

## TOOL USE AND PERFORMANCE: RELATIONSHIPS BETWEEN TOOL-AND LEARNER-RELATED CHARACTERISTICS IN A COMPUTER-BASED LEARNING ENVIRONMENT

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### ABSTRACT

It is still unclear on what and how tool and learner characteristics influence tool use and consequently performance in computer-based learning environments (CBLE's). This study examines the relationships between tool-related characteristics (tool presentation: non-/embedded tool and instructional cues: non-/explained tool functionality) and learner-related characteristics (self-efficacy and goal orientation) as well as their effects on tool use (quantity and quality) and performance in a CBLE. One hundred and forty students, without statically difference in prior knowledge, were randomly assigned to the four conditions (Embedded and non-embedded with explained tool functionality and embedded and non-embedded with non-explained tool functionality) to study a hypertext. Results reveal that embedding tools influenced positively quantity of tool use and negatively quality of tool use. Partial effects of explained tool functionality were found. There were significant interactions of goal orientation (mastery avoidance) and condition on quality of tool use. Performance approach influenced quality of tool positively and self-efficacy influenced negatively quantity of tool use. Only quantity of tool use affected performance. The implications of these results for future research on tool use in CBLE's are discussed.

**Keywords:** adjunct questions; self-efficacy; goal orientation; tool presentation; instructional cues

### INTRODUCTION

In computer-based learning environments (CBLE's) support devices, also referred as tools, (Iiyoshi & Hannafin, 1998; Viau & Larivée, 1993) are often implemented under the assumption that tool use can have a positive impact on learning outcomes/performance (Moos & Azevedo, 2009). Tool use is generally explored either quantitatively and/or qualitatively. The frequency in which learners access tools and the time they spend on the tools are commonly considered as indicators of quantity of tool use. On the other hand, when and how learners use the tools and whether the usage is in line with the instructional intentions of particular tools are considered as the quality of tool use.

Jiang and Elen (2011) reported that the quality of tool use, specifically the use of adjunct questions (i.e., reading attention, reading sequence and the answers provided to the questions) accounts for the performance (post-test). Quantity of tool use (frequency of tool use and time on tool) showed mixed effects on performance. In a different study, Viau and Larivée (1993) examined the effects of the usage of two tools, namely a glossary and a navigation map, on performance. They found that the quantity of tool use (frequency of tool use and time on tool) were the best predictors of performance (post-test). Quality of tool use was not studied.

While the clear effects of tool use on performance are not concrete, they give an indication that using tools appropriately can lead to better performance and therefore tool usage should not be taken for granted. However, positive effects of tool use on performance can only be expected, according to Perkins (1985), only if the tool(s) is present and functional, if learners recognize the tools and the tools' functionality and if learners are motivated to use the tools and use the tools optimally. Unfortunately, learners tend to not use the tools and when they do, they do it suboptimally (e.g., Aleven, Stahl, Schworm, Fischer, & Wallace, 2003; Elen & Louw, 2006; Perkins, 1985). This problematic tool use may related to the interaction between different learner and tool characteristics (see reviews: Aleven, et al., 2003; Clarebout & Elen, 2006) which is congruent with the theory of aptitude-treatment interaction (ATI) (Cronbach & Snow, 1977). The ATI points out that instructional strategies or treatments, namely tools interact with aptitudes, defined as any measurable characteristic of the learner (Regian & Shute, 1992), in this case learner-related characteristics.

The present contribution will explore in a CBLE the relationship between different learner-related and tool-related variables on tool use and performance. These variables are described in detail as follows.

### LEARNER CHARACTERISTICS

Prior knowledge has been identified as a learner characteristic affecting tool use and performance (Aleven, et al., 2003; Clarebout & Elen, 2006). Elen and Louw (2006) found that learners with higher prior knowledge had

better performance in the post-test. Renkl (2002) reported that low prior knowledge learners used tools more frequently than high prior knowledge learners. Iiyoshi and Hannafin (1998) suggested that prior knowledge may impact performance through different quantitative and qualitative aspects of tool use, for instance, the frequency of tools use. While prior knowledge seems to be an important characteristic regarding tool use, this study only controls for prior knowledge and focused on Perkins's last condition on tool use (learners are motivated to use tools), hence learner motivational characteristics will be investigated.

Motivational characteristics seem crucial to determine tool use (Perkins, 1985). Motivation is a broad term that derives in many associated constructs exploring different motivational aspects (Murphy & Alexander, 2000). Self-efficacy and goal orientation are two motivational characteristics that have caught the attention of research on tool use (Aleven, et al., 2003; Newman, 1994). Self-efficacy is defined as the beliefs about one's capabilities to organize or perform the courses of action to produce a given achievement (Bandura, 1997). Goal orientation is defined as the set of beliefs that reflect the reasons and intentions to engage and achieve a task (Dweck, 1986).

Subcategories of goal orientation have been identified, mainly a mastery orientation (defined in intrapersonal terms) and a performance orientation (defined in normative terms) (Dweck & Legget, 1988), which at the same time are further subdivided and valenced into mastery avoidance and mastery approach as well as performance avoidance and performance approach, respectively (Elliot & McGregor, 2001). Mastery approach, positively valenced, refers to the focus of individuals on developing competence, expanding knowledge, task completion and understanding, learning, mastery, solving problems, and developing new skills. Mastery avoidance, negatively valenced, refers to the focus individuals have about striving to avoid misunderstanding or failing, avoid making mistakes or doing anything wrong or incorrectly from an intrapersonal perspective (Elliot & McGregor, 2001). Performance approach, positively valenced, is exemplified by learners' concerns about how well they perform and how others perceive their behavior. It focuses on personal ability, a normative social comparison with others, and a desire for public recognition of performance. Performance avoidance, negatively valenced, focuses on avoiding normative competence, refers to low competence expectancies, fear of failure and avoidance of failure (Elliot & Church, 1997; Elliot & McGregor, 2001).

In this study, it is expected that self-efficacy and the different subscales of goal orientation will influence tool use in relation to different tool characteristics. This expectation is based on empirical studies which have given some indication that different self-efficacy levels and goal orientation may affect tool use to a certain extent. However, the results of these studies are rather inconclusive and further research where tool characteristics interact with these motivational variables is has yet to be reported. For instance, it has been suggested that learners with high self-efficacy levels increase quantity of tool use; that means, they used tools more frequently (Wu, Lowyck, Sercu, & Elen, 2012). In contrast, Jiang and Elen (2010) indicated that high levels of self-efficacy affected the quantity of tool use negatively (i.e. the frequency of use) but the quality of tool use positively (e.g., the answers provided on adjunct questions).

Regarding goal orientation, the effect has also not been consistent. It has been found a negative relationship between mastery approach goal orientation and quantity of tool use (time spent on tool) (Clarebout & Elen, 2009) and (frequency) (Nesbit et al., 2006), also a positive relationship between performance goal orientation (approach and avoidance) on quantity of tool use (frequency) (Crippen, Biesinger, Muis, & Orgill, 2009). However, Huet, Escribe, Dupeyrat, & Sakdavong (2011) reported a significant negative correlation between performance goal orientation (approach and avoidance) and quantity of tool use (frequency of tool use). That means, learners with high performance approach and avoidance accessed the tools less frequently (Huet, et al., 2011). No results from mastery avoidance goal orientation on tool use were retrieved in either study.

