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TOOL USE IN A PSYCHOMOTOR TASK: THE ROLE OF TOOL AND LEARNER VARIABLES

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Research on the use of learning tools has brought to light variables that influence the learner on using or not using the tools. A deeper analysis on the current findings is attempted in this study. It adds a psychomotor task; it assesses the actual functionality of the employed tools, and it further explores learner-related variables that influence tool use, most importantly on perceived tool functionality (the beliefs of learners that a certain tool would be the most optimal one). Fifty-eight learners had to build a LEGO® figure. Two tools were used: a video with intentionally low functionality demonstrating the figure assembly, and a step-by-step guideline with pictures. Based on the tools, there were three experimental conditions: guideline (G), video (V) both tools (GV); and one control condition (C) without tools. To analyze the functionality of the tools, the effect of tool use on performance was monitored at two different moments in all conditions. To examine the perceived functionality of tools, the tool use by the learners was monitored in the (GV) condition. Moreover, we checked for the effect of prior knowledge, metacognition and self-efficacy on tool use in the (GV)condition. Results revealed that the tools were functional. The (G), (V) and (GV) conditions significantly outperformed the (C) condition, but contrary to our assumptions, the (V) condition outperformed the other experimental conditions. Regarding perceived functionality, all learners perceived the tools as functional, that means all learners picked a tool. They, however, could not identify from which tool they would benefit the most, i.e. they could not recognize the most functional tool. Concerning the other learner-related variables, no significant effect was found. Theoretical implications for further research are discussed. First on what kind of tool-related variables influence tool use. Second on the effect learner-related variables, especially perceptions, might have on using tools.

Key Words: tool use, tool functionality, perceived functionality, learner variables, tool variables

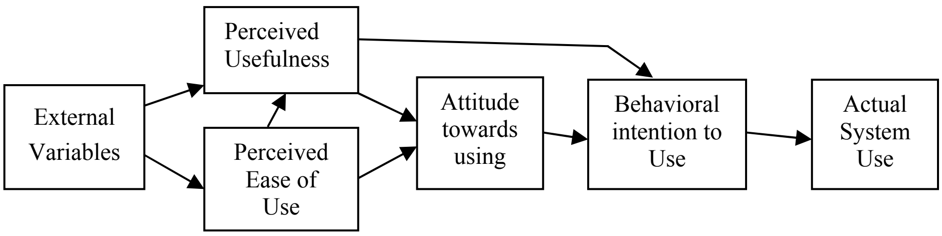
INTRODUCTION

Instructional design aims at aiding the learning of the individual by systematically arranging planned and designed environments that support learning processes adequately (Gagné, Briggs, & Wager, 1988). This support should be well-targeted in order to enhance learning. A way to provide this support is through instructional interventions (Elen & Clarebout, 2006). Instructional interventions often refer to guidance, strategies or tools (Elen & Clarebout, 2006). Depending on the type of learning supported, a distinction is made between information tools, as tools providing information to be learned, scaffolding tools, as tools that support learning efforts, and cognitive tools, as tools that allow interaction with the information (Hannafin, Land & Oliver, 1999). Hence tools support learners differently in accordance with their functionality. Tools added in a learning environment, then, can be considered a learning opportunity (Clarebout & Elen, 2009). However, these learning opportunities (tools) are either not always grasped by learners (Perkins, 1985) or their functionalities are not always recognized (Kvavik, 2005) and when they are; they are often used inadequately, mistakenly, or not used at all (e.g. Aleven, Stahl, Schworm, Fischer, & Wallace, 2003; Clarebout & Elen, 2006a; Elen & Clarebout, 2006; Zydney, 2008). Therefore, if learners do not make use of the tools provided or use them inadequately, the tools will hardly have a positive effect on the learning process. This reveals that tool use in learning environments is a complex issue, not only in regard to the way tools are used but also in regard to the variables that might influence this behavior (e.g. Azevedo, Cromley, & Seibert, 2004; Clarebout, Horz, Schnotz, & Elen, 2010). Learner-related variables and tool-related variables are two main different types of variables that have been emphasized in the tool use interplay (Aleven et al., 2003).

