Writing and commenting on professional procedures: In search of learning designs promoting articulation between school and workplace learning.

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Abstract: The present study investigated the effect of scaffolding in a learning design in which apprentices were asked to reuse workplace experience to comment on peers' written productions. Apprentices were asked to perform an authentic workplace task, to explain how they got to the solution and then to comment on a peer's solution. Two conditions of scaffolding were compared: In the high scaffold condition, guiding questions were provided both for explanation and commenting, while in the low scaffold condition, a general instruction was given. The findings showed that, for the first tasks, the high scaffold group outperformed the low scaffold one with regard to the quality of the quotes and self explanations, but that the pattern reversed by the end of the activity. These results show that scaffolding is a useful tool for supporting reflection and learning, but that it should be adapted to the different steps of the activities.

Theoretical background

According to Tynjala (2008), "the development of vocational and professional expertise requires the integration of different types of knowledge and interaction between theory and practice, and the development of the workplace as a learning environment both for employees and students is important to ensure the continuous development of competence. This requires close collaboration and partnership between education and work" (p.131).

In the case of vocational training, professional procedure acquisition represents a key issue in apprentices' professional development. Learning theories (e.g., Taatgen, Huss & Anderson 2008, Anderson, 1982) generally support the idea that direct teaching alone is not sufficient for the acquisition of procedural knowledge. Although largely untested, these theories suggest that teaching can only provide declarative knowledge, and that procedural knowledge should be acquired by the compilation of declarative knowledge through practice and feedback.

Nevertheless, learning theories focusing on procedure acquisition emphasize the role of direct instruction. Procedural knowledge development typically involves three steps (Weill-Fassina & Pastré, 2004). First, novices learn to apply a definite set of rules according to typical situations. In the second stage, workers learn to distinguish between classes of situations, particularly critical situations, and to behave accordingly. They form pragmatic "concepts", in the sense that they are oriented toward an improvement of the action performed, and not towards a better comprehension of the situation. Ochanine (1981) found that experts formed "operative images", which are simplified and biased representations of the objective situation, but are more relevant for the practice. For example, experts air traffic controllers typically under-estimate the distance between planes, which result in taking a larger security margin than strictly necessary (Bisseret, 1995). In the third stage, with the development of expertise, several operative concepts are formed and articulated, resulting in a more abstract representation of the task, which enables workers to handle efficiently a larger number of situations.

The main recent cognitive research in procedure acquisition still follows the central model ACT-R proposed and revised by Anderson (1993). In his revised model, ACT-R, Anderson (1993) focuses on the declarative memory of the examples demonstrating how the procedures should be performed. The first use of examples represents an analogy. Then, the production rules are compiled on the basis of this analogy. Moreover, it is assumed that the individual works on a declarative representation of the example. In other words, procedure acquisition would require a declarative representation of an example (but not necessarily in its long-term memory) because the procedure acquisition is done by learning from declarative traces of previous problem solving. This model emphasizes the importance of having a well developed declarative representation of the procedure in order to support the "compilation phase" meaning the passage from this declarative representation to the actual shortcut mastery of the procedure. In addition, according to Pirolli and Bielaczyc (1989), understanding the procedure's steps as well as the context to which the procedure is linked are essential elements for the procedure acquisition. It appears that the transferability of procedural knowledge is determined by a process of rules understanding (Kieras and Bovair, 1986). The initial acquisition of a procedure represents a process of understanding and not just a mimetic reproduction of the procedure's steps. The procedure acquisition is fostered by representing the procedure in its context, and understanding the different procedural steps in their own context (Broudy, 1977;

Bonner and Walker, 1994). Considering all those aspects of procedure acquisition, this study aims at finding means to support the construction of a strong declarative representation of a procedure as well as supporting the comprehension of its steps and the context in which it takes place.

Deeper processing of prior knowledge and examples represents a facilitating factor for supporting procedure comprehension and transfer (Chi, Bassok, Lewis, Reimann and Glaser, 1989). One effective way of avoiding superficial knowledge processing (King, 1992) and supporting deeper cognitive and metacognitive treatments - that students are likely to naturally avoid in the process of learning – is using external guiding under the form of prompts. These prompts are questions or hints supporting for efficient learning processes.