### **TOOL CHARACTERISTICS**

Theoretically, the effectiveness of CBLE's may be enhanced if appropriate cognitive tools are provided (Iiyoshi & Hannafin, 1998). Cognitive tools are support devices that scaffold the cognitive processes associated with learning or performing (Derry, Hmelo-Silver, Nagarajan, Chernobilsky, & Beitzel, 2006). By using cognitive tools, learners may be able to identify, locate and retrieve relevant information, to present relevant information they encounter, to structure and establish conceptual relationships, to manipulate information or to simplify their own learning, among others (Iiyoshi, Hannafin, & Wang, 2005). The distinctive role the learner may be able to execute is based on the type of cognitive tool. Adjunct questions, for example, are a cognitive tool that has the potential to guide students to organize, interpret (Elen & Louw, 2006) and influence what it is learned from the learning material (Hamaker, 1986).

Empirically, there is still lack of understanding in the influence of cognitive tool use in CBLE's (Iiyoshi & Hannafin, 1998); more specifically the positive effects of adjunct questions on learning are not always consistent (e.g. Dornisch & Sperling, 2006). Iiyoshi and colleagues (2005) point out that in order to attain positive effects of cognitive tools on learning, learners should receive more procedural assistance and sufficient guidance to use the tools. Therefore, aside from the type of tool, in this case cognitive tool, two additional tool characteristics come into sight.

One of these tool characteristics is tool presentation (Schnotz & Heiss, 2009). Tool presentation refers to the level to which learners are induced to use the tools in the way intended by the designers/instructors. The presentation of a tool can be embedded or non-embedded (Clarebout & Elen, 2006). Tools are non-embedded when learners can decide whether to use the tools or not; on the other hand, when learners have no choice but to use the available tools then the tools are embedded (Clarebout & Elen, 2006). Having the tools embedded or non-embedded is in line with the learner control literature (Lawless & Brown, 1997) because non-embedded tools could benefit those learners that recognize the tool functionality and possess the motivational characteristics that would lead them to use the tool (Perkins' conditions: Perkins, 1985). However, embedded tools could benefit those learners unable to recognize the tool functionality and not motivated (Schnotz & Heiss, 2009).

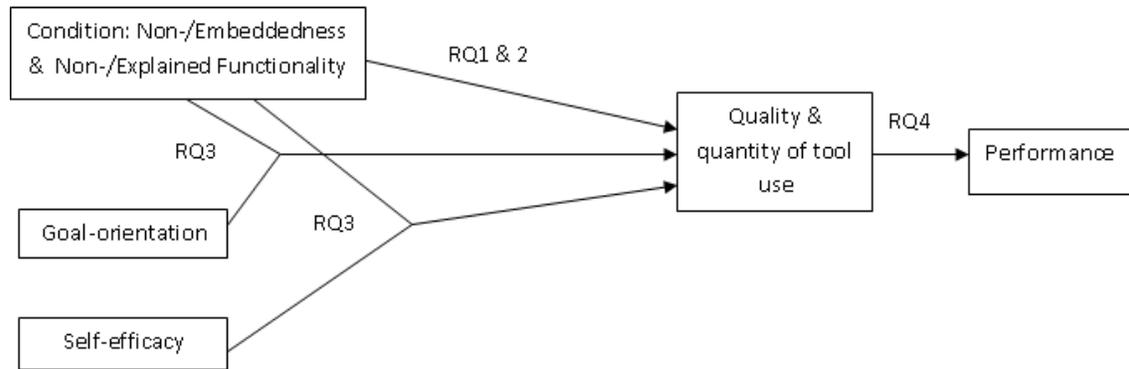
Effects of the tool presentation, however, remain unclear. Greene and Land (2000) analyzed undergraduate learners' use of cognitive tools: non-embedded (internet search engine machine) and embedded (guiding questions) while they worked on a project. The findings indicated that learners' quality of tool use was low. First, they had difficulty using the searching tools properly. Their searches were too broad or irrelevant in many of the cases. Regarding the embedded questions, learners' use of tools was suboptimal, that is, learners tended to omit questions and/or give superficial answers which did not allow them to benefit from the purpose of the tool. In more recent research (Clarebout, Horz, Schnotz, & Elen, 2010), 60 participants were divided into two conditions: with embedded tool and with non-embedded tools (tools: graphs). The results indicated that the quantity of tool use in the embedded condition was significantly higher. This means that learners spent proportionally more time on graphs. However, the quality of tool use (interpretation of graphs) was significantly better in the non-embedded condition.

Given that embedding or not embedding tools seems insufficient to assist the learner on the use of tools, instructional cues (Lee & Lehman, 1993) –another tool characteristic–, also addressed as advice (Clarebout & Elen, 2008) or pedagogical agents (Atkinson, 2002), among others have been implemented to increase tool use probabilities without 'forcing' the learner (Atkinson, 2002; Clarebout & Elen, 2008; Lee & Lehman, 1993).

Instructional cues aim at making tool functionality more 'discernible' to the learner. This discernability may help the learner decide when and how to use or not to use tools (Lawless & Brown, 1997). These cues can either provide guidance to the learner during the task (Atkinson, 2002), highlight the use of tools that provide information that the learner has not accessed (Lee & Lehman, 1993), or provide information about the functionality of the tools, as well as, the learning benefits a tool can offer if used (Clarebout & Elen, 2008). Evidence has not only shown positive effects on quantity of tool use and performance (Atkinson, 2002; Lee & Lehman, 1993), but also mixed effects (Clarebout & Elen, 2008). These mixed effects showed that the advice was often ignored (Clarebout & Elen, 2008). Moreover, interactions between advice and learner characteristics have been found.

The purpose of this study is to examine the role of self-efficacy and goal orientation in relation to tool presentation (non-/embeddedness of tool) and an instructional cue on the use of tools, namely adjunct questions. The instructional cues will be addressed, from now on, as explanation of tool functionality. The explanation of tool functionality followed the same focus as previous research (Clarebout & Elen, 2008) and will therefore provide information about the tools and their learning benefits. Tool use will be explored in a quantitative and a qualitative way. Lastly related to Perkins' (1985) first condition of the 'tool is there,' this contribution addresses tool functionality by analyzing the effects of quantity and quality of tool use on performance. The addressed questions illustrated in figure 1 are:

1. Does non-/embeddedness of tool influence quality and quantity of tool use?
2. Does the (no) explanation of the tool functionality influence quality and quantity of tool use?
3. Do self-efficacy and goal orientation influence tool use in relation to embeddedness and the explanation of the tool functionality? If so, how?
4. Do quality and quantity of tool use influence performance?



**Figure 1.** Schema of research questions. The schema is in abbreviated forms for simplicity and clarity.

## METHODOLOGY

### Participants and design

Participants were one hundred and forty first-year university students of Educational Sciences which represented 89.74 % of the whole population. Participation was a part of a course on Learning and Instruction. The average participants' age was 18 ( $SD= 2.59$ ), and the majority was female (94.3%). This was a quasi-experimental pre-post-test study with a 2 (non-/embedded tool)  $\times$  2 (with/without explanation of tool functionality) design. Participants in the study were randomly and equally assigned to one of four conditions (35 participants in each condition): a condition with embedded tools and the explanation of the tool functionality, a condition with non-embedded tools and the explanation of the tool functionality, a condition with non-embedded tools and no explanation and a condition with embedded tools and no explanation.

