

The effectiveness of classroom control systems in a traditional classroom environment

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Technological advances related to information and communication technologies are having profound impacts on the education and training industries and learning processes. As technology-mediated learning (TML) becomes commonplace back-dropped against continued primary reliance on the traditional classroom (TC), there are significant implications for TC learning. Moreover, in light of Leidner and Jarvenpaa's (1993) observation that "...interactive student use of computers is a prerequisite for effective computer-based teaching methods. (p.47)," we may infer that examining how students actually use TML applications in a TC environment is critical for understanding the potential effectiveness of computer-based teaching methods. We use a longitudinal quasi-experimental field study to assess students' actual on-task and off-task use levels under unrestricted and restricted conditions. Based on objective data, the findings indicate that students will engage in more off-task than on-task uses by a significant margin. We also conclude that technical solutions alone are not sufficient to restrain off-task use, and that it may be advisable to augment these technical solutions with behavioural modification and reform efforts.

Keywords: Technology-mediated learning, classroom control systems, computer monitoring, longitudinal, field study

1. Introduction

Technological advances related to information and communication technologies are having profound impacts on the education and training industries and learning processes [Hiltz and Turoff 2005, Alavi and Gallupe 2003, Alavi 1994, Young 2005, Arbaugh 2000]. Among information systems, management, education and education psychology researchers, a field of inquiry has emerged that some call technology-mediated learning (TML). Alavi and Leidner (2001) recently noted that "The IS field is uniquely positioned to contribute to the intellectual development of TML [...]. (p.2)"

We follow Leidner and Jarvenpaas' (1995) characterization of TML as learning experiences that are modified through use of information and communication technologies. TML has broadened universities' curricular delivery options beyond the traditional classroom (TC) to include distributed environments (DE) as well. While the number of universities that resort exclusively to DE or has introduced DE alongside the TC continues to increase, most universities remain in an initiation or early-growth stage [Alavi and Gallupe 2003]. Consequently, the greater share of curricular delivery remains in the TC environment.

Thus, as TML becomes commonplace back-dropped against continued reliance on the TC as the primary curricular delivery option, there are implications for TC pedagogy and learning. This raises many practical issues and research questions, which have received limited attention from IS researchers relative to TML in DE environments [Alavi and Gallupe 2003, Leidner and Fuller 1997, Leidner and Jarvenpaa 1993]. Leidner and Fuller (1997) alluded to this disparity when commenting that "...a parallel stream of research is needed to study how information technology can be effectively applied with in the classroom, since we think it unlikely that the conventional classroom environment will become obsolete in the near future." (p.150).

Our research objective is to examine the effectiveness of CCS, which we assess through two exploratory research questions: What is the nature and level of use in terms of on-task and off-task use behaviors? How do the nature and level of on-task and off-task uses differ between access settings? We use a

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longitudinal quasi-experimental field study to explore the nature and level of learners' computer use in the traditional classroom. The results are based on objective data that were collected through a monitoring program.

2. The centrality of use

Computer use in a learning setting is not new. For example, many computer science and information systems courses are wholly taught in computer labs due to the nature of the curricula. Alternatively these or other disciplines' courses may intermittently occur in a lab setting in order to offer learners primers or tutorials on one or few specific applications area. The novelty that we explore in this paper rests in the notion that computer use in a traditional classroom setting is both widespread (all students) and continuous (all sessions)—that computer use marks a change in pedagogy and learning than previously existed.

In light of Leidner and Jarvenpaa's (1993) observation that "...interactive student use of computers is a prerequisite for effective computer-based teaching methods. (p.47)", we may infer that examining how students actually use TML applications in a TC environment is critical for understanding the potential effectiveness of computer-based teaching methods. From among several IS and management studies [Leidner & Jarvenpaa 1993 Leidner & Fuller 1997 Alavi 1994, Althaus 1997, King, et al 1990], few have measured actual use. So there is an implicit assumption that students use TML applications at levels and in ways that coincide with administration and faculty intentions and expectations. However, the implementation literature conclusively shows that applications may not be used at all [McAfee 2003], and adaptive structuration theory suggests that applications are appropriated in unexpected ways [Poole and DeSanctis 1990, Chidambara 1996]. Thus, from a methodological point of view, a majority of these studies is limited in this regard.

