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Tool-use in a blended undergraduate course: In Search of user profiles

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ABSTRACT

The popularity of today's blended courses in higher education is driven by the assumption that students are provided with a rich toolset that supports them in their learning process. However, little is known on how students actually use these tools and how this affects their performance for the course. The current study investigates how students use the entire toolset at their disposal, whether tool-use patterns can be found and if these patterns affect performance for the course. Logging students ($n = 156$) actions throughout the content management system and registering students' use of the face-to-face support in an undergraduate course, the study reveals large student differences and an underuse for some tool-types. Further to this, K-means cluster analysis reveals three distinct tool-use patterns or user profiles: the no-users, the intensive users and the incoherent users. These patterns are characterized by different tool-choices and even different use intensity among students. Evidence is retrieved that these tool-use differences are problematic since multivariate analysis of variance reveals significant performance effects. Hence, these results imply that not all students seem to profit from the learning affordances that are provided. Similar as evidence in controlled settings, the results suggest that learner control in using tools cannot be taken for granted. Consequently, this study legitimates more research into the influencing (student and context) variables that can explain these differences.

1. Introduction

Today's higher educational area is characterized by an increased integration of Content Management Systems (CMSs) such as Blackboard, Moodle and WebCT (Dabbagh & Kitsantas, 2005) and this often into a traditional face-to-face constellation. The popularity of these blended learning environments is driven by the assumption that students are provided with a rich toolset that supports them in their learning process (Rivera, Mc Alister, & Rice, 2002). In most cases, these tools are non-embedded, which implies that using a specific tool is the learner's decision. Despite the widespread assumption that this unsupervised use of CMS tools provides adaptive support (Nutta, 2001) and stimulates a deeper and self-directed learning (Malikowski, Thompson, & Theis, 2007), it is not clear whether all students are good judges of their own learning and of the tool functionalities.

Evidence in similar learning environments with total student control reveals that not every student profits from the affordances of the learning environment (e.g. Beal, Qu & Lee, 2008; Clarebout & Elen., 2009; Lumpe & Butler, 2002). Hence, this evidence suggests that learner control in using tools might not always be beneficial. Although this evidence is mainly obtained in controlled settings characterized by non-embedded learning tasks and short time learning effects (Grabinger, 2008), it raises questions on how students use tools in ecological settings such as an undergraduate blended course. The current study addresses this concern.

1.1. Students' tool-use in a blended undergraduate course

Despite the popularity of blended courses, little seems to be known on how students deal with this blended experience i.e., how they profit from the combination of face-to-face and online instruction because most of the instructional technology based research is focused on

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the online part (Buzetto-More & Sweat-Guy, 2006). A qualitative study of Ellis, Marcus, and Taylor (2005) stresses the need for more research into the blended experience. In their study, they revealed that alignment between the online and the face-to-face tools is problematic i.e., a lot of participants were unsure of how to approach the online tools in ways that are likely to maximize the learning benefits in blended experiences. This interpretation is in line with the findings of Yen and Lee (2011) focusing on students' study behavior in a blended problem solving task. Taking into account the frequency of using digital and classroom support, they revealed three types of learning behavior; 1) the hybrid-oriented group, 2) the technology-oriented group, and 3) the efficiency-oriented group. Students in the hybrid-oriented group used all the available support but in a passive way, they did not reflect on the functionality of each 'tool'. In addition, students in the technology-oriented group were focused on the digital support but merely because of the novelty of these tools. Finally, the efficiency-oriented group used all the available support as supposed to; they used the classroom moments to reflect on the retrieved knowledge and the digital support to expand their current knowledge. Hence, these two studies indicate that although a blended learning environment provides a rich toolset, not all students are capable of using these tools in relation to each other. Although these studies are not focused on an undergraduate course, they stress the need for expanding technology based research with the face-to-face part. The current study addresses this need by investigating students' tool-use in a blended course, capturing the online and the face-to-face tools.

1.2. Students' tool-use in a content management system

As for CMS tools, theoretically they provide different kinds of support (Dabbagh & Bannan-Ritland, 2005) and stimulate a deeper and self-directed learning (Dabbagh & Bannan-Ritland, 2005; Malikowski, Thompson & Theis, 2007; Nutta, 2001). Nevertheless, these assumptions regularly get falsified. With respect to using *communication tools* such as a discussion board, multiple studies reveal student differences in the amount of items post and items read (Hammoud, Love, Baldwin, & Chen, 2008; Hoskins & Van Hooff, 2005; Huon, Spehar, Adam, & Rifkin, 2007; Woods & Kemper, 2009). Results are conclusive that only active use i.e., posting messages, is beneficial for students' learning in contrast to passive use i.e., reading messages (Hammoud et al., 2008; Hoskins & Van Hooff, 2005). Similar results are retrieved with respect to using *knowledge modeling tools* such as practice quizzes (Hoskins & Van Hooff, 2005; Huon et al., 2007; Macfayden & Dawson, 2010). It appears that although a majority of students used this kind of tools, only a minority spend effort in completing them. Only the latter was beneficial for learning (Macfayden & Dawson, 2010). In a twofold study by Grabe and Christopherson (2005; 2008) student differences were found in the moment students used *information tools* that gave the basic course content (e.g., outline notes, web lectures). Without taking the moment of use into consideration, both studies found a positive relationship between students' use of notes and their performance.