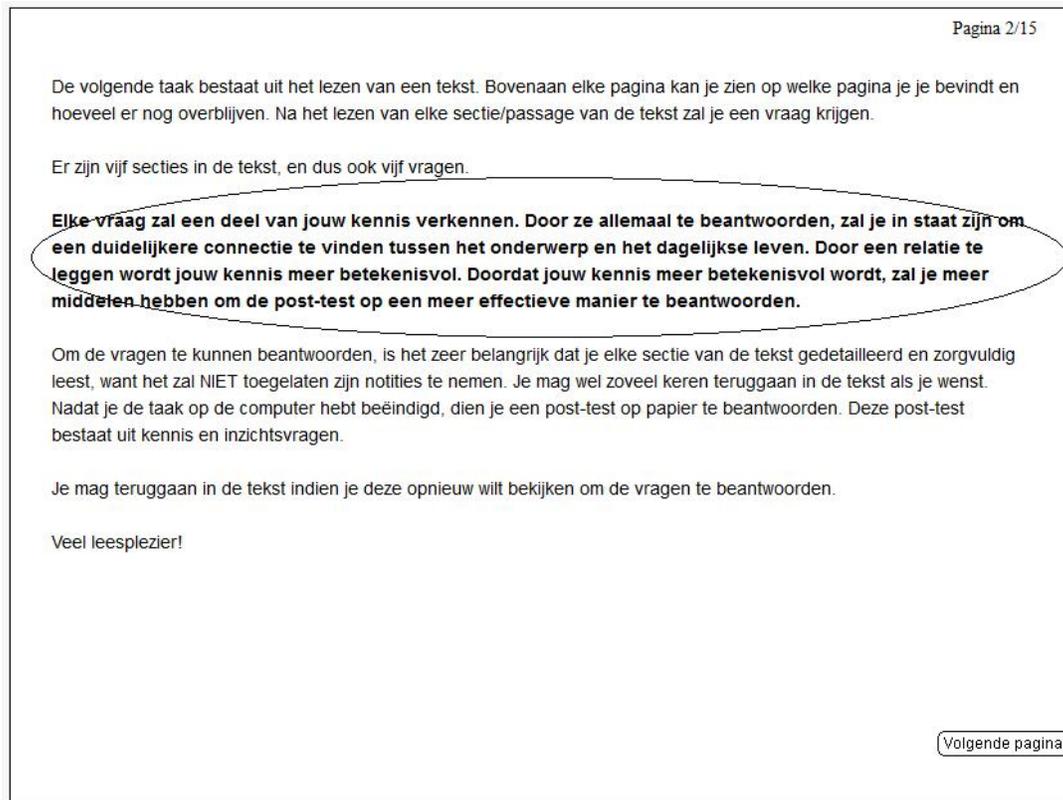
### Materials

Learning Environment. The learning environment consisted of a hypertext which was developed using Macromedia Director. Two introductory pages were displayed before the hypertext. Participants filled in their personal data on the first page. In the second page a description was given of the structure of the text.

The conditions with explained tool functionality had an extra paragraph on the second page with a detailed description of the functionality of the tool (adjunct questions) provided in the hypertext (figure 2). The explanation of the tool functionality read as follows: "Each question will explore a part of your knowledge. If you answer each of the questions, you will be able to find a clearer connection between the topic of the text and everyday life situations. By establishing this link, your knowledge will become more meaningful. If your knowledge is more meaningful, you will have more sources to answer the post-test in a more effective way."

After the introductory pages, the hypertext was presented. The hypertext was an environmental article titled *Waarom water broodnodig is* (Why water is essential)(Raes, Geerts, & Vanuytrecht, 2009). The article comprising 1,544 words was adapted in format for the task, and was therefore divided into five sections. Each section consisted of a page. After each section, an adjunct question (tool) was attached. In the non-embedded conditions, participants could access the tool through a button placed in the upper right of the page (figure 3). In the embedded conditions, the question was automatically displayed and had to be answered (figure 4). This text was not part of the curriculum and was chosen for this study as to raise environmental awareness.

Tool: Adjunct question. The adjunct questions in this study were "inserted high-order post questions" (Hamaker, 1986). This means that there was a question after each of the five sections of the hypertext, and the question elicited more than a simple collection of factual information as induced more complex cognitive processes in the learner (Hamaker, 1986). Ten adjunct questions were first designed by two researchers who agreed on selecting five of them. An example is shown in figure 4, and it is translated as follows: "Imagine that water was well-distributed on earth. Would food production still be a problem?" Example of another adjunct question (not shown in figure 4) is "According to the article, can the problem related to food production be solved by simple using less water?"

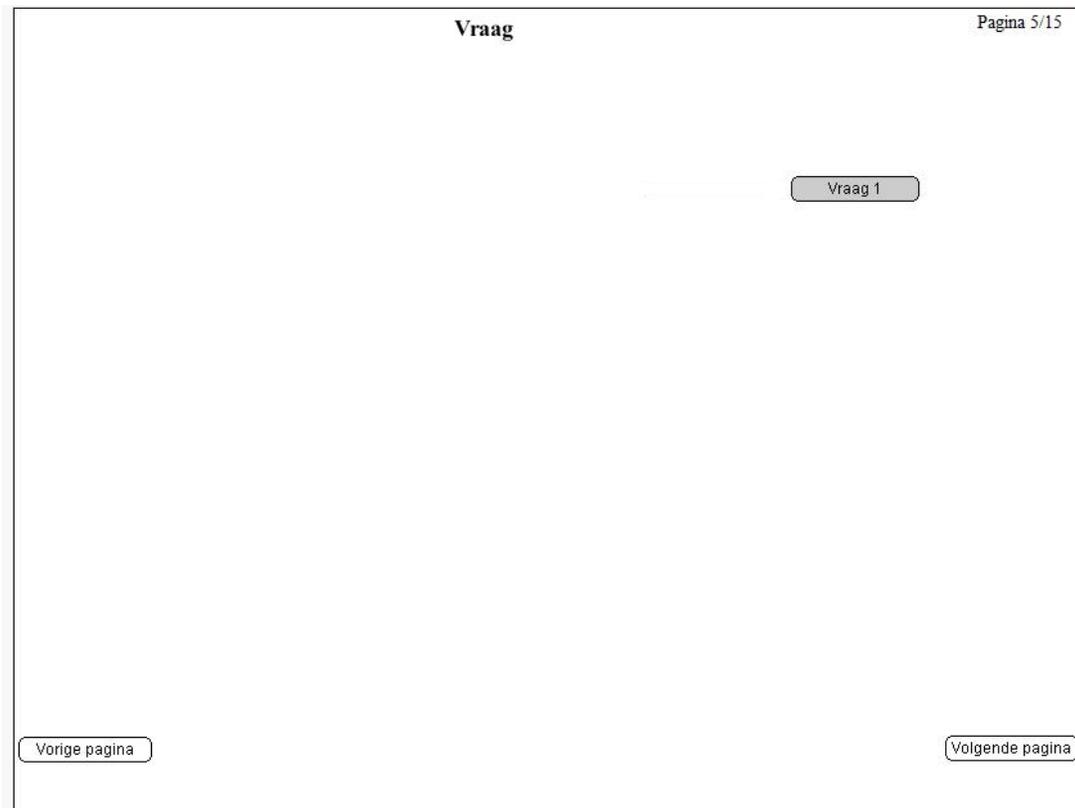


**Figure 2.** Second introductory page with explanation of tool functionality. The explained functionality is illustrated inside the ellipse. Participants only saw the explanation boldfaced without ellipse. Non-explained functionality conditions did not have the boldfaced explanation.