2.1 Controlling use through classroom control systems

Ideally students will remain on-task when using TML applications in a TC environment, however TML applications may be used for off-task purposes as well. In an effort to restrain off-task use behaviors, administrators and faculty may employ a classroom control system (CCS) to limit users' access to certain applications and devices. For example an instructor may allow access to the course management application and printers, while disallowing access to email and chat applications and the Internet. Thus, by selectively allowing some applications and devices while eliminating others through a CCS, the practical value of networked computers in a TC setting is presumably enhanced by balancing on-task uses against off-task ones. While our use of the term 'classroom control system' is intended to refer in a generic way to a variant of network security applications, the term may be used for branding as well. (See for example <http://www.enterasys.com/solutions/verticals/education>.)

In this study, we define learners' on-task (off-task) uses as those that are (are not) related to the classroom activity in progress. Classifying technology uses in this manner is context dependent, a methodological challenge that we address below. Set through the CCS, 'access setting' refers to the TML applications that are made available for access during class sessions. We qualify an unrestricted (restricted) access setting as less (more) impeded—allowing students access to relatively more (fewer) applications.

Research Methodology

Research setting

The research setting is a required freshmen course at a business college in the Northeastern United States. We refer to the course as Business Introduction. Business Introduction is offered in seven sections, and each section is capped at 60 students. A team of two faculty members teach each section. Business Introduction lasts two semesters, and it adopts a multidisciplinary perspective by interweaving topics and concepts from different academic disciplines (or functional areas). The pedagogical approach

is heavily applied, which fits the college's tradition and pedagogical philosophy. Moreover, much of the curricula was designed and delivered under the assumption that each student has a dedicated computer during class sessions, consequently there is heavy reliance on IT inside the classroom. In January 2006, the course received an Excellence in Education Award from the U.S. Association for Small Business and Entrepreneurship (USASBE) for its innovative and entrepreneurial pedagogical approach.

Research design

The research design is a longitudinal quasi-experimental field study. Subjects came from four Business Introduction sections, which were instructed by two teaching teams. Each team instructed one section in unrestricted access and another in restricted access. Unrestricted access allowed use of all applications including course management software, shared file servers and printers, the email system and the Internet. Restricted access prohibited use of email (including chat) and the Internet, except on occasions where the instructors deemed them to be pedagogically relevant. This exception normally involved allowing Internet access for some learning activity. The sequence of unrestricted and restricted sections was alternated between the two teams. The teaching teams shared teaching materials, and their efforts to ensure uniform course requirements across sections resulted in a relatively standardized curriculum. However, curriculum delivery was not scripted and was subject to idiosyncratic teaching styles and the dynamic nature of discussion periods. Instructors were generally non-directive in controlling students' computer use.

Sampling

Four-hundred-twenty freshmen were asked to participate. The subjects were not informed about the specific research questions, however they were made aware that participation involved unobtrusive monitoring of their computer use during Business Introduction class sessions (primary data), filling out a survey (primary data), and releasing course performance and SAT data (secondary data). Utmost care was taken to ensure that students understood that participation was voluntary and that their involvement, or lack thereof, would not influence their grade in anyway. While subjects were not randomly assigned to sections, the access setting was designated for each section well after the student registration period, so no self-selection bias occurred when selecting a Business Introduction section during course registration.

One-hundred and twenty-two subjects volunteered to participate, which represents a 29% (=122/420) participation rate. From these 122 subjects, we obtained 95 monitoring log files and 89 surveys of which 71 overlapped. Four subjects were dropped, because they switched sections during the term's drop-add period, after the monitoring program recording periods were assigned causing the recording period and session start and end times to not coincide. We have primary data on 67 subjects.

Variables and Measures

Use behavior. Computer monitoring software logged computer use behavior into a database table only during the 80-minute Business Introduction sessions, which we refer to as recording time. During the recording time, all use activity was logged to the local hard drive, so all activity is recorded independent of whether the subject was connected to the network. Recording time occurred in stealth mode, and the monitoring program icon never appeared on the desktop, task bar or task list. Thus, no subject was ever alerted to the monitoring program. Data were recorded for 28 class sessions, which provide repeated measures on use.