Metacognitive theories (e.g., Ge and Land, 2004) support the assumption hat becoming aware of oneself as a learner allows the student to reflect, monitor, and revise the process and products of his or her own learning. It was found that helping students develop abilities to monitor and revise their own strategies and to use resources may enable them to improve general learning expertise that can be used in a wide variety of settings (Kauffman, 2004). On the basis of this theoretical frame we designed and implemented learning tasks involving prompted self-explanations about the procedure, its steps and rationales.

Moreover, it has been shown (Hausmann and Chi, 2002; Chi, Bassok, Lewis, Reimann and Glaser, 1989) that both good students and prompted students tend to give more self explanations that refine and expand the conditions of an action, explain the consequences of an action, provide a goal for a set of actions, relate the consequences of one action to another and explain the meaning of actions.

Writing self-explanations about a procedure can thus be a suitable manner of supporting procedure comprehension as well as improving the organization of the declarative phase of procedure acquisition. In addition, the production of written text per se may be seen as a learning activity because it involves the production of a message based on domain knowledge and therefore domain knowledge should be "recovered", reorganized and incorporated into a linear form, a message understandable to someone else. Collaborative and peer writing/commenting activities represent an appropriate mean for reinforcing reflection and knowledge organization by the means of confrontation and hindsight taking in the reflection (Dillenbourg & Self 1994). Nevertheless, up to now, little research has investigated the effects of peer tutoring for "writing to learn" activities (Gielen, Dochy, Tops, Peeters, 2007). One critical issue is the level of scaffolding of such peer-commenting activity. As for self-explanation, it was assumed that peer commenting would benefit from guiding questions that orient towards argumentative and reflective writing, rather than on shallow and detail statements.

The experiment

This paper reports a quasi-experimental study in which apprentices were asked to perform a task similar to a workplace situation (i.e. filling in a quote) and then describe how they got to the solution. Depending on the condition, self-explanation was either triggered by a general question (low scaffolding) or by guiding prompts (high scaffolding). They then were asked to comment on a peer's explanation, in the same scaffolding condition as their self explanation. Finally, they revised their quote taking into account the peer's comments.

We expected that prompted students would give more self-explanation statements (process measure) thus realizing deeper cognitive treatment than apprentices in low scaffolding condition, both for their own and for their peer's production. As a consequence, we expected that the "«high scaffold»" group would profit from deeper reflection activity and perform better in the two phases of the learning task (outcome measure).

Methods

Participants and context

This activity took place in Geneva dental care vocational training school. It was designed in collaboration with the dentistry course teacher and was implemented during the school hours. The topic "filling in an insurance quote" was part of the curricula. Participants were 3rd year apprentices from two classes of the dental care assistant school in Geneva, all women[1]. Overall 26 students aged of 18-23 years participated in the experiment and were randomly allocated in one of the two experimental conditions (low or high scaffolding) according to a one by 2 between-subject design. The activity took two consecutive school hours.

Material and apparatus

A wiki-based environment was used in order to support the apprentices' writing activities. An electronic equivalent of the quote form containing 4 tables (below, referred to as "table 3", "table 5", "table 7" and "table 9", see Figure 1) was proposed, each one referring to different aspects of the patient's dental problems, the medical treatment and the financial dimension. The "table 3" had to be filled in with information about the

[1] There were no men in this dental care assistant school.

damages caused by the accident (type of damage, teeth involved), the "table 5" referred to the diagnostic and treatment measures to be taken, the "table 7" enumerated the measures to be taken as a definitive treatment and finally "table 9" concerned the financial aspects (medical treatment, points, price and some other specific details).