Self-efficacy. The questionnaire consisted of eight questions using elements from the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & McKeachie, 1991) and the Self- and Task-Perception Questionnaire (STPQ) (Lodewyk & Winne, 2005). The questions were adapted to the context of tool use and translated to Dutch using the translation/back translation method in order to avoid semantic problems. This questionnaire has previously been used and shown high reliabilities (Jiang & Elen, 2010). Examples of the items are “I believe I will receive an excellent grade in the test over the text” or “I’m certain I will master the skills necessary for learning this text.” A six-point Likert scale was employed where one indicated total disagreement and six indicated total agreement. The reliability obtained was  $\alpha=.84$ .

Goal orientation. Goal orientation was measured by merging two questionnaires of Elliot et al. (Elliot & Church, 1997; Elliot & McGregor, 2001). The initial questionnaire of Elliot et al. (Elliot & Church, 1997) only measured three dimensions of goal orientation (mastery approach, performance avoidance and performance approach). The revised questionnaire (Elliot & McGregor, 2001) incorporated mastery avoidance and mastery approach making a 2 x 2 framework of goal orientation (performance avoidance, performance approach, and mastery avoidance and mastery approach). Participants also responded on a six-point Likert scale. One indicated totally disagree and six totally agree. The reliabilities were above an  $\alpha$  value of .70: Performance approach ( $\alpha=.93$ ) and avoidance ( $\alpha=.83$ ), mastery approach ( $\alpha=.84$ ) and avoidance ( $\alpha=.71$ ).

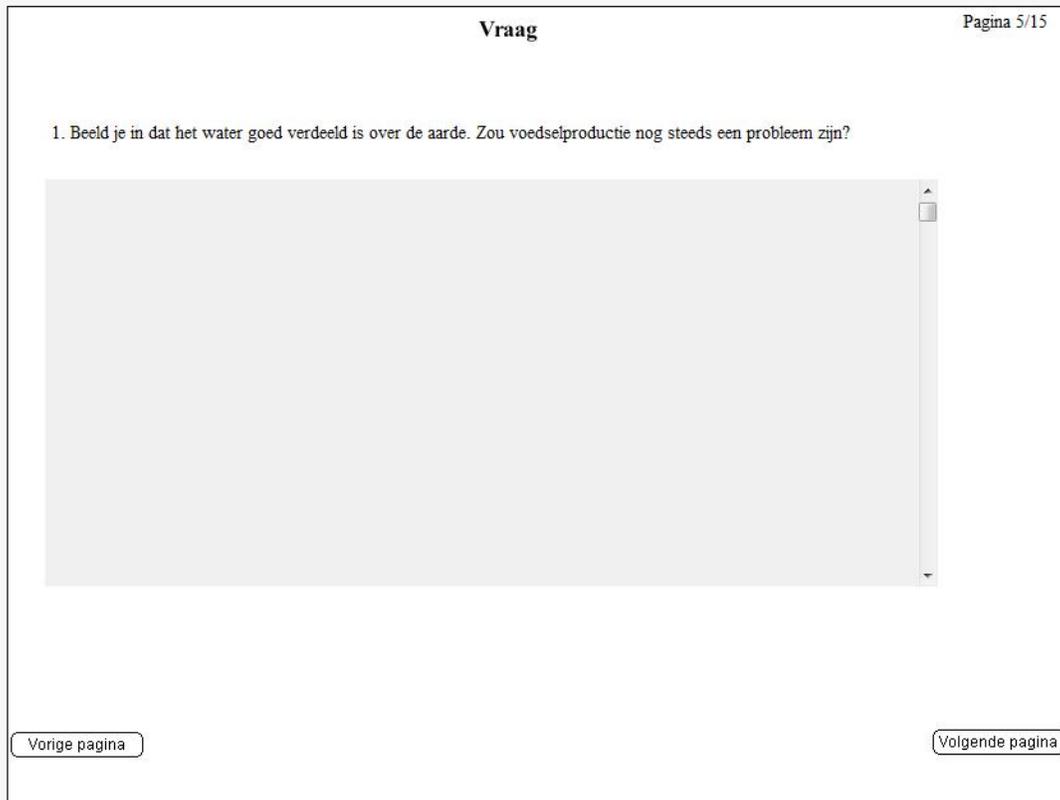
Tool use: Quantity- Time spent on tool and frequency of tool access -. The time spent on the tool was considered as a measure for quantity of tool use in all four conditions. Log files were kept in a Microsoft Access database which contained the learner’s identity and the time spent on the tools in seconds. Another indicator of quantity of tool use was considered but only in the non-embedded conditions. This was the clicks made to access the tool, namely, frequency of tool use. This data was also obtained through the log file which recorded the amount the times the learners click on the button to access the tool, namely adjunct question.



**Figure 3.** Screenshot of non-embedded conditions. After learners read a section they had a blank page with a button that read ‘vraag’ (question). Learners had the option to access the tool or not by clicking on that button.

Tool use: Quality. Answers on the adjunct questions were individually logged as text files. The correctness of the answers was used as the quality indicator of tool use. Participants could obtain from zero to three points per answer on each adjunct question. Zero indicated no answer, an incorrect answer or an incorrect answer without any rationale. One point was given to a correct answer without rationale and/or explanation. Two points were given to a correct answer but with little or no rationale. Three points reflected correct answer with a high rationale and well thoroughly provided answer. Participants could obtain in total 15 points. The answers were scored by three different researchers. The inter-rater reliability using Intraclass correlation (ICC) was considered to be appropriate if the value was above .80 (Shrout & Fleiss, 1979). The ICC for grading the adjunct questions showed outstanding agreement among the three raters (ICC= .99,  $p < .001$ ). Two out of the three raters were social researchers who were not involved in the present study.

Learning outcomes. Prior knowledge was measured by a pre-test ( $n_{\text{items}}=9$ ) in order to assess possible differences among conditions. Performance was assessed using a post-test ( $n_{\text{items}}=13$ ). Both tests were designed by three researchers, authors of this paper, two of which had experienced in the design of these types of materials. Consequently, the design of the pre- and post-test followed similar criteria used in previous studies (Clarebout, et al., 2010). The nine pre-test questions were multiple choice questions which explored learners’ factual knowledge related to the topic of the hypertext. Each question had four different choices. Two examples of such questions are as follows: “How much water in average does a Belgian use per year?” and “What does water footprint refer to?” Each correct question was worth a point. Therefore, learners could obtain a maximum nine points. In the post-test, learners could obtain up to 16 points. It included seven multiple-choice factual knowledge questions (e.g., what does FAO stand for?) and six insight questions among which three were open questions (e.g., what did the author imply with “more crop per drop”?) and three were fill-in-the-blank questions with optional words (“In the next 50 years the demand of food will \_\_\_\_\_”). Every correct answer was given one point except for the open questions which could be graded from zero to two. Learners obtained two points for correct answer and a deep rationale answer, one point for a correct answer weak rationale answer and zero points for no rationale, no answer or incorrect answer. The inter-rater reliability for the scoring procedure of the open questions among the three raters was found to be outstanding (ICC= .97,  $p < .001$ ). As in the pre-test two out of the three raters were researchers from other study domains.