Periodically, the log file was copied from each subject's local hard drive to a file server by a custom-designed server-side program called the "harvest" program. The "harvest" program required that any subject establish a network connection, but that connection could occur at any time. The precise timing of log file "harvesting" was jointly determined through the random occurrence of subject network login

and time of last harvest, and generally occurred about every seven to ten days. The harvest program operated inconspicuously.

Sample log files are shown in appendix tables A1 and A2, which may be found at <http://www.gtdngt.com/research/icte2006/appendix.htm>. Fields include (subject) name, application name, key counter, active time and inactive time among others. A record is generated each time a user sets the window focus. From the log data examined in time sequence and awareness of each class session's topic and activities, records can be coded with respect to use behavior as on-task or off-task. The coding process is partly subjective and not entirely error free, therefore two independent raters coded each record. The raters were in agreement 82% of the time, coding 89,260 out of 109,057 records the same. Records on which the raters disagreed were removed from subsequent analyses. After further examination and "cleaning" of the data, there were 87,095 usable records.

The on-task and off-task codes are shown in the far right two columns. If the record represents on-task (off-task) behavior, then the on-task column is coded as '1' ('0') and the off-task column is coded as '0' ('1'). Some records are coded as '0' in both columns, because they represent neither on-task nor off-task use, or they are indeterminate with respect to use. Records that represent neither use behavior are mostly instances where the system changed focus on the user, which usually resulted from system-generated alerts— notifying the user that the operating system needed a patch or the virus definition file required update for instance. Some records were indeterminate because there was not enough information to form a judgment. In no case may a record be coded as '1' in both columns, because no use can be simultaneously characterized as on-task and off-task.

Each sample log sequence highlights use activity that is either predominantly on-task or off-task behavior. Table A1 highlights on-task behavior, where the subject is taking notes on a problem solving exercise related to breakeven analysis. In table A2, the sequence highlights off-task behavior where the same subject at a different date and time is in an instant message dialog with another person. (Refer to the Keystrokes column.)

Four measures *each* for on-task and off-task use behavior were computed—focus change, keystroke count, active time and inactive time. **Focus change** is a count on the number of records, and represents the number of times that the user sets the window focus for that behavior. **Keystrokes** is the sum on the key counter column, and represents a count on the number of keystrokes for that behavior. **Active (inactive) time** is the sum of the active (inactive) time column, and represents the amount of active (inactive) time *in seconds* spent on that behavior. All use measures are ratio scaled.

The use measures' nominal (proportional) figures are shown in the top (bottom) part of table 1. These data show that about two-thirds of all use behavior is off-task when measured by keystroke count and active time. The focus change measure shows that 79% of behavior is off-task. The percentage of on-task behavior ranges from just under 18% to about 37% depending on the measure used. Finally, neither use accounts for a relatively small percentage. Log records classified as 'Neither' are removed from subsequent analyses. We show first-order correlations among the use measures in table 2.

	Focus Change	Keystrokes	Active Time	Inactive Time
Off-task	69,027	1,265,658	680,022	1,586,176
On-task	15,362	652,371	315,403	1,016,356
Neither	2,706	6,238	11,352	120,011
Total	87,095	1,924,267	1,006,777	2,722,543
	Focus Change	Keystrokes	Active Time	Inactive Time
Off-task	79.3%	65.8%	67.5%	58.3%
On-task	17.6%	33.9%	31.3%	37.3%
Neither	3.1%	0.3%	1.1%	4.4%
Total	100.0%	100.0%	100.0%	100.0%

Pearson Correlations		On-task				Off-task		
		Focus	Keystroke	Active	Inactive	Focus	Keystroke	Active
On-task	Focus Change	1.00						
	Keystroke Count	0.68**	1.00					
	Active Time	0.81**	0.90**	1.00				
	Inactive Time	0.68**	0.71**	0.75**	1.00			
Off-task	Focus Change	0.37**	-0.02	0.12	-0.09	1.00		
	Keystroke Count	0.18	-0.10	-0.02	-0.15	0.73**	1.00	
	Active Time	0.19	-0.14	-0.02	-0.23	0.89**	0.86**	1.00
	Inactive Time	0.04	-0.20	-0.08	-0.20	0.63**	0.57**	0.63**

** p<.01, * p<.05

Results and Discussion

Our research objective is to examine the effectiveness of CCS, which we assess through two exploratory research questions: What is the nature and level of use in terms of on-task and off-task use behaviours? How do that nature and level of on-task and off-task uses differ between access settings? We present results related to the first research question and follow with the second.