Regarding tool-related variables, tool design, tool embeddedness and tool type are some of the variables that have been examined (Aleven et al., 2003; Clarebout & Elen, 2006b; Clarebout et al., 2010). However, reports on tool-related variables influencing tool use are not as broad as they are on learner-related variables. The provided evidence on tool-related variables influencing tool use has indicated that tool design and tool type seem to influence learners' tool use (Amadieu, van Gog, Paas, Tricot, & Marine, 2009; Zydney, 2008). Zydney (2008, 2010), for instance, found out that different types of tools supported different aspects of defining a problem in learners and that the fact of providing one or more tools seemed to influence the learners' performance.

Learners' perceptions are part of learner-related variables. More specifically, perceptions is a metacognitive learner-related variable (Elen & Clarebout, 2006). Evidence suggests that learners perceptions may act as cognitive filters that influence tool use (Lowyck, Elen, & Clarebout, 2004). In the same vein, Clarebout and Elen (2009) indicated in their findings that learners' perceptions may have influenced the way learners used tools. While numerous variables have been considered in tool research, it is until now still unclear how the role of perceptions influence learners' behavior. In this line, the Technology Acceptance Model (TAM) (Davis, Bagozzi, & Warshaw, 1989) illustrated in figure 1 can provide more evidence on the role of perceptions. This model suggests that there are external variables that influence two main belief constructs which are perceived usefulness (one's belief that a system will enhance performance) and perceived ease of use (one's belief that a system will be effortless). Perceived ease of use affects perceived usefulness, and they both predict attitude (one's evaluation of the desirability to use a system). Attitude and perceived usefulness influence the intention to use the system which predicts the actual use of the system.

Figure 1. The Technology Acceptance Model (TAM) (Davis et al., 1989)



The TAM offers a good basis to point the role of perceptions in the present investigation. It, however, only focuses on predicting computer adoption and has been extensively applied to studies of technology use (e.g. Cho, Cheng, & Lai, 2009; Davis, 1989; Hong, Cheng, & Liau, 2005). In this respect, research has already called for a need to establish belief constructs that focus more specifically on tool use (see: Lowyck et al., 2004). Therefore, in order to adapt the constructs to tool use, we took the main belief construct of the TAM (perceived usefulness) and adapted it to that of perceived functionality "one's beliefs that using a certain tool would enhance performance in order to reach a goal". Thus, perceived functionality aims to be a belief construct focused on tool use.

Another example of a learner-related metacognitive variable is metacognition. Metacognition, thinking about one's thinking, has demonstrated to improve achievement, accuracy of knowledge monitoring and application of learning strategies in learning environments. It has also been suggested that the lack of metacognitive skills in environments where tools are being used makes the task process difficult for learners (Sánchez-Alonso & Vovides, 2007).

Other learner-related variables that have come into play in relation to tool use are cognitive and motivational variables. Herein, prior knowledge and self-efficacy are some variables that can be identified. Prior knowledge is a cognitive variable that has been broadly studied. Levels of prior knowledge (high and low) revealed to affect students's use of tools while reading a hypermedia document (Akyel & Ercetin, 2009). Akyel and Ercetin (2009) found that learners with high prior knowledge relied on their existing knowledge and selected the sequence of the reading based on their interest, while low prior knowledge learners used information tools more to compensate for their lack of prior knowledge and followed a hierarchical sequence in the hypertext. Self-efficacy is an example of a motivational variable. It seems to motivate directly and indirectly by influencing personal goal settings, and contributing to academic achievements (Bandura & Cervone, 1983; Zimmerman, Bandura, & Martinez-Pons, 1992). In the same line, self-efficacy seems to influence the quality of tool use (Jiang & Elen, September 2010).

Aside from the variables influencing tool use Perkins (1985) suggested that one of the conditions to use tools was that the learners should recognize the functionality of the tools provided. This implies that the functionality of tools has to be tested. If the functionality is not tested, it can hamper the tool use of learners, and this can have consequences on performance (Goodwin, 1987) and the effectiveness of the tool itself (Brush & Saye, 2001). In the same vein, Iiyoshi, Hannafin and Wang (2005) also emphasize the need to further study the functionality of tools.