Hence, the above studies stress that even in ecological learning environments it cannot be assumed that students take the opportunities offered to them (Perkins, 1985). Furthermore, the distinct performance effects imply that not all students are likely to profit from the opportunities that are provided in CMSs. Despite these important insights, contemporary research on CMS use is mainly focused on students' use of a specific tool. It is still unclear how students use the tools simultaneously. Since a broad toolset is at students' disposal in an undergraduate course and since students are active agents, it is possible that students will make choices in using different tools and will differ in their use dependent on a specific tool.

1.3. Research questions

In addition to existing evidence on students' use of CMS tools, the current contribution investigates how students use the blended toolset at their disposal. Further to this, the study looks not only for tool-use differences but investigates whether these differences reflect distinct tool-use patterns or profiles. Specifically, the study addresses the following research questions:

- Do tool-use differences among students reflect distinct tool-use patterns or user profiles?

It can be expected that students will differ in their *diversity* of tool-use (Liu & Bera, 2005; Liu, Bera, Corliss, Svincki, & Beth. 2004) i.e., the choices that they make. Based on the literature we expect at least three groups of users, a) the *no-users* as the ones that do not use the available tools, b) the *incoherent users* as the ones who use the face-to-face tools and only those CMS tools with a clear link to the face-to-face context e.g., course material outlines (Ellis et al., 2005), and c) the *intensive users* as these students that use all the available tools. Additionally, it can be expected that differences in students' *activeness* of tool-use can be found as well (Bera & Liu, 2006; Liu & Bera, 2005; Liu et al., 2004). In line with previous evidence on using CMS tools, it can be expected that differences will exists among intensive users in the frequency and the intensity of their tool-use.

- What are the learning effects of students' tool-use patterns?

2. Methods and materials

2.1. Participants

Participants were 156 of the 175 first year Educational Sciences undergraduates (90%) at the Katholieke Universiteit Leuven. There were 151 woman and 6 men. Most of the students were 18 years (73.2%). The distributions in gender and age represent the demographics of the whole cohort of 175 and are typical for Flemish Educational Sciences courses.

2.2. The blended course unit

At the university of Leuven (KUL), 'Learning and Instruction' is a first year bachelor course at the department of Educational Sciences.

Additional to the lectures, a CMS was provided and a team of support staff was at students' disposal. The support staff organized three learning support sessions that students could attend voluntarily. The first session supported students in making an exercise as preparation

for the exam assignment (cf. infra). The second and the third session elaborated on difficult parts of the course materials. Next to these, a feedback session was organized during which students got feedback on their exercise.

The CMS was designed using Blackboard (version 9), which is a widely used software program that provides a variety of educational tools to facilitate learning and communication. The access and the use of the learning environment were under control of the student. A variety of learning support was available on the course; (1) administrative information about the course (e.g., course info, the announcements, and the planning); (2) basic information about the course content (e.g., the course material, the web lectures and the assignments); (3) elaborated information about the course content (e.g., external links) (4) knowledge modeling via two self-assessment quizzes i.e., practice quiz (5) an opportunity for collaboration and communication with peers, instructor and course content i.e., discussion board and finally (6) some conceptual scaffolds (e.g., study tips, feedback on practice quizzes).

2.3. Measurement instruments

2.3.1. Tool-use

Information on use of the digital (CMS) tools was collected through logging students' actions in the Blackboard course, from the first college week until the exam. Next to overall CMS use, students' use of the CMS tools was registered as presented in Table 1.

Use of the face-to-face tools (the three learning support sessions and the feedback session) was registered by the support staff who tracked students' participation.

2.3.2. Performance

Students' performance on the course was assessed by an exam and an assignment. The exam consisted out of three parts that measured different aspects of students' learning. The first part contained items wherein students had to reproduce their knowledge of the course content, hence these items were labeled 'factual items'. The second part consisted out of items that forced students to relate different aspects of the course content to each other. Since these items assume that the student understand the content, these were labeled 'comprehension items'. The items in the last part of the exam required the student to interpret specific situations in terms of the course content. Hence, these items were labeled 'application items'. The assignment consisted out of the following proposition: 'Good education implies the use of active didactical methods' about which students had to argue. For this assignment, students had to apply their content knowledge into critical arguments regarding their agreement or disagreement with the proposition.