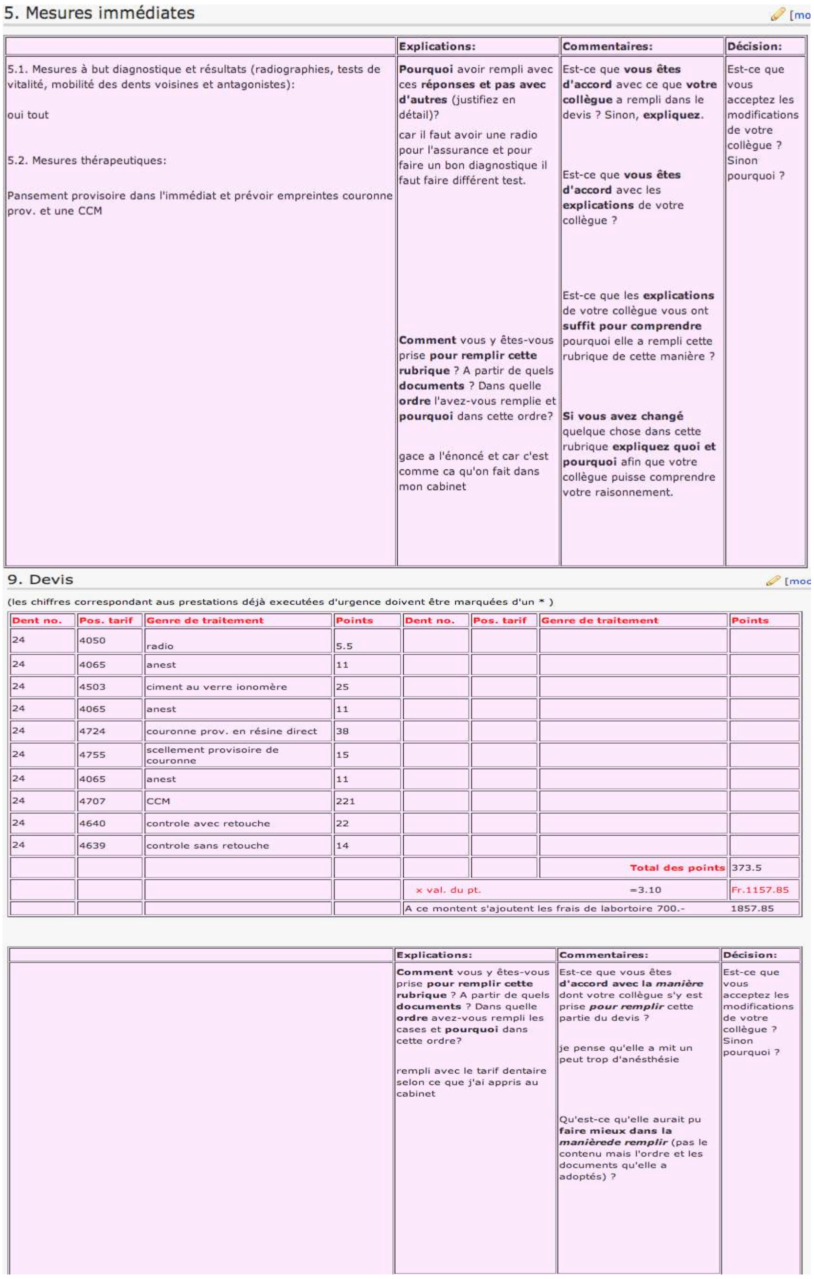

Figure 1. Screen capture of the wiki-based learning environment used in this study. From left to right: student A's answer, her self-explanation, student B's comment and A's final decision.

They were preceded by a yes/no question asking the apprentices about their previous familiarity at the workplace with this task.

Each table had two extra columns: one for students' explanations and the other one for the peers' comments. All apprentices were already familiarized with the use of the wiki tool since they already had used it for previous school activities. Depending on the condition, two versions of the material were designed, differing only on the content of the two extra columns of the quote: explanation and commenting. The "«high scaffold»" condition provided, for each of the tables, in the explanation column, a set of five questions guiding their answers. The questions were built on the 5W criteria (why, when, who, where, how) and used the Lin and Lehman's (1999) "reason justification", "rule based" types of prompts. In the «low scaffold» condition, there was only the general prompt: "Explain".

Procedure

The apprentices were welcomed by the teacher, as for a normal class. In the first phase, starting from an authentic case study proposed by the teacher, the apprentices had to fill in an electronic quote and explain how they did it. In the high scaffolding condition, the apprentices had to explain why they had filled in that way, how they did to fill in, on which material/knowledge they based themselves and finally in which order they filled in the table and why. The «low scaffold» group had the same task but for the explanation column they didn't have any scaffolding questions, they only had the instruction to "Explain". In a second phase, a colleague had the task to correct a peer's quote and also comment about the changes she had done and explain, using the same level of scaffolding as for the first phase. The "high scaffold" group had a list of specific questions aiming to see if they agreed with the way the table had been filled in, if they had changed/corrected anything and why and if they considered the explanations given by the peer satisfying, while the "«low scaffold»«low scaffold»" group had only the instruction to "Comment".

Data analysis

For each of the quote's tables we analyzed the percentage of filling in the quote, the explanations and the comments, as well as the quality for each of these three writing tasks.

For the percentage of filling in, we coded with 0 when there was nothing written, 1 when the table was filled in at 30%, 2 when it was at 50%, 3 at 75% and finally 4 representing a completely filled in table, by taking into account the number of fields to be filled in. These codes concerned only the fact of having filled in the table regardless of the entries' correctness.

