Computers in Human Behavior 25 (2009) 501–509

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

The relationships between learner variables, tool-usage behaviour and performance

Lai Jiang *, Jan Elen [1], Geraldine Clarebout

Katholieke Universiteit Leuven, Department of Educational Sciences, Centre for Instructional Psychology and Technology, 3000 Leuven, Belgium

ARTICLE INFO

Article history:
Available online 7 January 2009

Keywords:
Prior knowledge
Goal orientation
Log files
Tool use

ABSTRACT

A variety of learner variables have been asserted to affect learners' tool-usage behaviour. However, direct empirical evidence on which learner variables influence tool-usage behaviour and how is limited. In order to better understand the impact of learner variables on tool use, the current study investigates the relationships between learner variables, the quantitative aspects of tool-usage behaviour and its outcome (i.e., performance). More specifically, the focus is on how the variation in tool use is related to prior knowledge and goal orientation and how this variation affects performance. Tool-use data were extracted from log-file data collected in an open-ended learning environment [Clarebout, G. (2005). The enhancement of optimal tool use in open learning environments (Doctoral dissertation). Katholieke universiteit Leuven, Leuven.]. Results partly revealed the hypothesized relationships between learner variables, tool-usage behaviour (the proportion of time spent on tools) and performance. The results suggest that in order to have a more thorough understanding of the relationships between learner variables, tool-usage behaviour and learning outcomes, log-file data may need to be complemented with direct observations to acknowledge the qualitative aspects of the tool-usage behaviour (i.e., mixed method approach).

1. Introduction

Under the assumption that learner control could benefit motivational aspects (e.g., improving students' attitudes: Kinzie & Sullivan, 1989) as well as cognitive aspects (e.g., adapting a learning environment to students' needs: Friend & Cole, 1990), designers add a variety of support devices, which we call tools, to learning tasks. A striking feature of such tools is that learners are given the choice of whether or not to use them and how to use them. While tools are provided in view of fostering learning, an increasing number of studies reveal that students do not always perform more optimally with the available tools (e.g., Clark, 1990; Srinivasan et al., 2006). Meanwhile, the phenomenon of students' non- or inadequate use of tools (e.g., tools used to gather, but not organize or synthesize problem-related information) were reported consistently across various studies (e.g., instructional explanation tool: Renkl, 2002; tools for managing hypermedia: Oliver & Hannafin, 2000). Assuming that the provided tools are potentially functional, the actual inefficiency of the tools might be due to students' suboptimal tool-usage behaviour (Elen & Clarebout, 2005, 2006). The argument stresses the importance of better understanding tool-usage behaviour and the variables that influence it.

Two types of factors (i.e., the nature of tools and learner variables) as well as their interactions have been suggested to affect students' tool-usage behaviour (Bartholomé, Stahl, Pieschl, & Bromme, 2006). Studies focusing on the effectiveness of tool characteristics show that tool features, such as substance content of tools (e.g., functional and operative: Dutke & Reimer, 2000) and degree of learner control (Carrier, Davidson, & Williams, 1985; Simons & Klein, 2007) are important factors that influence the effectiveness of tool utilization (i.e., optimal use of tools and optimal learning results). In Simons and Klein's study (2007) a hypermedia program *Up, Up & Away!* was provided to facilitate students problem-solving processes. Students were assigned to three conditions: (1) a none condition, where students were left to their own to solve the problem, (2) an optional condition, where students could decide whether or not to use *Up, Up & Away!* and (3) a required condition, where students were required to use it under teachers' supervision. The analysis of the group notebooks showed quantitative differences among these three groups of students. Specifically, when support devices are offered for optional tool use, students produced lower quality notebooks (i.e., less organized, less accurate problem-relevant information).

As to the importance of learner variables on tool use, a series of studies indicates that the effectiveness of the tool is related to the capacity of students to properly use the tools (e.g., Azevedo, Cromley, & Seibert, 2004; Elshout, Veenman, & Van Hall, 1993). A diverse set of students' cognitive and metacognitive variables are seen as indicators of this capacity, such as prior knowledge (domain-

* Corresponding author. Tel.: +32 16 326259; fax: +32 16 326274.
E-mail addresses: jiang.lai@student.kuleuven.be (L. Jiang), jan.elen@ped.kuleuven.be (J. Elen), geraldine.clarebout@ped.kuleuven.be (G. Clarebout).
[1] Tel.: +32 16 325733; fax: +32 16 326274.

0747-5632/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.chb.2008.11.006

related and instructional knowledge: e.g., Iiyoshi & Hannafin, 1998; Lowyck, Elen, & Clarebout, 2004) and self-regulation strategies (Greene & Azevedo, 2007; Winne & Jamieson-Noel, 2002). In addition, the effects of students' motivational aspects on their willingness to use tools can hardly be ignored (Elen & Clarebout, 2006, 2007). It has been suggested, for instance, that tool use in a computer-based learning environment may be affected by motivational variables such as domain-related interest (e.g., Shute & Gluck, 1996) and goal orientation (Aleven, Stahl, Schworm, Fischer, & Wallace, 2003). Furthermore, tool features interact with learner variables and influence the efficiency of tool-usage (e.g., Renkl, 2002; Arroyo, Conejo, Guzman, & Woolf, 2001; Wood & Wood, 1999).