The results in table 1 show that about two-thirds of all use is off-task and about one-third is on-task. Thus, in terms of level, a majority of use behaviour is off-task although a sizeable amount is on-task. This is unfortunate. When given tools to be more effective in a classroom setting, subjects gravitate toward off-task use behaviours. This suggests that subjects may have poor discipline and lack an ability to focus. Alternatively, it may be that substantive slack time exists during class sessions so subjects concurrently participate in both on-task and off-task uses. In the unfortunate circumstance of ineffective teaching, it may be that subjects feel they can spend their time more wisely in off-task ways.

We further elucidate the nature of on-task and off-task use by examining for each two characteristics—use distribution across applications and across sessions. Because the four use measures for on-task and off-task are positively correlated at $p < .01$, we yield largely the same results independent of the chosen measure. We use focus change here.

Table 3 shows use distribution for the top five applications under on-task and off-task use behaviours. The percentages show the percent of records (or focus changes) for the respective applications. For example, 25.1% for winword.exe indicates that just over one-quarter of the monitoring records for on-task use show that the user was working in the Word program. (For a more complete list of use distribution across applications, see appendix Figures A1 and A2 at <http://www.gtdngt.com/research/ict2006/appendix.htm>.)

On-task Use		Off-task Use	
Application	Records %	Application	Records %
winword.exe	25.1%	aim.exe	38.8%
explorer.exe	20.4%	iexplore.exe	23.0%
frontpg.exe	12.2%	explorer.exe	13.5%
excel.exe	12.2%	outlook.exe	7.2%
iexplore.exe	11.6%	studio.exe	1.8%

According to these data, subjects were working most in winword.exe (word-processing), explorer.exe (file management), frontpg.exe (web authoring), excel.exe (spreadsheet modelling) and iexplore.exe (htm file viewing, browsing) for on-task use. These programs were integrated into numerous exercises that were conducted during class sessions. For off-task use in contrast, subjects were working most in aim.exe (AOL instant messaging), iexplore.exe (htm file viewing, browsing), explorer.exe (file management), outlook.exe (email) and studio.exe (multimedia viewing). These results show that the kinds of

applications that subjects employed in on-task and off-task uses differed. Though not shown here, the number of different applications that was employed under on-task uses was 40, far fewer than the 289 different applications employed under off-task uses. This result shows that subjects employed about seven times more applications for off-task purposes when compared to on-task use.

Finally, we looked at on-task and off-task use levels over time. Figure 1 shows both on-task and off-task use levels across sessions. The y-axis between the two graphs is identical, so the higher level of off-task use behaviour is apparent. Another observation is the erratic pattern of use levels over time. These results suggest that the sessions' activities as set through curricula design may play a significant role in affecting use.

In order to assess the nature and level of on-task and off-task uses between access settings, we ran independent samples t-tests on the mean differences in on-task and off-task use levels between access settings. The results are shown in table 4a. In order to aid interpretation, we also show independent samples t-test results on the mean differences in restricted and unrestricted access settings between on-task and off-task use averages in table 4b. Proportional use measure totals are shown in tables 5a and 5b also to aid interpretation.

Table 4a: Use Measures by Use Behavior, Access Setting

		Focus Change	Keystrokes	Active Time	Inactive Time	
Offtask	Restricted	681	12,859	7,588	18,851	(a)
	Unrestricted	1,279	23,155	11,905	26,860	(b)
	Significance	p<.01	p<.05	p<.05	p<.05	(c)
Ontask	Restricted	246	13,277	5,560	18,963	(d)
	Unrestricted	222	7,057	4,128	12,429	(e)
	Significance	n.s.	p<.05	n.s.	p<.05	(f)