Based on this theoretical framework, this paper, therefore, aims to assess the functionality of the tools and to examine perceived functionality and the role that learner-related variables of prior knowledge, metacognition and self-efficacy on tool use and performance. This is intended to be done by exploring psychomotor learning (see: Bloom, 1956) through a psychomotor task and two different kinds of tools. Therefore, it has been firstly hypothesized that perceived functionality influences the way learners use the tools, and learners will use tools based on their perception. Secondly that self-efficacy, prior knowledge and metacognition influence the way learners use tools. Consequently, the following research questions guided the current study: a) Do learners identify the most functional tool? b) Is this selection influenced by perceived functionality or any other learner variables?

METHOD

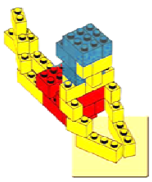
Participants

Fifty-eight first-year master degree students (74% female), on average 23 years old (*SD*=3.51).The students enrolled in the research as part of their course and received credit points for their participation.

Design

A quasi experimental design was used with three experimental conditions and one control condition. Participants had to complete a psychomotor task which involved the making of the LEGO® figure illustrated in Figure 2. They completed the figure in two phases, a practice phase (with tool) and a learning phase (without tool).

Figure 2. LEGO® figure



Participants were assigned to one of four conditions. Conditions differed with respect to the presence of tools. Two tools were used: a guideline and a video. The video was self-made and it was projected on a laptop individually. It showed someone's hands building the figure with the exact bricks in color and shape that were provided to the participant. It was projected at a high pace (two minutes 10 seconds), without pause nor verbal guidance. It was designed under the assumption that it would be less functional than the guideline. The guideline was downloaded from the official LEGO® website and consisted of two sheets. It was in color and showed step by step, piece by piece the assembly of the figure through pictures.

There were 17 participants in each of the three experimental conditions: guideline condition (G), video condition (V) and guideline and video condition

(GV); and seven participants in the control (C) condition in which no tools were provided (see explanation below). The reason why we opted to have so few participants in the control condition was because our main interest was to examine the functionality of tools and perceived tool functionality. The control condition had no tools and little analysis could be done. We only wanted to corroborate the effects of no tools in performance, thus, we reduced the number of participants in order to augment the participants in the conditions of our main concern, the experimental conditions.

Guideline condition (G)

Participants were provided with a guideline that had visual instructions on how to build the figure step by step.

Video condition (V)

Each participant was provided with a laptop in which the video on how to build the figure was projected. Participants were allowed to watch it as many times as they wanted as long as they did not stop it, pause it, rewind it or forward it. They could leave the video in the last frozen image of the figure.

Guideline and video condition (GV)

Each participant was provided with a guideline that had visual instructions on how to build the figure step by step and a laptop in which the video on how to build the figure was projected. Participants could use the video and/or the manual indistinctively and as much as they wanted. It was left entirely to the users' discretion. There was only one restriction; this was in the video. They were allowed to watch it as many times as they wanted as long as they did not stop it, pause it, rewind it or forward it.

Control condition (C)

Participants only received the image of the result they were intended to come up with (Figure 2). Based on that image, they were expected to build the figure.

Instruments

Prior knowledge

To analyze prior knowledge, we only asked learners if they knew LEGO® and if they were familiar with it. If they responded 'yes' we coded it as 1 if the answer was 'no' the score was 0.

Self-efficacy

The questionnaire administered was an adaptation of the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & McKeachie, 1991) and the Self- and Task-Perception Questionnaire (STPQ) (Lodewyk & Winne, 2005). From the two 31-item-sections in the MSLQ questionnaire, only seven questions from the first section (motivation section) were selected and adapted to the task in question. From the STPQ also divided in two sections – self-efficacy for performance and self-efficacy for learning- one item from the self-efficacy for learning section was used and adapted to the task. In total there were eight items in the questionnaire that were applied to measure self-efficacy. This instrument has previously been used in other studies, and it has been shown to have a strong reliability (see: Jiang & Elen, 2009, August). Participants answered each item on a six-point Likert-type scale where one indicated strongly agree and six strongly disagree.

Metacognition

To assess metacognition, the Metacognitive Awareness Inventory (MAI) was used (Schraw & Dennison, 1994). It is comprised of 52-items. Each of these items was part of one of the eight component processes subsumed under knowledge about cognition and regulation of cognition. The knowledge of cognition scale includes declarative knowledge, procedural knowledge and conditional knowledge. The second scale, regulation of cognition includes planning, information management strategies, comprehension monitoring, debugging strategies, and evaluation. The internal consistency of both knowledge and regulation of cognition has been reported as excellent ranging from .93 to .88 (Schraw & Dennison, 1994). Participants answered each item on a six-point Likert-type scale where one indicated totally not applicable and six totally applicable. Some of the items were “I ask myself periodically if I am meeting my goals”, “I change strategies when I fail to understand”.