**Figure 4.** Screenshot of embedded conditions. Embedded conditions accessed the tool after clicking the button to go to the next page. The darkened space was provided to write the answer.

### Procedure

The study was carried out in two steps. First, the self-efficacy and goal orientation questionnaires were administered to all participants during their Learning and Instruction class. Answering the questionnaires was a pre-requisite to attend the second part of the experiment; also, participants had to register themselves in a learning platform where they selected a session time in which they could attend. The second part was spread over different sessions in a computer laboratory with a maximum of 20 participants assigned to different conditions per session (maximum 40 minutes duration).

In the second part of the experiment, first, participants answered the pre-test on paper. Afterwards, they were introduced to the CBLE and started reading the hypertext. When the participants finished, they raised their hand and waited in silence until the researcher approached them. Once the researcher, who was conducting the research session, approached them, she checked the log files and made sure the learners' answers to the adjunct questions, time and clicks were recorded. If everything was appropriately saved, the researcher closed the program and handed the post-test on paper to be answered. Once participants completed the post-test, they were given proofs of the attendance and left the computer lab.

### Data analyses

First, a MANOVA was used to check whether the conditions differed with respect to goal orientation, self-efficacy the pre-test (prior knowledge) and the post-test (performance). Condition was the independent variable and the learner characteristics, pre- and post-tests were the dependent variables. If groups showed a difference among conditions, then any of these variables were to be considered covariates in the further analyses.

**Research questions 1& 2: Does non-/embeddedness of tool influence quality and quantity of tool use? Does the (no) explanation of the tool functionality influence quality and quantity of tool use? And Research question 3: Do self-efficacy and goal orientation influence tool use in relation to embeddedness and the explanation of the tool functionality? If so, how?**

For questions 1 and 2, descriptive statistics were run between conditions and quantity and quality of tool use to see the effect of condition, more specifically, non-/embeddedness and (no) explained functionality on tool use.

Next, to answers research questions 1,2 and 3, a MANOVA was conducted with all the conditions; self-efficacy, performance approach, performance avoidance, mastery approach and mastery avoidance respectively as independent variables to see their effect on quality and quantity (time spent on tool) of tool use (dependent variables). For the effect of frequency of tool use (quantity), only the non-embedded conditions were considered. It is important to mention that all participants were considered given that all of them accessed the tools. Herein, a factorial ANOVA was conducted in which non-embedded conditions; self-efficacy, performance approach, performance avoidance, mastery approach and mastery avoidance were independent variables and quantity of tool use (frequency) the dependent variable.

**Research question 4: Do quality and quantity of tool use influence performance?**

To answer the last research question, first, correlation analyses were conducted in order to see any possible correlations among tool use measurements. Second, regression analyses were conducted. The first regression with performance as dependent variable and tool use, namely quality of tool use and time spent on tool as independent variables. The second regression was done with frequency of tool use (quantity) as independent variable and only in the non-embedded conditions.

**RESULTS**

The MANOVA indicated that the mean of each condition regarding self-efficacy, the scales of goal orientation, the pre-test (prior knowledge) and the post-test (performance) did not significantly differ between conditions, *Wilks' lambda* = .84; *F* (21,373)= 1. 12, *p*=. 32  $\eta^2_{partial}$  =.06. Therefore in the further analyses, none of these variables were considered as covariates.

**Research questions 1& 2: Does non-/embeddedness of tool influence quality and quantity of tool use? Does the (no) explanation of the tool functionality influence quality and quantity of tool use?**

The descriptive statistics in Table 1 show that both embedded conditions and non-embedded conditions used all tools. The MANOVA indicated a significant effect of condition on quality and quantity of tool use (time spent on tool) *Wilks' lambda*=0.632, *F* (6, 230)=9.89, *p*<.001.  $\eta^2_{partial}$  =.20. The separate ANOVA's on the outcome variables confirmed this significance: quality of tool use *F* (3, 116) = 4.22, *p*<.01,  $\eta^2_{partial}$  =.10 and quantity *F* (3, 116) =17.04, *p*<.001,  $\eta^2_{partial}$  =.31. Post hoc analyses using the Tukey post hoc criterion for significance indicated that the time spent on tools was significantly higher in the embedded condition with explained functionality (*p* <.005); and without explained functionality (*p*<.05) in comparison with both non-embedded conditions. However, the embedded condition with explanation was significantly higher than the embedded condition without explanation (*p*<.001).

**Table 1.** Descriptive statistics of quantity (time spent in seconds) and quality (answers on adjunct questions) of tool use across conditions. Non-embedded conditions show also tool use frequency, that is, clicks learners made to access tool.

Condition	Tool use	<i>N</i>	Mean	<i>SD</i>
Embedded, explained functionality	Quality (max. 16 points)	34*	9.12	2.17
	Quantity: Time spent (seconds)	35	793.03	370.85
	Performance (max. 13 points)	35	11.26	1.67
Embedded, non-explained functionality	Quality (max. 16 points)	35	8.43	1.82
	Quantity: Time spent (seconds)	35	583.31	235.23
	Performance (max. 13 points)	35	11.26	2.10
Non-embedded, explained functionality	Quality (max. 16 points)	35	9.77	2.30
	Quantity: Time spent (seconds)	35	402.17	143.04
	Quantity: Frequency (clicks)	35	16.77	9.38
	Performance (max. 13 points)	35	11.71	2.08
Non-embedded, non-explained functionality	Quality (max. 16 points)	35	9.94	1.51
	Quantity: Time spent (seconds)	35	398.11	175.95
	Quantity: Frequency (clicks)	35	18.09	10.77
	Performance (max. 13 points)	35	11.06	2.01

