Introduction

The Learning-by-Teaching Pedagogy

The learning-by-teaching pedagogy was perhaps first applied as a formal educational tool named as *Lernen durch Lehren* (LdL) by Jean-Pol Martin in German in the 1980's (Grzega & Schöner, 2008). As the French essayist Joseph Joubert said, "To teach is to learn twice over." Aligning well with this hypothesis, earlier researches show that tutors might learn as much as or even learn greater than their tutees during the teaching and learning process (Allen & Feldman, 1973; Cloward, 1967).

Later study suggests that the interactions between the tutor and tutees, especially the explanation and feedback process, are indeed the key factor in the teacher's learning (Annis, 1983). As Vygotsky stated, "Speech is the external expression of thoughts" while "A word without meaning is just an empty sound" (Vygotsky 1987). In order to express themselves through dialogues, tutors have to do the mind reviews, reformulates information into knowledge and reorganise the content materials (Gartner, Kohler & Riessmann, 1971; Zajonc, 1966). It could benefit tutors from all age groups across different subject domains (Cohen, Kulik, & Kulik, 1982; Cook, Scruggs, Mastropieri, & Casto, 1986; Mastropieri, Spencer, Scruggs, & Talbott, 2000; Mathes & Fuchs, 1994; Rohrbeck, Ginsburg-Block, Fantuzzo, & Miller, 2003).

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The Knowledge-Building and the Knowledge-Telling LdL Model

However, recent studies show that such benefits are not guaranteed (Cohen, Kulik, & Kulik, 1982; Mathes & Fuchs, 1994; Renkl, 1995; Rohrbeck et al, 2003). The effect sizes for elementary and middle school tutor are always small while greater gains always exist in Math or Science compared to reading programs (Roscoe & Chi, 2007). In order to account for these findings, the terms *knowledge-building* and *knowledge-telling* are thus proposed. Knowledge-building is defined as the "metacognitively reflection upon their own expertise and comprehension, and constructively establishment upon their prior knowledge by generating inferences, integrating ideas across topics and domains, and repairing errors" while knowledge-telling is defined as "lecturing or stating what they already know by summarizing facts with little elaboration or self-monitoring". Although self-explanation could also facilitate such activities (Chi, Bassok, Lewis, Reimann, & Glaser, 1989), explaining to others seems to be more effective since it provides more potential benefits by having the gaps and inconsistencies clarified during the explanation process (Coleman, Brown, & Rivkin, 1997; Webb, 1989). Although knowledge-telling can have a positive impact on the tutor's learning, the knowledge-building process is argued to result in a better understanding (Roscoe & Chi, 2007).

How do tutors choose between them?

Despite the benefits of knowledge-building, tutors always rely heavily on knowledge-telling even training had been provided (Dufrene, Noell, Gilbertson & Duhan, 2005; King, Staffieri, & Adelgais, 1998) while untrained tutors will adopt knowledge-telling spontaneously (Roscoe, & Chi, 2008). Roscoe (2014) suggests that lack of expertise knowledge and metacognitive skills might be the reason. In most cases, peer tutors are unlikely to be experts in the corresponding domain or pedagogy content knowledge. They might not possess the abilities (eg. Questioning, Reasoning, explanation and metacognitive skills) for knowledge-building strategies. Eventually, tutors choose knowledge-telling for "comfortable" and "safety" without being criticised.

Hypothesis and Research Questions

If the above literature reviews are correct, metacognitive skills are indeed very essential and critical to the LdL. As noted before, the two main factors determining the use of knowledge-building and knowledge-telling strategy are expertise knowledge and metacognitive skills. The domain knowledge is indeed the product of the whole teaching-and-learning process. It is the goal we want to achieve and thus an assumption of strong domain knowledge before the teaching-and-learning process could be considered as "unreasonable". As reported by King et al. (1998) knowledge-building could be facilitated by training, which implies that it could be enhanced by high pedagogy content knowledge (Roscoe, 2014). However, the effect is very limited (Dufrene et al. 2005; King et al., 1998) and knowledge-telling is still dominant. The choice between knowledge-building and knowledge-telling strategy is, therefore, determined by the tutors' metacognitive skills. Given that knowledge-building strategy could result in better learning outcomes while tutors usually start by using the knowledge-telling strategy, promoting the knowledge-telling to knowledge-building is the key to the success of LdL. If there exists any metacognitive benefit after introducing the knowledge-telling strategy, tutors will be promoted to

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knowledge-building strategy and thus greater learning outcomes could be achieved eventually. In other words, if an educator would like to adopt the LdL as his major teaching pedagogy rather than a one-time-use strategy, the effects of the knowledge-telling strategy on the metacognitive skills would be critical to his success in LdL.