Field dependence-independence

The Group Embedded Figures Test (GEFT) was used (Oltman, Raskin, & Witkin, 2003). This is because building the LEGO® figure requires visualization of spatial reasoning and re-organization of spatial representations such as embedding and disembedding. This was applied in order to check if there was any difference between learners’ field dependent-independent abilities and performance in building the figure. Reliabilities of the GEFT have been computed before and corrected by the Spearman-Brown prophecy formula producing a reliability estimate of .82 (Witkin, Oltman, Raskin, & Karp, 1971, 2002).This questionnaire includes 25 figures. It is divided in three sections, and it requires students to recognize and identify a simple form hidden in a complex pattern. The score is based on the number of simple forms correctly identified which ranged from 0 to 18, each correctly found figure is awarded a point. Higher scores imply greater field independence.

Functionality: Pre-finished figure and performance evaluation

The functionality was assessed in two phases. The first phase was called 'practice phase'. In this phase, learners built the figure using a tool. The result was called pre-finished figure. If they finished it and completed it as targeted, they were granted a 1 (yes) if they could not complete it they were granted a 0 (no). The second phase was called 'learning phase'. In the learning phase, learners had to built the figure again for the second time, but this time without a tool. The result from the learning phase was considered the performance. Performance was measured by researchers through an evaluation sheet. An evaluation sheet was filled out per figure in all conditions. The evaluation sheet illustrated the figure, each of the bricks of the figure and asked if the brick was placed in the right position. That means, that the figure had to be disassembled brick by brick in order to evaluate it. For each brick placed in the right position, same color and same brick, a point was granted. Since there were a total of 34 bricks, the maximum amount of points a student could get was 34, one point per brick correctly placed. To strengthen the results and minimize errors in the evaluation, two to three pictures per completed figure were taken as well. This was done in case, the researcher(s) forgot where or how the piece was placed before they disassembled it.

Intermediate task

This was a distracter used between the practice and the learning phase. It consisted of a of a nine- by-ten word letter puzzle where participants had to find seven words. The level of difficulty was very low and could be solved in less than three minutes.

Perceived tool functionality: Tool choice and tool sequence observation

For perceived functionality, the (GV) condition was the only condition taken into account. Two different observations were done. The tool choice observation and the tool sequence observation. The tool choice observation consisted of recording the tool learners chose. Thus, there were four options: only guideline, only video, both guideline and video and no tool. The tool sequence observation consisted of observing those learners that picked both guideline and video. Here the way learners used both tools was recorded, i.e. the sequence on how both were used. For example, if learners started with the video and went to the guideline and then back to the video, then it was recorder video, guideline, video. Perceived functionality was assessed through a behavioral aspect since it has been stated that perceptions result from the interaction between instructional conceptions and an actual learning environment and can only be captured during or after instructional experiences (Lowyck et al., 2004).

Procedure

The study was done in two 30-minute sessions. In a first session, with all the participants present, the GEFT, MAI, self-efficacy questionnaires were administered. After this, participants enrolled through a virtual platform for the second research session. In the second session, participants attended in groups of maximum four and were randomly placed in a condition (G, V, GV, C). There were 17 participants assigned to each experimental condition and seven to the control one. At the beginning of the second session, participants were asked to answer the prior knowledge questionnaire based on LEGO® . Once this information was collected, the 'practice phase' took place. Participants were given the LEGO® bricks (N= 34) required to do the figure, and the instructions based on the condition they were assigned to. Herein, they got 10 minutes to build the figure possibly using the support tools (guideline and/or video). If they were in the (V) or (GV) condition, the number of times they watched the video was recorded in the observation. After the ten minutes were over, the resulting figure was collected. If the participants finished the figure perfectly well, i.e., according to the wanted result, it was recorded as yes (1) or no (0) if they were not able to conclude the figure. The resulting figure in this phase was recorded as pre-finished figure. Then, they were given the intermediate task which served as a distracter. Here, they had maximum three minutes. Once they concluded the intermediate task, the learning phase began. They were given the pieces to build the figure again. This time no tool in any condition was provided. In this phase, participants were to assemble the figure with what they had just learned. They were given 15 minutes maximum. The figure they in this phase was stored to verify the number of pieces placed correctly. This was considered the indicator of performance.