Consequently, students' performance was measured by five indicators representing students' overall grade for the course, students' performance on the factual items, the comprehension items, the application items and the assignment.

2.4. Transformation tool-use variables

In order to define tool-use patterns or user profiles among students, a cluster analysis with all the tool-use variables, cf. Table 1, was performed. However, box-plots, as represented in Fig. 1 and Fig. 2, reveal many cases that are outside the box, indicating that they are extremities. These extreme values cannot be deleted since they suggest the student differences this study attempts to reveal. Nevertheless, a data distribution like this will bias the cluster analysis (Hair, Black, Babin, & Anderson, 2010).

Therefore the CMS variables- with exception of the discussion board and the outline notes-were transformed based on their distribution. The 33.33% lowest, intermediate, and highest scores received a score of 1, 2, and 3, respectively, indicative of low, moderate and high use. For the discussion board, the two variables 'items read' and 'items posted' were merged into a new variable 'discussion board use'. Similar to

Table 1
Variables measuring students' tool-use.

Digital (CMS) tools	Face-to-face tools
Overall CMS use	Use of learning support session 1
#Homepage hits	Participation on first session
Use of discussion board	Use of learning support session 2
#Messages read	Participation on second session
#Messages posted	
Use of knowledge modeling tool_ Quiz 1	Use of learning support session 3
#Quiz attempts	Participation on third session
Mean time[a] on quiz 1	
Use of knowledge modeling tool_ Quiz2	Use of feedback session
#Quiz attempts	Participation on feedback session
Use of information tool: web links	
#Web links viewed	
Use of scaffold tool	
#Downloads of learning support	
Use of information tool: outlines	
First view course material X[b]	
Date of view	
Use of information tool: web lectures	
#Views web lectures	
Mean time[a] on web lectures	

[a] Duration and mean time were expressed in seconds.
[b] The study was focused on the first access because after the first access some participants continue using the outlines online while others print or store the outlines on their computer. Hence the study can only consistently account for the first access.

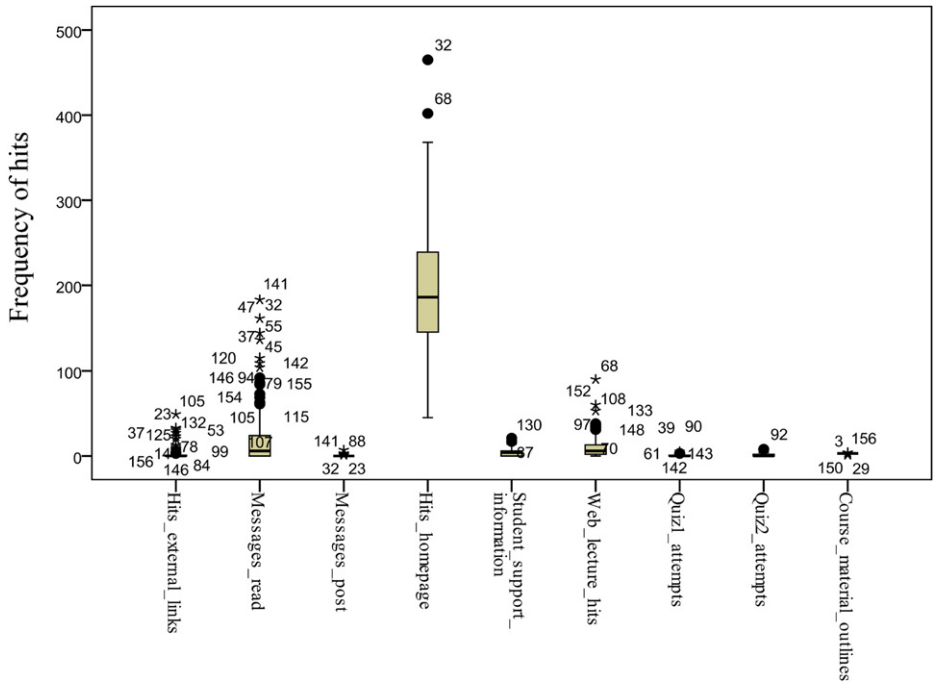

Fig. 1. Box-plots tool-use variables, frequency of hits.

previous research (Hoskins & Van Hooff, 2005) this variable contains (1) the non users, (2) the passive users (as those who only read messages) and (3) the active users (as those that read and posted messages).