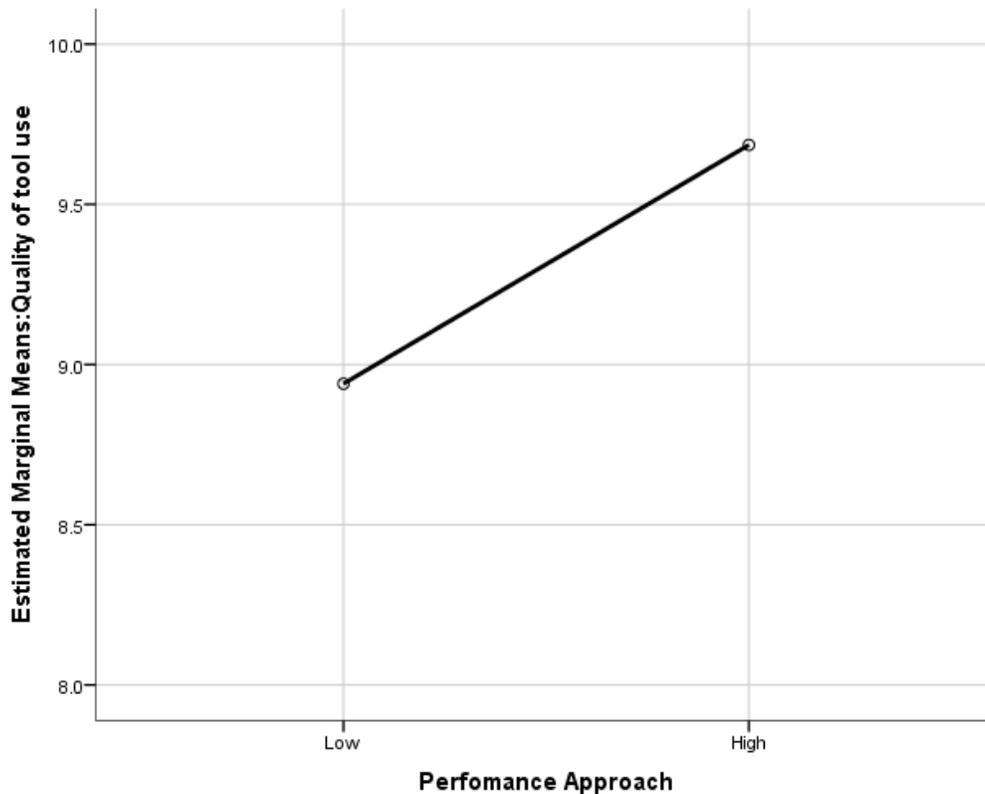
\* Data from one participant was lost

The descriptive statistics also revealed that non-embedded conditions tool usage quality was higher than the embedded conditions. The Tukey post hoc narrows down this finding and points out that non-embedded condition with explained functionality ( $p < .05$ ) and without explained functionality ( $p < .005$ ) were significantly different only with the embedded without explained functionality. However, significant differences between the embedded condition with explanation and without explanation on quality of tool use were not retrieved in the post hoc test ( $p = .55$ ).

Although the descriptive statistics in the non-embedded conditions suggested that participants accessed tools relatively more frequently in the condition without the explanation of tool functionality ( $M = 18.09$ ) than in the condition with explained functionality ( $M = 16.77$ ), the ANOVA indicated that such difference was not significant  $F(1, 58) = .19, p = .67, \eta^2_{\text{partial}} = .00$ .

**Research question 3: Do self-efficacy and goal orientation influence tool use in relation to embeddedness and the explanation of the tool functionality? If so, how?**

Performance approach had a significant direct effect on tool use, Wilks  $\lambda = 0.95; F(2, 115) = 3.09, p < .05, \eta^2_{\text{partial}} = .05$ . Univariate ANOVA's revealed that performance approach did influence quality of tool use  $F(2, 95) = 3.88, p = .05, \eta^2_{\text{partial}} = .03$  but did not affect quantity of tool use (time). The particular effect of performance approach on quality of tool use was mainly positive meaning that learners with high levels of performance approach used tools more qualitatively in comparison with learners with low levels of performance approach (Figure 5).



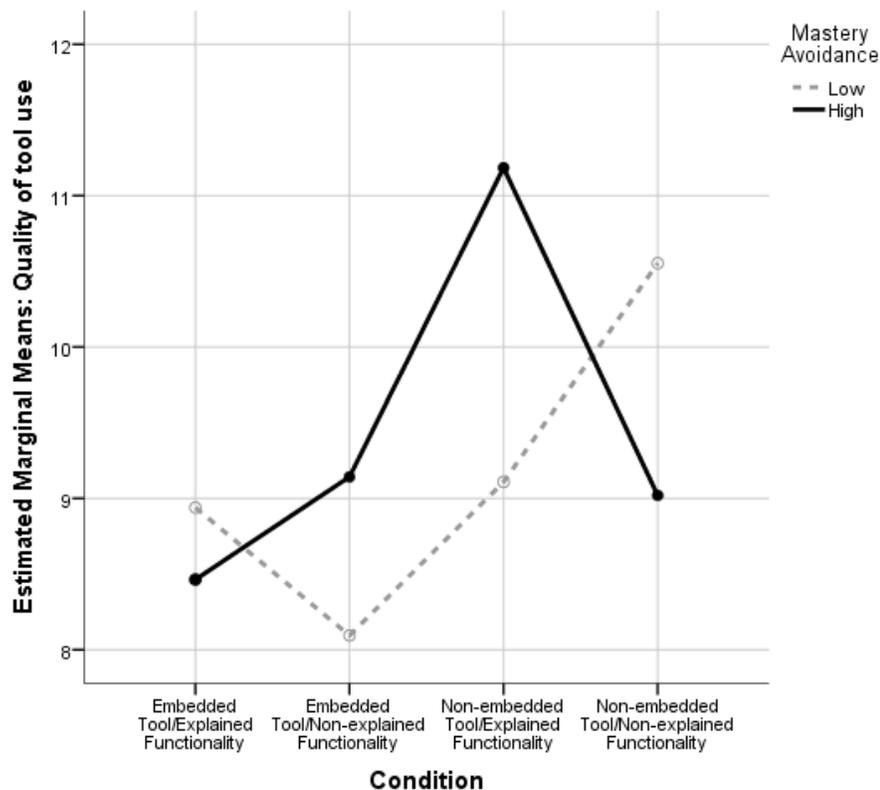
**Figure 5.** Effects of performance approach on quality of tool use.

Another variable that showed an effect on tool use was master avoidance, but this in interaction with condition. This effect could only be observed using Roy's statistics. Roy's largest root = 0.88;  $F(3, 116) = 3.40, p = .02, \eta^2_{\text{partial}} = .08$ . The further univariate ANOVA's confirmed that master avoidance in interaction with condition did influence quality of tool use  $F(3, 116) = 3.19, p < .05, \eta^2_{\text{partial}} = .08$  but did not affect quantity of tool use (time). Both low and high levels of master avoidance used tools more qualitatively in both non-embedded conditions (with explained and non-explained functionality) than in both embedded conditions. The interaction effects can be observed in more detailed in table 2 and figure 6 which show the estimated marginal means given that means

of unequal sizes were compared. The MANOVA revealed no further significant (interaction) effects of performance avoidance, master approach and self-efficacy on tool use.

**Table 2.** Estimated marginal means, standard errors for quality of tool use of the different conditions, and the low and high levels of master avoidance.

Condition	Mastery Avoidance levels	<i>N</i>	Estimated Marginal Mean	<i>SE</i>
	Embedded, explained functionality	Low	18	8.94
	High	17	8.46	0.61
Embedded, non-explained functionality	Low	25	8.09	0.45
	High	10	9.14	0.71
Non-embedded, explained functionality	Low	25	9.11	0.45
	High	10	11.18	0.69
Non-embedded, non-explained functionality	Low	22	10.55	0.47
	High	13	9.02	0.67



**Figure 6.** Interaction effects of mastery avoidance and condition on quality of tool use.

The ANOVA analysis in the non-embedded conditions ( $N=70$  each) showed that no variable in interaction with condition had a significant impact on frequency of tool use. Only after it was controlled for condition, self-efficacy had a significant effect on quantity of tool use (frequency)  $F(1, 58) = 8.45, p < .01, \eta^2_{\text{partial}} = .13$ . This effect was negative, meaning that the lower the self-efficacy in learners the more frequent they accessed the tools (Figure 7).