However, study about the knowledge-telling and its effect on metacognitive skills is very limited. The present study contributes towards filling this gap by exploring the potential of the knowledge-telling strategy to promote college students' metacognitive skills. According to Brown (1978, 1987), metacognitive skills could be divided into (a) Prediction (eg. How difficult is the task), (b) Planning (eg. What shall I do to execute the task), (c) Monitoring (eg. What do I yet not know in order to attain my objective) and (d) Evaluation (eg. Have I got the full meaning of the answer), the potential of the knowledge-telling strategy to promote college students' prediction, planning, monitoring and evaluation skills will also be examined.

Methodology

Bargh and Schul's (1980) study is believed to be one of the first studies to separate the stages of LdL into preparation and in-class activities. They founded that there do exists a cognitive effect during the preparation phase. Additional studies further suggest that expecting to teach could result in a better gain than expecting to take a test in terms of learning outcomes (Benware & Deci, 1984; Fiorella & Mayer, 2013; Fiorella & Mayer, 2014; Nestojko, Bui, Kornell, & Bjork, 2014). Therefore, this study will follow their design for a fair test. It is divided into three stages: mixed-classes lecture, preparation and group presentation.

Stage One: Mixed-Classes Lecture

In the first phase, 35 senior one students of two classes in a public school in China are arranged to a 3-hour normal lecture (4.5 periods) to equip them with the basic knowledge of a particular mathematical topic, statistics. It includes the sub-topics of mean, mode, median, variance and standard deviation. Lecture-cum-Demonstration Method is used because it includes the merits of both the lecture and demonstration method meanwhile their shortcomings or limitations are removed (Suneetha , Rao, & Dr Rao, 2004). It allows the teacher to distribute large amount of information within a limited teaching period of time while demonstration allows students to understand the principles or laws effectively. The metacognitive pre-test is then conducted.

Stage Two: Preparation

In the preparation phase, participants are divided into two groups, named as sample and control, by random selection. Eventually, the sample group and control group contains 17 and 18 students respectively. The details of the presentation in the next phase are told to the sample group only. Within the group, participants are free to divide into 4 mini-groups without any restriction. However, the maximum size of each mini-group is set to be 5 in order to maximize the chance to express themselves in presentation in limited hours of lecture. Methods such as peer discussion, use of the internet and seeking advice from teachers are all allowed. In other words, participants are free to prepare their presentation materials by any means while there is no specific action or duty for the control group in this phase.

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Stage Three: Group Presentation

Overall speaking, the design of this phase follows one of the common practice of LdL reported by Duran (2017). Each mini- group in the sample group is given half an hour to report summarize what they have learnt in the lecture. The workload is shared among members in a mini-group and all members are required to take part in their presentation. The use of PowerPoint is compulsory and at least one sample question with solutions are required to be presented. However, classwork is encouraged but not compulsory.

To balance the studying hours spent in both groups, the control group is assigned as audiences during the presentation. Since Knowledge-telling strategy is the focus, interactions such as discussion are allowed but not compulsory. After all, the second metacognitive test (The pro-test) is given to them and the scores are recorded. 15 mins Individual interviews are conducted to 4 students (Two per each group) in order to further investigate the result qualitatively.

Method of Evaluation

Assessment of metacognition is difficult because metacognition is a complex construct and might be confounded in practice with both verbal ability and working memory capacity (Lai, 2011). Although students' academic performances and achievements, standardized achievement scores such as GPA are correlated, they are not good indicators for metacognition (Favieri, 2013).

In the meantime, recent metacognitive instruments might not be appropriate to this study. Although instruments such as questionnaires, interviews, observations, thinking-aloud protocols, eye movements, computer registrations of activities, note taking, stimulated recalls have been widely used (Desoete & Veenman, 2006), each of them has its own strengths and weaknesses (Sperling, Howard, Miller, & Murphy, 2002). For example, the oral interview could externalize participants' thoughts, however, it might not be a good choice for children because there could be a gap between children' conversations and actions (McLain, Gridley, & McIntosh, 1991). Moreover, metacognition could be domain-specific or at least partially domain-specific (van der Stel & Veenman 2008; Wang, 2015). A student could show variations in metacognition across different domains or Key Learning Areas such as Mathematics and English reading comprehension. Therefore, a tailor-made metacognitive pre-test and protest are used.

Both metacognitive pre-test and protest consist of four parts: Prediction, Planning, Monitoring and Evaluation. In *prediction*, participants will be given certain types of question and they are asked to indicate which one is the most difficult. One point will be scored if the correct answer is chosen. In *planning*, some steps about solving a certain question but in disorder. Their task is to rearrange them in the correct order. One point will be scored if the correct answer is chosen. Next, participants will be asked to mention at least one possible common error occurs in solving a particular problem in *monitoring*. One point will be scored if the statement is correct. Finally, in *evaluation*, numerical questions are given and they are requested to calculate the answers. Participants have to choose an option which indicates whether they feel about the correctness of the answer. However, marks are given according to the consistency between their feelings and the correctness of the answer. For example, if "absolutely certain" is chosen while the answer is correct, two points are scored; if

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"partially certain" is chosen while the answer is correct, one point is scored; if "absolutely certain" is chosen while the answer is incorrect, zero points are scored. A percentage over full mark will be used for consistency.