In accordance with previous research of Grabe and Christopherson (2005; 2008) students' use of the course material outlines was captured by logging the first access of a specific outline, and the date the outline was accessed in relation to the moment the outline was presented in class. Based on these variables, the researchers created a new variable 'course material outline use'. The variable included; (1) *no-use*; (2) *cram* –the proportion of outline notes first accessed within the study period (3) *after* – the proportion of outline notes first

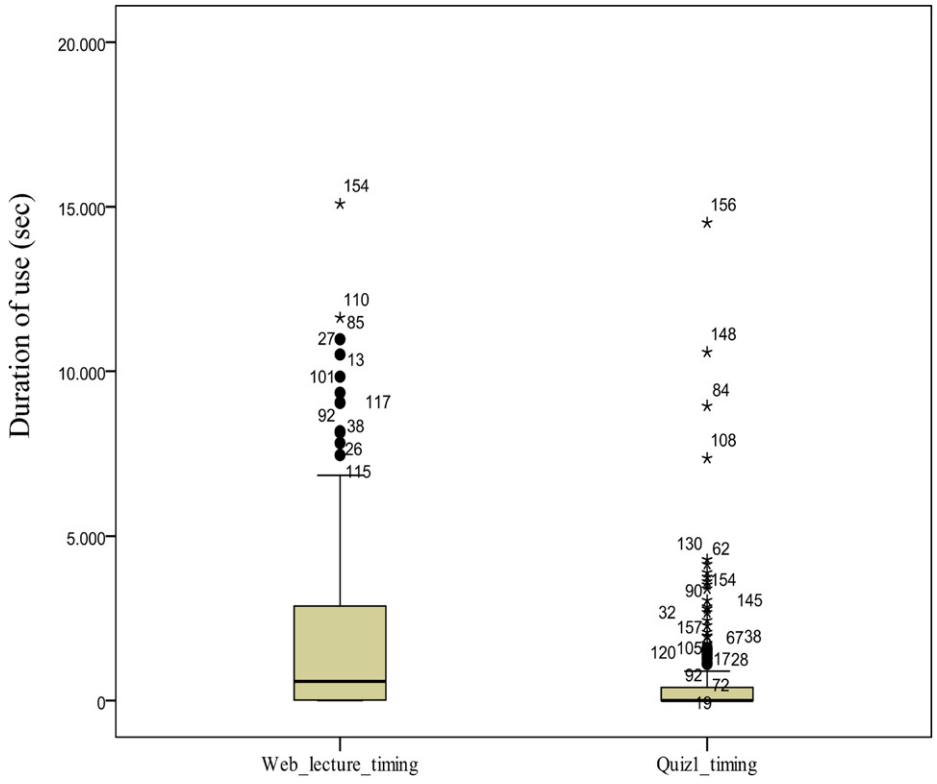

Fig. 2. Box-plots tool-use variables, duration of use.

accessed after they were used in class and before the study period (4) *before* - the proportion of outline notes first accessed before the date when the outlines notes were used in class.

3. Results

3.1. Students' tool-use: different tools

Descriptive statistics of the (transformed) variables are represented in Table 2, Table 3, Table 4, and Table 5. With respect to students' use of the face-to-face tools, Table 2 reveals that many students used the face-to-face support: learning support I, II, III, and the feedback session. Table 3 reveals that most students accessed the CMS system on a low or moderate basis. Furthermore, Table 3 reveals that students' use of the scaffold tools varied a lot in contrast to students' use of the face-to-face scaffolds (cf. Table 2). As for the specific information tools, results in Table 4 reveal that most of the students did not access the web lectures to a high extent, nevertheless the intensity of watching them (the timing) varied from low to high. Most of the students downloaded the course material outlines for the first time after the specific lecture and most of the students did not use the web links. Finally, Table 5 illustrates that most of the students were passive participants on the discussion board and did not use the two practice quizzes.

3.2. In search of tool-use patterns as indicators of students' tool-use behavior

In order to deduce individual differences in students' tool-use pattern, a K-means cluster analysis was performed in Matlab on the standardized (transformed) tool-use variables. K-means cluster solutions with two to ten clusters were fitted using 1000 restarts (for a discussion of the use of K-means cluster analysis, see Steinley, 2003). Fig. 3 shows a scree plot, in which the number of clusters is plotted against the sum of squared residuals. This measure decreases monotonically as the number of clusters increases, but from three clusters onwards, the decrease flattens markedly. The location of such an 'elbow' indicates the appropriate number of clusters (Tibshirani, Walther, & Hastie, 2001).

In order to investigate if students from different clusters used the tools differently, a multivariate analysis of variance with all the clustered variables as dependent and cluster membership as independent variables was carried out. The assumption of homogeneous covariance as tested with the Box-text was not accepted, $F(182, 39474) = 370.58$, $p = .00$. The assumption of homogeneous variances was tested with the Levene's test, only the learning support_III session, $F(2, 154) = .07$, $p = .93$, and the slides, $F(2, 154) = 3.06$, $p = .05$, meet this assumption, for the other variables the Tamhane's correction in the post-hoc tests will be used. Results of the multiple analysis of variance reveal that students from the three different clusters used all the tools differently, *Wilk's Lambda* $F\,(26, 284) = 28.84$, $p = .00$. The three cluster profiles are shown in Fig. 4.