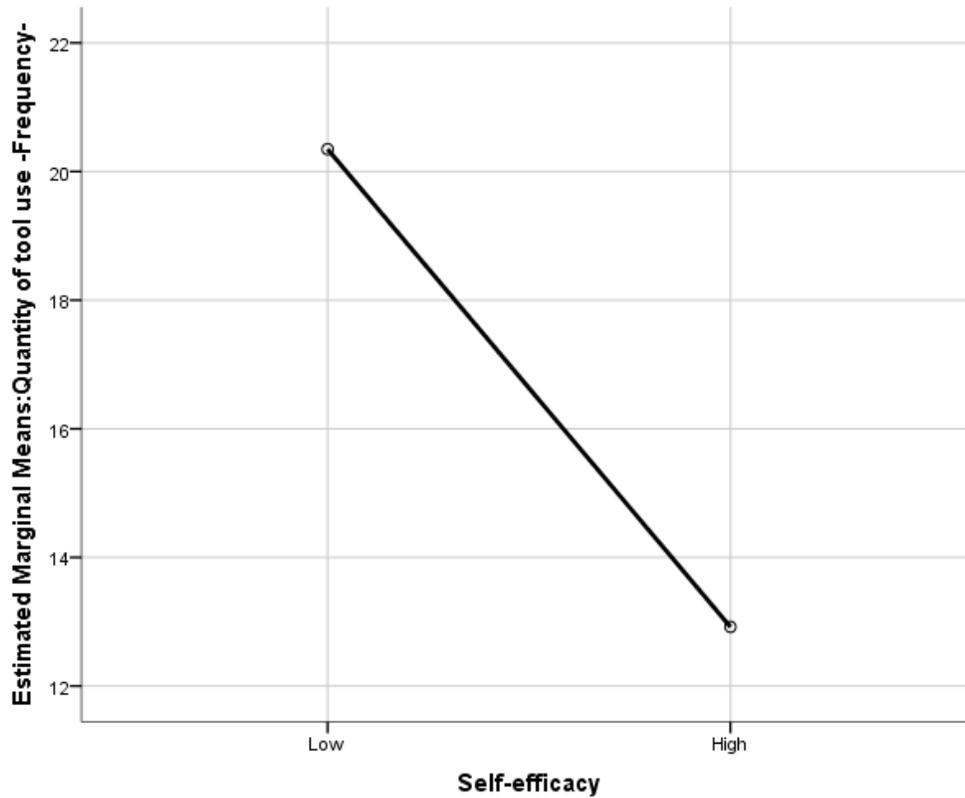


Figure 7. Self-efficacy on frequency of tool use.

**Research question 4: Do quality and quantity of tool use influence performance?**

A significant negative correlation between frequency of tool use and quality of tool use was observed ( $r = -.26, p < .05$ ) but none of these tool use measurement affected performance significantly. That means that, as illustrated in Table 3, only quantity of tool use, namely time spent on the tool, seemed to be the only aspect of tool use that affected performance. Although all learners in all conditions used the tools, it seemed that only time spent on tool had a significant impact.

Table 3. Regression analyses on the effects of tool use on performance.

	Performance all conditions*			Performance non-embedded conditions**			
	B	SE B	$\beta$	B	SE B	$\beta$	
<b>Step 1</b>							
(Constant)	10.57	0.37		(Constant)	11.67	0.50	
Quantity (time on tools)	0.001	0.001	0.19***	Quantity (frequency)	-0.02	0.03	-0.08
<b>Step 2</b>							
(Constant)	9.23	0.85					
Quantity (time on tools)	0.001	0.001	0.20***				
Quality tool use	0.14	0.08	0.15				

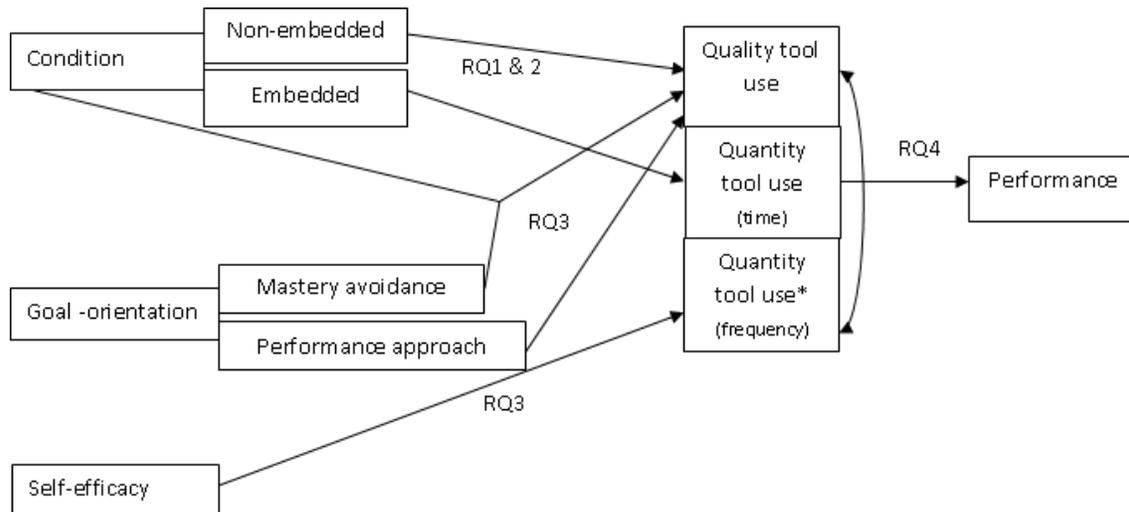
\* $R^2 = .19$  for Step 1,  $p < .05$ .  $\Delta R^2 = .24$  for Step 2,  $p = .08$ .

\*\* $R^2 = .01$  for Step 1,  $p = .52$  (one step only)

\*\*\*  $p < .05$

## DISCUSSION & CONCLUSION

This contribution was aimed at gaining more insight into learners' quantitative and qualitative use of tools by exploring the impact of tool characteristics (non-/embeddedness, with/without the explanation of tool functionality) and motivational characteristics (self-efficacy and goal orientation) on performance in a CBLE. Some learners had to answer the questions (embedded conditions) whereas others could choose whether to use the questions or not (non-embedded conditions). Within these conditions the explanation of the tool functionality was added in two of the four conditions (one embedded and one non-embedded condition).



**Figure 8.** Summary of significant results from present study.

One of the results illustrated in figure 8 is that learners in both embedded conditions spent proportionally more time on the tools than both of the non-embedded conditions. Moreover, the results from the Tukey post hoc test also suggested that the explanation of tool functionality affected the time spent on the tool. This is because the embedded condition with explained functionality was significantly higher (in time) than the embedded condition without explanation. Additionally, learners in the non-embedded conditions with and without explained functionality had better results in the quality of tool use which means they answered the adjunct questions more thoroughly than the embedded condition without explained functionality, but not more than the one with explained functionality.

The findings on the relationship between tool presentation (non-/embedded tool) and quantity (time) and quality of tool use are similar to previous research (Clarebout, et al., 2010) where participants in the embedded condition used tools more but less qualitatively than participants in the non-embedded condition. Therefore embedded tools may be in the end a straightforward solution to avoid non-use of tools, but non-embedded tools may ensure the quality of tool use. This discrepancy brings to light the two standpoints of the learner control debate (see: Lawless & Brown, 1997). One point supports the idea of giving the learners control over their learning, as for example, in the component display theory (Merrill, 1983) whose one of the main principles is that learners should be given control over the number of instances or practice items they receive. The second point claims that learning is not effective in environments with little control over learning. However given that in the present study quality of tool use did not impact performance, possibly in the present experimental setting embedding tools may be more optimal.