The aim of this article is to analyse the relationship between learner variables, tool-usage and performance. In the study, tool-usage is analysed when learning with a computer program called STUWAWA (Clarebout, 2005). STUWAWA offers an open-ended environment for ecological problem-solving, whose purpose is to foster students' acquisition of complex problem-solving skills. Since an open learning environment by definition implies a great deal of learner control (Hannafin, 1995), learning with STUWAWA requires students to explore and manipulate the environment, to determine how to benefit sufficiently from different tools to acquire sufficient understanding, to look for an adequate solution, etc. However, considering the observations that students are not always capable of adequately choosing for themselves (Large, 1996; Williams, 1996), such learner controlled environment may cause problems for learners. This is because "learner control cannot be expected to overcome the persistent fact that individual characteristics not under the control of the individual will determine to a significant extent what and how much that individual will learn in a given instructional setting" (Snow, 1980, pp. 152–153). In other words, the amount of learner control makes students' individual characteristics salient in terms of their impact on tool use. For instance, prior knowledge and goal orientation may influence the way in which students manipulate the tools in STUWAWA to solve the problem. Some researchers (Cook, 2006; Oliver & Hannafin, 2000; Wood & Wood, 1999) have suggested that students who have less domain-related knowledge may have more difficulty to use tools and, therefore, may be less likely to exert optimal usage behaviour. Moreover, another study showed that students who had different goal orientations were inclined to use tools differently (Clarebout & Elen, in press). It was noted that mastery goal orientation is less likely than performance goal orientation to show a maladaptive, noninquisitive usage pattern. Arbreton (1998) found that students with mastery goals asked more often for hints (instrumental help) to solve the problem by themselves, whereas students with performance goals tended to ask for help simply to get the right answer (executive help). Hence, the current paper focuses on the impact of these two learner variables which, as reported in previous research, could be related to tool use.

1.1. Learner variables

1.1.1. Domain-related prior knowledge

As highlighted in a series of studies (e.g., Aleven et al., 2003; Elen & Louw, 2006; Martens, Valcke, & Portier, 1997; Uduma & Morrison, 2007), domain-related prior knowledge can have a profound effect with regard to the tool-usage outcomes (e.g., performance). Additionally, studies suggest that the prior knowledge may have an impact on performance through various quantitative and qualitative aspects of tool use, such as the initiative to use tools (e.g., Martens et al., 1997), the proper selection of tools (e.g., Iiyoshi & Hannafin, 1998; Renkl, 2002), tool-usage strategies (e.g., Oliver & Hannafin, 2000; Wood & Wood, 1999).

Different explanations were given to interpret the observed correlations. For example, Aleven et al. (2003), based on an in-depth analysis of the literature, postulated that prior knowledge impacts the efficiency of tool use through help-seeking behaviour. Help-seeking behaviour originally was mostly studied in classroom situation. In a computer-based learning environment, help-seeking behaviour refers to using available tools to secure the necessary help and to continue the learning processes when they encounter problems.

Studies on help-seeking in computer-based environments generally agree that students with less prior knowledge may have less adaptive help-seeking behaviour which would cause less efficient tool-usage (e.g., Aleven et al., 2003; Clarebout, 2005; Wood & Wood, 1999). For instance, Wood and Wood's study (1999) showed that lower prior knowledge students had less adaptive help-seeking behaviour, that is, they gave less accurate judgments of the need for help and knew less how to use help properly to achieve a maximum benefit from seeking help. As a consequence, when they made errors students with less knowledge less frequently used the tool for help. Those who attempted to use the tool just quickly requested help without trying to first self-correct the errors as higher knowledge students did. In turn, suboptimal tool-usage negatively impacts on tool-usage outcomes (e.g., performance).

With regard to the impact of prior knowledge in ill-structured learning conditions, Martens et al. (1997) linked the qualitative differences between low and high prior knowledge groups to an aptitude-treatment effect. They argue that a high level of prior knowledge can compensate for the lack of structure in ill-structured learning conditions (e.g., problem-solving learning environment), because the available organized knowledge structures in long-term memory (schemas) help to organize and link relevant information together. This increases the likelihood that relevant information will be available for related learning tasks (Glaser, 1990). In contrast, low prior knowledge might lead to a negative impact on study outcomes under such conditions.

Based on the studies that analysed relationships between domain-related prior knowledge and tool use, we hypothesize that tool-use patterns are related to domain-related knowledge.

1.1.2. Goal orientation

Taking advantage of tools autonomously is essential for success in open-ended learning. Goal orientation (mastery/learning goal orientation and performance goal orientation: Ames, 1992; Dweck, 1986; Elliot, 1999) has been proposed as a potential variable influencing the initiation of tool use through help-seeking behaviour (Aleven et al., 2003). In general, mastery goal orientation is found when students focus on developing competence, expansion of knowledge, and achieving mastery of the material or of the task (Ames, 1992; Kaplan & Maehr, 2002). On the other hand, performance goal orientation is identified with students who incline to focus much more on how they will do good or bad at the task and on how they will be perceived by others (Lens & Vansteenkiste, 2006). In general, it seems that mastery goal orientation is presumed to promote optimal tool use. For example, it was noted that mastery goal orientation is less likely than performance goal orientation to show a maladaptive, noninquisitive pattern of help-seeking behaviour (Arbreton, 1998; Newman & Schwager, 1995).

However, the impact of students' goal orientation on their taking the initiative to use tools is unstable since reports from different studies are incongruent. For instance, in Ryan and Pintrich's study (1997), mastery goal oriented students (seventh and eighth graders) believed that using tools would be beneficial for their well-being, and therefore, they were more likely to ask for adaptive help. On the other hand, students' performance goal orientation