Ethics Concern

Extra care is taken on the interpersonal relationship between the researcher and the participants because the researcher is one of the teachers in the school. Since students tend to be afraid of the teachers' authority, direct contact between them is thus avoided as best as it could. Therefore, the interview is conducted by a student helper who is selected by the researcher from the senior three students in the same school. The choice of the interviewees is decided by the student helper without any prior consent from the researcher.

In order to avoid any misleading questions and answers, the interviews are conducted in Chinese, the mother language of both the interviewer and interviewees. Moreover, a brief introduction is given by the teacher before the two metacognitive tests. The use of difficult vocabulary is also avoided or being further explained.

Handling of data

All quantitative data collected is analysed by using SPSS 24. 2x2 ANOVA is conducted such that all simple and interaction effects are revealed. One sample group and one control group student are absent in the pre-test and the pro-test respectively and thus their data is replaced by using the mean of the corresponding data set

Result

The effects of the knowledge-telling strategy on both the sample and control group were examined in terms of metacognitive benefits. The results revealed that there was no significant interaction effect between the groups and their overall metacognition level with $F(1, 33) = .001$, $p = .975$. The main effect of participant groups and metacognition levels were not significant with $F(1, 33) = .414$ $p = .524$ and $F(1, 33) = 2.876$ $p = .099$. It suggests that there are no significant differences in metacognition level between the pre-test and the pro-test.

Further analysis revealed that there was no significant interaction effect between the groups and their prediction skill too with $F(1, 33) = .402$, $p = .530$. In contrast, the main effect of participant groups and prediction skill were significant with $F(1, 33) = 10.515$ $p = .003$ and $F(1, 33) = 4.773$ $p = .036$. It suggests that the prediction skill of the tutor is significantly greater than the audience and there are significant differences in prediction skill between the pre-test and the pro-test. In other words, both groups have similar gains in prediction skill from the intervention.

Similar to the above, planning skill shows no significant interaction effect with $F(1, 33) = 1.064$, $p = .310$. The main effect of participant groups was not significant too with $F(1, 33) = .108$ $p = .745$. However, significance result is obtained in the main effect of planning skill $F(1, 33) = 4.41$ $p = .043$. It suggests that the planning skill of the tutors is significantly greater than the tutees due to the higher initial level of background among the tutors.

There was also no significant interaction effect between the groups and their monitoring skill with $F(1, 33) = .135$, $p = .715$. The main effect of participant groups and monitoring skill were significant

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with F (1, 33) =.002 p =.962 and F (1, 33) = .028 p =.869. There are no significant gains in monitoring skill during the intervention.

In the meantime, no significant interaction effect between the groups and their evaluation skill could be obtained with F (1, 33) = 2.194, p = .148. Both the main effect of participant groups and evaluation skill were not significant with F (1, 33) =.079 p =.780 and F (1, 33) = .650 p =.426. It means that No significant difference is observed in evaluation skill before and after the intervention.

Discussion

Although LdL might be effective in promoting learning outcomes (Allen & Feldman, 1973; Cloward, 1967), the result suggests that the overall metacognitive benefit from adopting knowledge-telling is ambiguous. The contribution of knowledge-telling shows a variation among the metacognitive skills with the greatest significance gains exists in prediction skill. A simple summarization does not deepen students' planning, monitoring and evaluation skills towards the learning context. As student B stated, "because each group are presenting the same content, if someone cannot get it at the first time, they won't do it in the second time and so the third … (Knowledge-telling) is useful to familiarize the concepts, but this does not mean understanding." It is very unlikely that students would switch into knowledge-building strategy after the use of the knowledge-telling strategy. In the meantime, the metacognitive gains among tutors are indifference compared to those of the tutees. This further implies that listening to the same context again could be a substitute to knowledge-telling strategy in terms of metacognition gain. Therefore, the significance of knowledge-telling strategy is very limited. Without any precautions or measurements to facilitate the use of the knowledge-building strategy, the effects of LdL is questionable.

Conclusion

The successfulness of LdL depends on whether the knowledge-building strategy or the knowledge-telling strategy is used by the tutor. However, tutors have a very high tendency to adopt the knowledge-telling strategy. The result of this study shows that the knowledge-telling strategy is very unlikely to enhance the metacognitive skills of the tutor and thus it has no improvement in shifting towards knowledge-building. It implies measurements have to be taken; otherwise, tutors will keep using the low efficient knowledge-telling strategy.

Limitation and Further Study

Care should be taken when interpreting the result of this study due to the small sample size. Dilution effect might exist because the workload of presentation is shared among the group mates. Further study in investigating the solutions to shift knowledge-telling strategy into knowledge-building strategy, is suggested.

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