Data analysis

First, we tested the reliabilities of the questionnaires –except GEFT since they have extensively been tested- by using the Cronbrach α. In line with Nunnally (1978), an α value of 0.70 was considered as representing good internal consistency. Then, we conducted descriptive statistics and ran four ANOVA's: each with one of the learner-related variables (prior knowledge, self-efficacy and metacognition and field dependence-independence) as dependent variables and conditions as independent variable to see if the groups differed. Second, in order to explore tool functionality, we conducted a factorial analysis of variance (ANOVA) with condition and pre-finished figure in the learning phase as independent variables and performance as a dependent variable. Descriptive statistics were also performed. Third, to address learners' perceived functionality of the tools, an observation was conducted and recorded only in the (GV) condition. This was done during the practice phase in order to see what tool(s) and in what sequence participants chose the tool(s) (tool choice and tool sequence). Then, some descriptive were done, and in order to see if tool choice and tool sequence had an influence on performance, two Kruskal-Wallis non-parametric ANOVA's (due to the amount of participant in the (GV) condition) were run. One with tool choice as independent variable and performance as dependent variable and another with performance as dependent variables and tool sequence as independent variable. Finally, a logistic regression analysis was undertaken with tool choice as dependent variable and learner variables as independent to see if there was any interaction.

RESULTS

Test reliabilities

With respect to the learner variables, prior knowledge was not put into the analysis since the results in the questionnaire showed that all participants knew LEGO® and were familiarized with it. This means the answer was yes with all participants. Reliabilities of the GEFT were not conducted since they have been computed and have reliability estimate of .82 (Witkin, Oltman, Raskin, & Karp, 1971, 2002). Although the internal consistencies of the MAI have been shown reliable, reliabilities were conducted on each of the eight component processes subsumed in the questionnaire under knowledge about cognition and regulation of cognition. From these eight processes only two of them appeared to have good reliability, one subprocess in each category (see Table 1). For knowledge about cognition, it was procedural knowledge and for regulation of cognition, information management strategies. The reliability of the self-efficacy questionnaire was overall good, as well. The descriptive statistics on the results and the reliabilities obtained in the questionnaires exploring the learner variables can be observed in Table 1.

In order to find out if conditions differed significantly with respect to the learner variables, ANOVA's were performed with condition as independent and the learner variables as dependent variables. Results revealed that the conditions did not differ with respect to self-efficacy $F(3,54) = 1.01$, $p= .40$, $\eta^2= .05$, procedural knowledge $F(3,54) = .53$, $p= .67$, $\eta^2= .03$, information management strategies $F(3,54) = .99$, $p= .40$, $\eta^2= .05$ and field dependence-independence $F(3,54) = .77$, $p= .52$, $\eta^2= .04$.

Table 1. Descriptive statistics on learner-related variables

	N	Mean	*SD*	α
Self-efficacy	58	4.18	.78	.89
Field dependence-independence	58	13.91	3.35	.82*
Procedural knowledge	58	3.78	.76	.71
Information management strategies	58	4.58	.57	.71

*Spearman-Brown prophecy

Tool functionality

Concerning the effect of tool use on performance to check tool functionality, the difference between conditions, pre-finished figure and performance is indicated with descriptive statistics on table 2. This table shows the experimental conditions outperformed the control condition. The factorial ANOVA showed that the pre-finished figure was significantly related to performance $F(1,51) = 4.47$ $p < .05$ $\eta^2=.08$. However, the significant effect of condition remained higher $F(3,51) = 5.64$ $p <.005$ $\eta^2=.25$. The Tukey post hoc test revealed that the video condition was significantly with better performance than the other experimental conditions (*ps* <.005). Consequently, it can be concluded that the tools were functional and influenced learners performance in achieving better results.