Post-hoc results reveal that for learning support I, II, III and the feedback session, students in Cluster one differ significantly from students in Cluster two and Cluster three ($p = .000$). As Fig. 4 illustrates, students in Cluster one did not use the face-to-face tools. As for overall CMS use, post-hoc comparisons reveal that all the clusters differ significantly ($p = .000$). As Fig. 4 illustrates, students in Cluster two, $M = 79$, $SD = .71$, used the CMS more frequently than students in Cluster three, $M = -.29$, $SD = .78$, and Cluster one, $M = -1.03$, $SD = .39$.

With respect to using the specific CMS tools, post-hoc results are more complex. Students in Cluster one used the online scaffold tools, $Mls = -.72$, $SD = .64$, and the course material outlines, $Mco = -.68$, $SD = 1.07$, significantly lesser than students in Cluster two and three. Students in Cluster three used the online scaffold tools, $Mls = .28$, $SD = .98$, and the course material outlines, $Mco = .25$, $SD = .91$, more frequently than students in Cluster two, $Mls = .15$, $SD = 1.00$, $Mco = .17$, $SD = .88$. This distinction is illustrated in Fig. 4. As for the web lectures, students in Cluster two used them more frequently and intensively than students in Cluster one and three ($p = .000$). With respect to the web links, the discussion board, quiz_1 and quiz_2, post-hoc results reveal that students in Cluster two used them more frequently than students in Cluster one and three ($p = .000$). Students in Cluster three used these tools more than students in Cluster one.

Consequently, these three clusters represent different tool-use behavior among students characterized by different tool-choices and distinct intensity in using them as illustrated in Fig. 4.

Cluster one ($n = 36$) groups those students who did not use the available face-to-face tools and accessed the CMS with a low frequency. They used some CMS tools like the course material outlines, although they accessed them for the first time in the exam period and they used the web lectures with a low or medium frequency and for a short time. Hence, cluster one represents the no-users.

Table 2
Descriptives, students' use of the face-to-face scaffold tools.

Tool	Distribution	Standard deviation
Learning support_I		$SD = .44$
1 (Not used)	(1) $n = 41$	
2 (Used)	(2) $n = 117$	
Learning support_II		$SD = .49$
1 (Not used)	(1) $n = 60$	
2 (Used)	(2) $n = 98$	
Learning support_III		$SD = .49$
1 (Not used)	(1) $n = 59$	
2 (Used)	(2) $n = 99$	
Feedback		$SD = .47$
1 (Not used)	(1) $n = 52$	
2 (Used)	(2) $n = 106$	

Table 3
Descriptives, students' overall CMS use and use of online scaffold tool.

Tool	Distribution	Standard deviation
Overall Use		$SD = .81$
1 (Low use)	(1) $n = 56$	
2 (Medium use)	(2) $n = 54$	
3 (High use)	(3) $n = 48$	
Scaffold tool		$SD = .86$
1 (Low use)	(1) $n = 70$	
2 (Medium use)	(2) $n = 38$	
3 (High use)	(3) $n = 50$	

Cluster two ($n = 67$) represents the students who used the available face-to-face tools and accessed the CMS with a high frequency. They used the web links, the web lectures, the second quiz more frequently and used the discussion board and the first quiz more intensively than students in cluster one and cluster three. Consequently, cluster two represents the intensive users.

Finally, *cluster three* ($n = 53$) are students who used the available face-to-face tools and accessed the CMS with a medium frequency. In comparison with students in cluster two, they were selective in using CMS tools, but, on average, they used the scaffold tools and the course material outlines more. Since these two online tools relate to the face-to-face context, this cluster reflects the incoherent users.

3.3. Effects on performance

In order to find performance effects of students' tool-use pattern, a multivariate analysis of variance was performed with the five, standardized, performance indicators as dependent and students' tool-use pattern as independent variables. The assumption of equal covariance matrices as measured with Box's test, $F(30, 46343) = 1.106$, $p = .315$, and the assumptions of homogeneous variances, $p \geq .09$, were met. Results reveal a main effect of students' tool-use behavior on the five, standardized, performance indicators, *Wilks' Lamda* $= .85$, $F(10,300) = 2.58$, $p = .01$, $\eta^2 = .08$. More specific, students' tool-use pattern influenced the total course grade, $F(2,154) = 5.06$, $p = .007$, $\eta^2 = .062$, and the assignment score, $F(2, 154) = 7.767$, $p = .001$, $\eta^2 = .092$. As for the assignment score, the incoherent users, $M = .09$, $SD = .96$, and the intensive users, $M = .31$, $SD = .78$, outperformed the no-users, $M = -.41$, $SD = .94$. For the total course grade, a significant difference was found between no-users and intensive users. The intensive users, $M = .29$, $SD = .89$ outperformed the no-users, $M = -.25$, $SD = .81$.