When coding the quality of the quotes, we counted, in each table, the number of correct answers, the number of acceptable answers (representing neither correct nor incorrect answers) and the number of incorrect answers. We also calculated the sum of correct/acceptable/wrong answers for the entire quote, in its first and second version. With regard to the quality of the explanations, we counted the number of valid arguments, the number of details mentioned, as well as the number of incorrect explanations for each one of the four tables. Comments we classified into two categories, informative and non-informative. The comments classified as informative were those providing useful information to the author for improving the quote while the non-informative ones were the social ones (containing support, acknowledgement etc.)

Results

In the first place, we checked out if there was any influence of the apprentices' declared familiarity with the task at the workplace and their performances at the quote activity in the classroom. We conducted an ANOVA, which showed no significant differences between the quality of the "familiarized" apprentices' quotes and the quotes of the ones declaring not being familiarized with this procedure ($F(1,23) = 4.85$, $MSE = 21.33$; $p < .05$).

Following our hypotheses, we looked for the differences between the two experimental groups with respect to 1) the proportion of filling in each of the quote's tables; 2) the quality of the entire quote as well as table by table; 3) the quality of the explanations; 4) the quality of the comments.

Percentage of information entered in the quote

We looked at the number of information completed in the entire quote in its first and second version, as well as each of the four tables separately, regardless of their accuracy.

The proportion of completion of the entire quote was computed as the ratio of the number of information entered against the total number of answers required for each apprentice. An ANOVA analysis did not reveal any significant differences between the two experimental groups ($p > .05$), neither in the first, nor in the second versions.

Considering each table separately in the first and second version, the ANOVA analysis revealed one significant difference – the high scaffold group filled in more in the first version of Table 3 than the low scaffold group ($F(1,24) = 8$; $MSE = 22.15$; $p < .05$). Nevertheless, this difference faded away in the second version of the quote where no significant difference between the groups was found anymore.

Correctness of the quotes

The quality of the quotes was evaluated through the number of correct answers to the first and second version of the quote for each apprentice. ANOVA test revealed that the low scaffold group produced better quality quotes than the high scaffold group in the first version ($F(1,24) = 4.82$; $MSE = 36.9$: $p < .05$) as well as in the second version of the quote ($F(1,19) = 5.82$; $MSE = 35.9$: $p < .05$).

A deeper analysis concerning the differences between the two groups with regard to the correct and wrong answers in each of the quote's four tables revealed interesting information.

In the first draft, the high scaffold group produced significantly better answers for the table 3 than the low scaffold group ($F(1,24) = 6.54$; $MSE = 0$; $p < .05$). Howver, we did not find any significant difference between

the groups in the second version of the table 3 – meaning that the «low scaffold» group compensated the difference after the revision of the quote.
Significant differences were also found in the quality of table 9. In the first as well as in the second version of this table, the low scaffold group gave significantly more correct answers than the high scaffold group (first version: $F(1,24) = 7.14$; $MSE = 30.15$; $p < .05$ second version: $F(1,19) = 4.58$; $MSE = 24.31$; $p < .05$). Moreover, the high scaffold group gave more incorrect answers in both versions of the table 9 (first version: $F(1,24) = 11.53$; $MSE = 3.84$; $p < .01$, second version: $F(1,19) = 7.13$; $MSE = 4.86$; $p < 0.5$). These results mean that participants in the high scaffold group did not take advantage of the comments on their first version to improve enough in the second draft in the extent that they would equalize or outperform the answers of the low scaffold group.

Differences between the first and second versions of the quotes

To evaluate the evolution of the quotes from the first to the second version, the difference between the number of correct answers over the two versions of the quote was computed for each condition. Neither the high nor the low scaffold group significantly improved the quality of their quotes from their first to their second versions. Nevertheless, if we look at the observed results, both the low scaffold and the high scaffold group improved the quality of the quotes between the first and the second version (Low scaffold: $M_{first} = 9.08$, $M_{second} = 9.82$; High scaffold, $M_{first} = 6.69$, $M_{second} = 7.2$).