Learner-related variables

Perceived tool functionality

To analyze learners' perceived functionality of the tool, the (GV) condition was the one taken into account because it was in this specific condition learners were confronted with two tools to be used indistinctively. The Kruskal-Wallis was conducted with performance as dependent variable and the tool choice as independent variable. There were four categories for tool choice: only guideline, only video, both guideline and video or no tool employed. From these four categories, only two were adopted by the participants: both guideline and video and only guideline. This means that participants identified that tools were functional since all participants picked a tool. Descriptive statistics showed that learners that picked only the guideline did slightly better in performance. However, the effects are reported at $p= > .05(.44)$. Performance was not significantly affected by the tool(s) they picked (H (1) = .60). Jonckheere's test corroborated this in the data $J = 28$ $z = -.77$ $r = -.19$.

Table 2. Descriptive statistics pre-finished figure and performance

Pre-finished figure	Condition	Mean*	*SD*	*N*
NO	C	9.29	3.09	7
	G	10.75	2.99	4
	V	16.80	4.75	15
	GV	11.25	6.08	4
	Total	13.50	5.41	30
YES	C	–	–	0
	G	13.15	5.01	13
	V	22.00	1.41	2
	GV	14.77	5.34	13
	Total	14.54	5.39	28
TOTAL	C	9.29	3.09	7
	G	12.59	4.65	17
	V	17.41	4.78	17
	GV	13.94	5.54	17
	Total	14.00	5.38	58

*Dependent variable: Performance

The observation of tool choice showed the following results. Fifty-three percent of the learners picked both guideline and video and 47% only picked the guideline. In the case where participants opted to pick both guideline and video (53%), the tool sequence observational data indicated that 67% of them started using the guideline, then switched to the video and continued using the video till the time was over, 11% of them chose the video first and ended with the guideline, 11% used the video first, then the guideline and then went back to the video, and the rest (11%) used the guideline first, then the video and finished with the guideline. Data also indicated that from all the participants in the (GV) condition, 88% of them chose to use the guideline in the first place, but only 59% of them concluded the task with the guideline. None of the participants selected just the video. Another Kruskal-Wallis test was run within the participants that chose both guideline and video to see if this tool choice behavior had any impact on performance. The results from the Kruskal-Wallis pointed to no significant difference between tool sequence and performance

H(3)=3.96 *p* = .27. This non-significant trend was again confirmed by the Jonckheere's test *J* = 28 *z* = -.77 *r* = -.19.

Self-efficacy, field dependence-independence and metacognition

Finally, the regression analysis shown in table 3 revealed that neither self-efficacy *b* = -.03, Wald χ^2 (1) = .001 , *p* = .97, field dependence-independence *b* = -.03, Wald χ^2 (1) =.23 , *p* = .63 procedural knowledge *b* = -.17, Wald χ^2 (1) = .02 , *p* = .90 nor information management strategies *b* = -.42, Wald χ^2 (1) = .08 , *p* = .77 significantly predicted the tool choice of learners.

Table 3. Logistic regression analysis

	B (SE)	Lowe r	*Odds ratio*	Upper
Intercept	1.00 (5.29)			
Self-efficacy	.10 (.21)	.73	1.11	1.69
Field dependence-independence	-.03 (1.01)	.13	.97	6.95
Procedural knowledge	-.17 (1.32)	.06	.84	11.08
Information management strategies	-.42 (1.46)	.06	.66	11.53

*Reference category: both guideline and video. R^2 = .03 (Cox & Snell) .04 (Nagelkerke). Model X^2 (4) =,52 p= .97

DISCUSSION

This contribution attempted to broaden the tool research by assessing the tool's functionality and the effect of metacognition, self-efficacy and specially of perceived functionality on tool use using a 'new' type of task. Concerning, learners' variables, they seemed to have no relevant effect between conditions. While there is a clear ground for assuming that these are important variables in tool use –except for the field dependence-independence, which was included only due to the task- , this might have been due to methodological reasons such as:

The sample: By looking at the means and the standard deviations in the results of the questionnaires, it can be concluded that the group was pretty homogeneous. The distinction between students with high metacognition or low or high self-efficacy may be called very arbitrary. Different results may be found in a larger and more heterogeneous populations.

The instruments: The metacognition instrument showed very low reliabilities in most of its processes. The self-efficacy questionnaire showed good reliabilities, but the result may have been affected again by the amount of participants in the study. Perhaps, the few participants in each conditions did not allow us to see interactions.