Although the other differences are not significant, the mean differences among the three clusters are interesting. As illustrated in Table 6, the no-users performed worse on all the performance indicators, except on the application items in comparison with the incoherent users. The intensive users performed best on all the performance indicators in comparison with the incoherent and the no-users.

4. Discussion

4.1. Tool-use, patterns and effects

The current study explored students' tool-use in an ecological setting by focusing on an undergraduate course containing face-to-face and CMS tools. This blended learning environment is so-called beneficial (Rivera, Mc Alister, & Rice, 2002) because the different tools it provides stimulate an active, deeper, and self-regulated learning (Nutta, 2001).

Results of this contribution are in line with previous research on students' use of CMS tools, namely that it indeed cannot be taken for granted. On average, students used the face-to-face tools more frequently than the CMS tools. As for CMS tools like the discussion board, the practice quizzes, the scaffold tool and the web links, results revealed large individual differences. Similar as in previous research of Hammoud et al. (2008), Hoskins and Van Hooff (2005), and Huon et al. (2007), students did not use the discussion board to a high extent. The students who did, read more messages than that they posted new ones. In line with results from the Huon et al. (2007) and Macfayden

Table 4
Descriptives, students' use of information tools.

Tool	Distribution	Standard deviation
Web links		$SD = .73$
1 (Low use)	(1) $n = 115$	
2 (Medium use)	(2) $n = 20$	
3 (High use)	(3) $n = 23$	
Course material outlines		$SD = .65$
1 (No use)	(1) $n = 2$	
2 (Cram)	(2) $n = 33$	
3 (Between)	(3) $n = 98$	
4 (Before)	(4) $n = 25$	
Web lectures_hits		$SD = .85$
1 (Low use)	(1) $n = 59$	
2 (Medium use)	(2) $n = 45$	
3 (High use)	(3) $n = 54$	
Web lectures_timing		$SD = .82$
1 (Short use)	(1) $n = 53$	
2 (Medium use)	(2) $n = 52$	
3 (Long use)	(3) $n = 53$	

Table 5
Descriptives, students' use of cognitive (communication and knowledge modeling) tools.

Tool	Distribution	Standard deviation
Discussion board		*SD* = .60
1 (no use)	(1) *n* = 64	
2 (passive use)	(2) *n* = 85	
3 (active use)	(3) *n* = 48	
Quiz_1		*SD* = 1.08
1 (No use)	(1) *n* = 88	
2 (Attempt)	(2) *n* = 29	
3 (Short Use)	(3) *n* = 21	
4 (Long Use)	(4) *n* = 20	
Quiz_2		*SD* = .50
1 (no use)	(1) *n* = 91	
2 (use)	(2) *n* = 67	

and Dawson (2010) studies, the two practice quizzes were not used often by the students. When students used the first quiz, only a minority finished it. This seems to indicate that despite the so-called advantages of a discussion board in stimulating active and critical thinking (Costen, 2009) and a practice quiz in supporting self-directed learning (Nutta, 2001), few students seem to acknowledge these advantages by using them. With respect to the course material outline notes or the slides, most of the students used them after the specific lecture. This is contradictory to previous research of Grabe and Christopherson (2005; 2008) and Babb and Ross (2009) where most students accessed the outline notes before the specific lecture. This suggests that in contrast to these studies, students did not use the outline notes to orient themselves toward the lecture but more for review purposes. Furthermore, these results stress the issue of learner control in a learning environment (Azevedo, 2005). An argument that underlies the idea of learner control is the adaptiveness of the learning environment to the learners' needs. However, this presupposes that learners are capable of making adequate decisions with respect to their learning process and the opportunities or tools that are available (Perkins, 1985). The fact that many CMS tools were underused by most students is in line with evidence from controlled settings (e.g., Beal, Qu, & Lee, 2008 Bera & Liu, 2006; Clarebout & Elen., 2009; Jiang, Elen, & Clarebout, 2009) and highlights that not every student seems to master the metacognitive skills required to control their learning (Clark, 1990; Hill & Hannafin, 2001; Land, 2000).

In addition to students' use of the different tools, the current study investigated if students' tool-use differences reflected distinct tool-use patterns. In line with our expectations, three usage patterns were found. Students in Cluster one represent the no-users since they did not use the available face-to-face tools and CMS tools. Students in Cluster two are the intensive users since they used all the available tools. Students in Cluster three can be considered incoherent users, as they only used the face-to-face tools, the course material outlines, and the online scaffold tools extensively. The two latter CMS tools have a clear link with the face-to-face context. The outline notes refer to the face-to-face lectures, as they give an overview of the lecture content.The online scaffold tools refer to the learning support sessions, as they give an outline of the learning support sessions.