Quality and quantity of the self-explanations

In terms of percentage of completing the explanations, ANOVA analysis did not reveal any significant difference between the two groups, meaning that the two groups produced more or less the same amount of explanations.
Nevertheless, there were significant differences between the two groups in the quality of the explanations. The high scaffold group gave significantly more arguments for the table 3 than the low scaffold group ($F(1,24) = 6$; $MSE = 6.5$; $p < .05$), but it also gave significantly more “details” ($F(1,24) = 7.38$; $MSE = 2.46$; $p < 0.5$). For the table 9, the situation was the exact opposite: the low scaffold group gave marginally significantly more arguments than the high scaffold group ($F(1,24) = 3.64$; $MSE = 26$; $p = .06$) but significantly less details ($F(1,24) = 4.52$; $MSE = 1.88$; $p < .05$).
Regression analysis performed on the entire data, without regard to the experimental condition, showed that more argumentative explanations given in table 3 ($Rsquare = .23$; $F(1,25) = 7.3$; $p < 0.5$) and table 9 ($Rsquare = .31$; $F(1,25) = 10.76$; $p < .01$), was related to better accuracy of these tables.

Type of Comments

For each group, comments were simply classified into two categories, according whether they were superficial or essential. The number of comments in each category was used to evaluate the quality of the comments. On the entire quote, we found a marginal significant difference in the favor of the low scaffold group, who made more essential comments than the high scaffold group ($F(1,20) = 4.26$; $MSE = 10.8$; $p = .053$). Analyzing table by table, we notice that the low scaffold group systematically gave more essential and less superficial comments than the high scaffold group, but none of these differences was statistically significant. We can only consider them as tendencies.
Regression analyses did not reveal any statistical significant relations between the quality of the explanations and the quality of the comments or between the quality of the quote and the quality of the comments.

Discussion

Apprentices’ declared familiarity with the procedure did not seem to account for their actual performance, tested with the class activity. This might be explained by the apprentices’ low self-evaluation competencies but also by the very heterogeneous workplace training they get. These conjectures reinforce the need to implement school activities based on apprentice’s professional experience as well as supporting knowledge sharing and collaborative reflection.
With regard to the effect of the scaffolding, the results partly contradicted our hypothesis by showing that for some tasks, the group with low scaffolding outperformed the group with high scaffolding. Having a synthetic look at the results, we noticed that the high scaffold group outperformed the low scaffold group at all levels (quality of the table, percentage of filling in the table, quality of explanations) in the starting task (table 3). The two groups have similar performances on the middle tasks (table 5 and 7, not reported here). When analyzing the final task (table 9), the low scaffold group has significantly better results (at all levels) than the high scaffold group.
Considering the quality of the self-explanations proposed by the two groups, we notice that even though they seem to produce the same amount of information, the high scaffold group produced more valid arguments in the explanations in the first table but ended up by proposing more superficial ones in the final table. The low

scaffold group had exactly the opposite behavior. Statistical analysis also confirmed that the quality of the explanations was a predictor for the quality of the quote.

These results support the idea that high scaffolding may have helped in the beginning of the activity in order to support good explanations and reflection (King, 1992), generates more correct answers, and orients the apprentices towards appropriated task solving approaches. Nevertheless, by the end of the activity, the low scaffold group caught up with the high scaffold one and even outperformed it. One could argue that high scaffolds can be useful in the beginning of the task, in order to orient the apprentices' cognitive strategies and give indications about how the task should be dealt with, but, shortly after becomes superfluous or even too burdening. This study underlines the idea that scaffolding is a powerful tool for fostering deep cognitive treatment of knowledge in self-explanation task on procedures. Nevertheless, it identifies the need of conceiving and implementing adaptive designs in which these prompts fade out along the task in order to give place at the adaptive and learning skills of the student to take the place.

However, it should be noted that the low scaffold group started with better performance in terms of global accuracy of the first version of the quote. No data in our study can disentangle the effect of scaffolded self-explanation and initial level of each group.

Regarding the effect of peer commenting, the results could not confirm the positive effect of this instructional methods through statistical analysis, though the observed results showed an improvement in performance in both scaffolding condition. It may be that self-explanation in itself has such a great instructional effect that the effect of peer-commenting could not be easily demonstrated using few measures with few students.

Last but not least, we have to take into account that this study took place in real class settings, and that other factors may have interfered. Students were not very familiar with self-explaining activities nor commenting ones. They might not have fully benefited by the instructional device (e.g., Ainsworth & Burcham, 2007). It is nevertheless a real situation, valuable for conceiving and implementing these types of designs in real vocational training classes. Future long term studies will investigate further this issue as well as the relation between the computer support and the commenting instruction.

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