The duration of the task: The task was perhaps too short to be able to obtain more results into perceived functionality. This calls for a need of a task that can provide more data regarding the way learners perceive tools

The analysis revealed that the tool design influenced participants' way of perceiving, selecting and using the tool. All the experimental conditions outperformed the control condition in pre-finished figure and performance. This suggests that tools were indeed functional. Had it not generated positive results, the tool functionality would have been questioned (Elen & Clarebout, 2006). In the (G) and (GV) conditions, most learners completed the figure in the practice phase (13 out of 17 in each) whereas in the (V) condition only 2 out of 17 could complete it. Nevertheless and contrary to our expectations, the video seemed to be the most functional tool in the learning phase. A reason why the (V) condition was the most functional tool might also go in line with research on the mirror neuron system. Evidence indicates that dynamic visualizations may be most efficient for tasks that involve human movement. This is because such visualizations automatically activate a process without effort of concrete simulation by the mirror neuron system which prepares the execution of similar actions (van Gog, Paas, Marcus, Ayres, & Sweller, 2009). This may explain to some extent why the dynamic visualization such as that of the video was more effective than the static visualization, in this case the guideline. When participants were placed in the (GV) condition, we could conclude through observation that they all identified that tools were functional since they all picked a tool. They, however, could not benefit from the most functional tool which was the video. When they watched it, they did it less than in the (V) condition. It seems that having two tools to choose from "disoriented" the learner (Iiyoshi & Hannafin, 1998). This also is in line with the findings by Zydney (2008, 2010) who indicated that combined tools were not found as effective as the individual tools. In addition, learners may have avoided the video in order to avoid cognitive complications (Aleven et al., 2003) and selected what was for them the tool that according to their beliefs was going to enhance their performance to reach their goal (perceived functionality). Finally, the construct of "perceived ease of use" of the TAM, which was not considered in this study might have also been a factor that affected the perceived functionality. It has been proved that perceived ease of use influences perceived usefulness (Davis, 1989), hence in this study, it was probably an influential factor for perceived functionality. Although it was not analyzed for the present study, it could be incorporated in future studies.

In the (GV) condition, lack of familiarity and knowledge about the video tool could have been another significant obstacle to an optimal tool use, thus performance. All learners knew about LEGO® and had used it before. The tool the LEGO® company provides, is mostly –if not always- a guideline. Thus, the video was not a tool learners were familiar with. Therefore, just like in previous studies (Bullen, Morgan, Belfer, & Qayyum, 2008; Leventhal, Teasley, Instone, Rohlman, & Farhat, 1993) learners used tools that most closely would mimic the tools they are more familiar with. Tool familiarity may have also influenced participants in the (G) condition. Most learners did find the guideline familiar and used it accordingly. In the same vein, Iiyoshi & Hannafin, (1998) identified that familiarity of the tools frequently affected the tool selection and use of appropriate tools for specific cognitive processes. However, as time progressed learners used the tools more frequently and the tool use with those “unfamiliar” tools became more accurate. This finding provides an explanation on why the (V) condition outperformed all the other conditions. Participants watched the video more times than the 53% of participants that used the guideline and the video in the (GV) condition, thus their use became the most accurate.

Shapiro (2008) states that even when learners get the chance to explore and have control over their learning, this ‘flexibility’ may also overwhelm them if they do not possess enough domain knowledge or at not skilled enough. This flexibility may have affected not only participants in the (GV) when they had to choose a tools, but also participants in the (G) condition. Informal observation indicated that learners did not use the guideline step-by-step and this, in multiple occasions, brought them confusion in building the figure. On the other hand, it could be observed that the lack of flexibility in the (V) condition caused discomfort while learners used the tool. These findings are in line with recent research (Clarebout et al., 2010). When learners had to use the tools provided, they used them more but superficially, and when they were given the option to use the tools, the quality of use increased. Clarebout et al. (2010) suggested in their conclusions that, from a motivational perspective, learners should be provided with tools that can provided them with the perception of control over their learning process in order to increase tool use). Another explanation to this finding sold be that learners were probably cognitively ill-equipped to use tools appropriately (Iiyoshi & Hannafin, 1998; Iiyoshi et al., 2005) or their mental models about tools– a representation of one’s personal understanding of a system or concept (Oliver & Hannafin, 2001) -affected their perceptions