The finding on the explanation of the tool functionality, on the other hand, seems inconclusive. While it provides evidence that (a) explained tool functionality may augment time spent on the tool when tools are embedded, and that (b) non-embedded tools (with and without explanation) and embedded tool with explained functionality may increase quality of tool use, it may also suggest that the non-/embeddedness has a stronger effect on tool use than the explanation itself. One possible reason why the explanation of the tool functionality was not significant could be attributed to the nature of the explanation itself. The explanation of the tool functionality was presented only once, namely at the beginning of the text. Having the explained tool functionality at one moment was probably too 'minimal'; moreover, the explanation to use tools was perhaps not formulated in an encouraging way for these types of learners. These two reasons may have lead to an ineffectiveness on the explanation of the tool functionality (Kirschner, Sweller, & Clark, 2006). This finding

may also explain why quality of tool use did not affect performance (further discussion below). Hence to increase the possibility of having a positive effect of explained functionality on the use of tools, and consequently on performance, a specific more guided instruction on the use of tools should be provided (Kirschner, et al., 2006). It is proposed that this could be done by increasing the amount of times the explanation of the tool functionality is present, for example, before accessing the tool and probably also by adapting the explanation in a way that encourage learners towards a more optimal tool use.

While a direct effect of the explanation of the tool functionality on tool use could not be confirmed, it could also be argued that the partial effect found through the post hoc tests could be mediated by affective characteristics. In broad terms, research has suggested that affective characteristics may impact use and effects of technology (Proost, Elen, & Lowyck, 1997). Moreover, it has been indicated that how learners perceive the explanation of the tool functionality may impact on the effect of the explanation (Clarebout & Elen, 2008). This means that the emotional reactions towards the tool were probably different among conditions (with/without explanation), making the emotional reactions towards the tool more positive in the conditions with the explained functionality. Further study research on tool use introducing qualitative approaches could possibly widen the perspectives on tool use, for example, through observations.

This contribution also revealed that two aspects of goal orientation (figure 8) influenced tool use. Specifically, high levels of performance approach positively influenced quality of tool use. This means that performance approach learners, namely learners with high concerns about how well they perform and how others perceive them, answered the adjunct questions more thoroughly. Crippen and colleagues (2009) also found that performance approach was positively related to tool use, but Huet, et al. (2011) revealed opposite results. In both studies (Crippen, et al., 2009; Huet, et al., 2011) the measures of tool use was based on the times learners accesses the tools (frequency). Our result is more in line with the results obtained by Crippen and colleagues (2009) because of the positive relationship found, and also add to the literature by suggesting that performance approach is also positively related of the quality of tool use. This result may also suggest that the quality of tool use was better in learners with high performance approach levels because quality of tool use was viewed as a simpler task to demonstrate success than spending more time on the tool or accessing it more (Crippen, et al., 2009).

Considering the definition of mastery avoidance, learners that strived at avoiding misunderstanding, failing or making mistakes from an intrapersonal perspective showed no direct effect on tool use. Only when interacting with condition an effect of mastery avoidance was found to influence the quality of tool use (students' answers given to the adjunct questions). Learners with high and low mastery avoidance levels in non-embedded conditions showed more quality of tool use. These findings are related to the results obtained from tool presentation and explanation of tool functionality on tool use which means they could confirm the fact that both non-embedded conditions use tools more qualitatively. Moreover, an indirect influence of the interaction between mastery avoidance and condition on frequency of tool use could also be suggested given that frequency of tool use and quality of tool use were negatively correlated. This influence would be negative, which implies that learners that avoided misunderstanding or making mistakes accessed tools less frequently in the non-embedded conditions. However no further implications could be made given that neither frequency of tool use nor quality of tool use influenced performance. In general, the finding showing the interaction effects of mastery avoidance could sustain the theory of aptitude-treatment interaction (Cronbach & Snow, 1977) and bring to light the role of learners characteristics in relation to tool characteristics, in this case the presentation of tools in CBLE's.

For the other aspect of quantity of tool use–frequency-, no interaction effects between learner characteristics and conditions were found. However, significant direct effect of self-efficacy, on frequency of tool use was found (figure 8). The further analysis suggested that high self-efficacy levels influenced negatively the frequency of tool use and hence -due to the found correlation- indirectly had a positive influence on the quality of tool use. Considering that self-efficacy is defined as “the beliefs in one’s ability to plan/execute a behavior” (Bandura, 1997), if people, in this case learners, believe they have a great ability to organize and execute the course of actions required to succeed and reach a certain goal, then they will be capable of adapting their use of tools. Moreover, this finding might also be related to the optimization stage for tool use (Iiyoshi & Hannafin, 1998), as to the third condition of Perkins (1985): Learners, with a high level of self-efficacy -a motivational characteristic-use the tools, attempted to optimize the tool use by decreasing the frequency of tool use.

In this study, it was assumed that quantity and quality of tool use would influence performance. Confirming this would fulfill Perkins's first condition (1985) of the tool is there, more specifically, the tool is functional for the learner (Clarebout, et al., 2010). The findings may raise the question on whether the present tool was fully

functional as they revealed that only the time spent on the tool (quantity of tool use) influenced performance and neither frequency of tool use nor quality of tool use revealed a significant impact.

Additionally, the fact that only time spent on tool had a positive effect on performance also question whether it is appropriate to explore tool use from a quantitative (time and frequency) and qualitative perspective in a single study. Literature on tool use has explored one of the three (frequency: Crippen, et al., 2009) obtaining positive results on performance. Other studies have focused on two of them (time & frequency: Elen & Louw, 2006; Viau & Larivée, 1993). Elen & Louw (2006), for instance, saw only partial effect of frequency of tool use on performance, while Viau & Larivée (1993) showed effects of both time and frequency on performance but only in one of the two tools. Few studies have explored the three of them (Clarebout, et al., 2010; Jiang & Elen, 2011). Clarebout and colleagues (2010) only found significant positive effects of time and quality on tool use on performance; Jiang and Elen (2011) had positive effects of quality of tool use on performance but negative effects of frequency of tool use on performance, partial effects of time on tool on performance were revealed. Other studies have not analyzed the effects of tool use on performance (quality: Greene & Land, 2000; frequency: Huet, et al., 2011).

The results in the present investigation could also question whether quantity and quality of tool use are separate measurements for tool use, given that a correlation between frequency of tool use and quality of tool use was found. It is also questioned whether the time spent on the tool could be indirectly related to what is conceived as the quality of tool use. That is to say, the time spent on the tool –adjunct question- could also be an indicator of quality of tool use because learners possibly took more time thinking on the question than actually writing down a thorough answer. Learners may see the value of thinking about the questions but not the value of writing all their thoughts down and making the answers look ‘perfect.’

Overall, the results reveal the complexity involved when using tools in CBLE’s. They also add to our understanding of the relationships between learner and tool characteristics on tool use in university students. In general, the findings suggest that goal orientation, self-efficacy and tool characteristics interact and affect the quantity and quality of tool use; and quantity of tool use affects performance.

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