Despite these satisfying results it can be questioned whether the 'intensive' users are all 'intensive' users. Taking a closer look at the descriptives, the cluster reflects a broader profile of students' tool-use. Not only does the cluster contain students who finished the first quiz, it also contains students who attempted to do so. The cluster includes students who actively participated on the discussion board, as well as students who were passive. These results suggest that this cluster consists of users with different levels of activeness in their tool-use. This was found as well in controlled settings in the Liu et al., (2004); Liu & Bera, 2005 and Jiang et al. (2009) studies. Nevertheless, the K-means clustering revealed an elbow at three clusters indicating that this is the optimal solution. A possible explanation for this lack of further distinction in the 'intensive users' is the fact that these activeness-differences are too subtle and the number of students with a high level of activeness is too small.

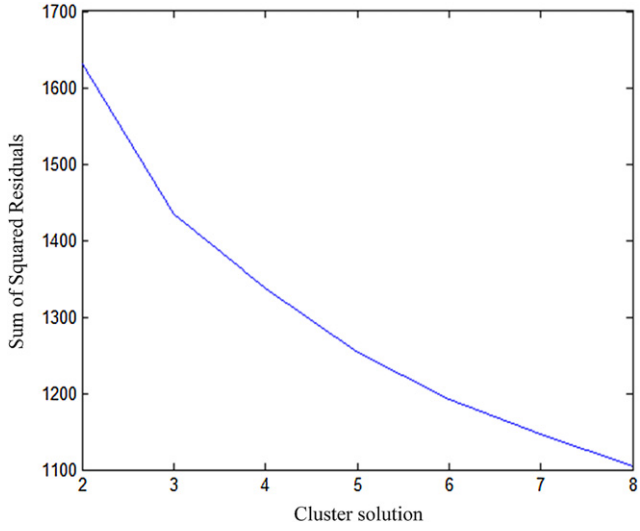

Fig. 3. Scree plot K-means clustering.

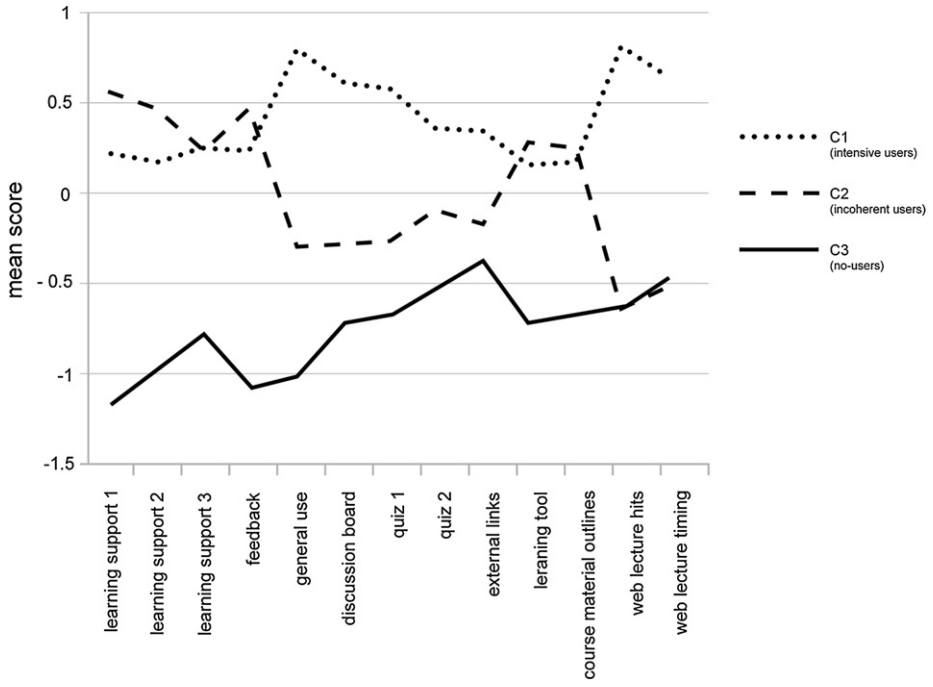

Fig. 4. The three obtained cluster profiles, or tool-use patterns.

The above tool-use differences are not necessarily a problem because an active and self-controlled learning process is stressed. It is however problematic if these differences affect students' performance on the course because this would indicate that not every student profits from the opportunities that are provided in the learning environment. A significant difference was found between the no-users and the others on the total course grade and the assignment. This illustrates that using the toolset is beneficial for the learning processes that take place.