(Winne, 1985). Back to our results, in the (GV) condition, for example, we saw that the majority (88%) of the participants opted to use the guideline as the first tool, then their perception in the functionality of the tool lead them to drop the use of the guideline tool and continue with the video. Only about half of them continued and finished with the guideline. The other half of the participants could in the end detect that the video tool was the most functional one. In the (V) condition, participants watched the video repeatedly, but we observed that they complained about the way the tool was designed and meant to be used. Nonetheless, they were the ones that performed better. This indicates that the learners in the (V) condition could not see the real benefits of their tool. In the (G) condition, learners were comfortable with the tool since they already knew it was a functional tool (perception already influenced by previous knowledge and tool familiarity). However, the results were not as good as expected, perhaps learners felt too 'comfortable' with the presence of this tool, i.e., they knew how it worked and how to use it and this experience probably influenced learners into suboptimally use of the guideline tool by not following the guideline step by step.

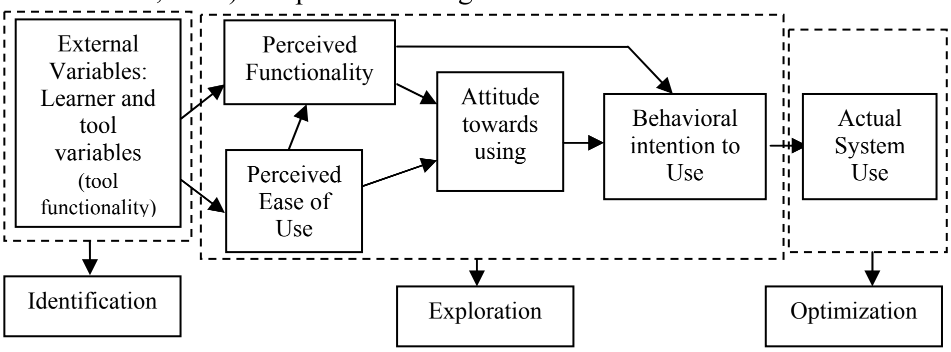
CONCLUSION

As a conclusion, these data offer information to establish a line of future research. First, on the role tool-related variables such as tool presentation and tool type have on tool use, and second on the role learner-related variables play on tool use, especially that of perceptions, and most importantly perceived tool functionality.

The TAM certainly contributes significantly on the role of perceptions, it, however, does not entirely focus on tool use. In this respect Iiyoshi and Hannafin made a contribution in 1998. They suggested that three different phases take place on tool use and that perceptions on tools might affect learners usage. They investigated the patterns and effects of the use of cognitive tools in an open-ended hypermedia environment for learning anatomy and physiology. Seven students were given different learning tasks in five sessions. These tasks increased in difficulty as the sessions progressed. The open learning environment was The Human Body, a multimedia CD-rom interactive system with 16 different tools such as information seeking tools, knowledge organization tools and knowledge generation. The results indicated that 81 % of the tools was used as intended (13 out of the 16) and that learners' perceptions of tools were mostly positive. This perception on tools could have been a factor that influenced the tool use. The conclusions suggested three common phases of tool use. These are 1) identification 2) exploration and 3) optimization. In the identification stage, learners discovered how each tool could help them to accomplish their goals and became aware of what tools did what. In the exploration stage, learners started recognizing which tools work better for their needs and goals. They combined tool use and tended to use tools more than in any other stage. In the final stage of optimization, learners attempted to use tools more optimally as they diminished the tool use.

By connecting the TAM (Davis et al., 1989), the findings from Iiyoshi and Hannafin (1998), and the results of the present study , we can provide in figure 3 a model that explains tool use. This figure illustrates that it is possible that in the identification stage learners identify the tools and how they function. This may be influenced by learner- or tool-related variables. In the exploration stage, perceived functionality and perceived ease of use, attitude towards using and intention to use the tools interact along. Finally in the optimization stage, we can say that once learners see the tool functionality and work on their perceptions by repeatedly testing the tool, they diminish tool use and then optimize it. While figure 3 attempts to explain tool use and to give an outline with respect to perceptions, especially perceived tool functionality, it also suggests the line for future research on tool use.

Figure 3. Research outline: TAM (Davis et al.,1989) tool use phases (Iiyoshi and Hannafin, 1998) and present findings.



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Special notes

Due to the task employed in the present study, a considerable of LEGO bricks were purchased and only some of them were used. The unused didactic material was donated to local elementary schools in the North bound of the Salonga National Park in the Democratic Republic of Congo.

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