Surprisingly, no significant differences were found between the intensive and the incoherent users. It implies that using CMS tools like the discussion board, the practice quizzes, and the web links, did not impact students' learning significantly. This result is unexpected since objectively they are so-called beneficial (Nutta, 2001) and a positive and significant relation was found in previous research (Hammoud et al., 2008; Huon et al., 2007). A possible explanation for this lack of effect can be the fact that there was variation among the intensive users in actively using these CMS tools (cf. supra). There is evidence that only actively using the discussion board (Hoskins & Van Hooff, 2005; Johnson, 2005; Macfayden & Dawson, 2010) and finishing the practice quiz (Macfayden & Dawson, 2010) impacts students' performance positively. Further analysis of the data supports this explanation. Multivariate analysis of variance with use of the first practice quiz as independent and the five performance indicators as dependent variables reveal that students' use of the practice quiz had a significant impact on their performance on the factual items, $F(3,153) = 2.61$, $p = .05$, $\eta^2 = .05$, on the application items, $F(3,153) = 2.73$, $p = .05$, $\eta^2 = .05$, and in total, $F(3,153) = 3.32$, $p = .02$, $\eta^2 = .06$. Students that finished the practice quiz performed significantly better than the others. Discussion board use did not have a significant impact on students' performance, *Wilks' lambda* $= .93$, $F(10,300) = 1.04$, $p = .41$, $\eta^2 = .03$, although the very low number of active users ($n = 11$) is a bias in finding performance effects. Nevertheless, descriptives reveal that the few active users performed better on all the performance indicators than the passive and the no-users. Hence, the fact that only a few of the intensive users actively participated on the discussion board and finished the quizzes can be an explanation for this lack of effect.

4.2. Limitations of the study

The study was characterized by some limitations. First of all, the research was executed with a very homogeneous sample of freshmen despite the fact that the higher educational context nowadays is characterized by a growing number of 'older' first years students as those that already have a bachelor/master degree or some work experience. Since there is first evidence that older students use the discussion board more actively (Hoskins & Van Hooff, 2005) it can be expected that including these groups and so working with a more heterogeneous group would make the activeness-differences within the intensive cluster more profound.

Table 6
Pairwise comparison: tool-use behavior and performance.

	M(No-users–Intensive users)	M(No-users–Incoherent users)	M(Incoherent users–Intensive users)
Assignment	−.722[a]	−.493[a]	.299
Factual items	−.448	−.308	.140
Comprehension items	−.395	−.174	.221
Application items	−.119	.152	.271
Total grade	−.545[a]	−.296	.248

[a] $\leq .05$.

Second, the research did not consider possible covariates although the study focused on students' use throughout the whole semester. Since this period is long, it can be assumed that other variables impacted students' performance as well which makes it hard to interpret the results regarding tool-use pattern – performance. Covariates such as ability (Hoskins & Van Hooff, 2005), prior experience with a CMS course, computer experience can influence the relation tool-use pattern – performance, although they were not considered.

Third, although the study captured students' learning behavior with unobtrusive measurement instruments, a gray-zone remains that can introduce additional variance. No insight is retrieved in the way students use the syllabus, whether they attend the face-to-face lectures, whether they use the email, whether they make the exercises etc. This blind angle can be another possible explanation for the lack of effect.

Next to these limitations, it remains unclear if the relation between students' tool-use pattern and performance is caused by the behavior or if this behavior just reflects other student characteristics such as motivation, ability, metacognitive capacities etc. that can explain this tool-use impact.

5. Conclusion

The purpose of this study was twofold. Firstly, it addressed students' tool-use in a blended course by considering students' use of face-to-face tools in relation to CMS tools. A perspective that is largely neglected in contemporary tool-use research. Secondly, it aimed to gain insight into students' use of the whole toolset instead of focusing on students' use of each tool separately. This focus is not found in current research on CMS use but is necessary given the dynamic nature of classroom studies (Salomon, 1999). In this way, the study aimed to gain insight into students' tool-choices and their tool-use intensity along the whole offer of affordances.

Results illustrate what Perkins (1985) already indicated in the 80s, that it cannot be assumed that students will use the learning opportunities at their disposal. It was found that students differed in using the different tools and these differences reflected three tool-use patterns or user profiles. A first pattern was labeled the no-users since these students did not use the available tools. A second pattern were the incoherent users characterized by using the face-to-face tools and only these CMS tools with a clear link to the face-to-face context. A third pattern were the intensive users that used the whole toolset at their disposal. In fact, the last group consisted out of two groups that differed in their activeness of tool-use. These student differences seem to be a problematic issue since significant performance effects were found. Specifically, the no-users performed worse and the most active users within the intensive cluster seemed to perform best. Hence, this result implies that not everybody profited from the affordances in the learning environment. This implication calls for more research into the reasons why students differ in their tool-use. More insight in this aspect is particularly interesting from an instructional design perspective in creating adaptive learning environments calibrated to specific student types. Further to this, the current research can be optimized since it was characterized by some limitations such as lack of encountering covariates, a specific sample, and a gray-zone of tool-use.

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