Table 4b: Use Measures by Access Setting, Use Behavior

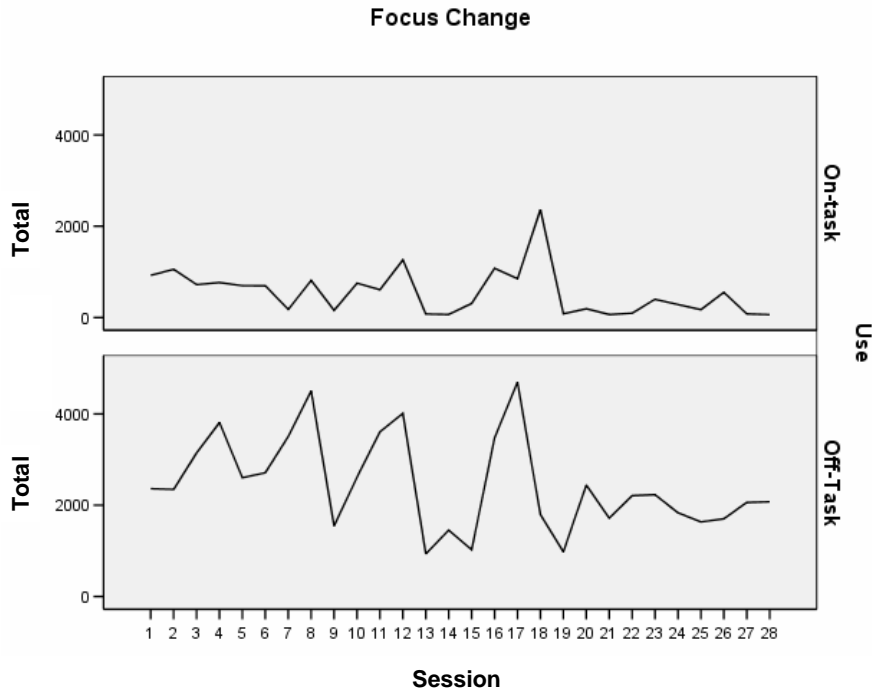
		Focus Change	Keystrokes	Active Time	Inactive Time	
Restricted	Offtask	681	12,859	7,588	18,851	(a)
	Ontask	246	13,277	5,560	18,963	(b)
	Significance	p<.01	n.s.	n.s.	n.s.	(c)
Unrestricted	Offtask	1,279	23,155	11,905	26,860	(d)
	Ontask	222	7,057	4,128	12,429	(e)
	Significance	p<.01	p<.01	p<.01	p<.01	(f)

Table 5a: Use Measures by Use Behavior, Access Setting

		Focus Change	Keystrokes	Active Time	Inactive Time	
Offtask	Restricted	29.6%	30.5%	33.5%	35.7%	(a)
	Unrestricted	70.4%	69.5%	66.5%	64.3%	(b)
	Subtotal	81.8%	66.0%	68.3%	60.9%	(c)
Ontask	Restricted	48.0%	61.1%	52.9%	56.0%	(d)
	Unrestricted	52.0%	38.9%	47.1%	44.0%	(e)
	Subtotal	18.2%	34.0%	31.7%	39.1%	(f)
Total	100.0%	100.0%	100.0%	100.0%	(g)	

Table 5b: Use Measures by Access Setting, Use Behavior

		Focus Change	Keystrokes	Active Time	Inactive Time	
Restricted	Offtask	73.5%	49.2%	57.7%	49.9%	(a)
	Ontask	26.5%	50.8%	42.3%	50.1%	(b)
	Subtotal	33.0%	40.9%	39.6%	43.6%	(c)
Unrestricted	Offtask	85.9%	77.6%	75.3%	69.5%	(d)
	Ontask	14.1%	22.4%	24.7%	30.5%	(e)
	Subtotal	67.0%	59.1%	60.4%	56.4%	(f)
Total	100.0%	100.0%	100.0%	100.0%	(g)	

Figure 1

As shown in table 4a, all four use measures indicate that off-task use is significantly higher at $p < .05$ in the unrestricted access setting compared to the restricted access setting. Two of the four use measures indicate that on-task use is significantly higher at $p < .05$ in the restricted access setting. These findings are largely consistent with expectations, however it is important to remain mindful of the fact that overall use is characterized by a preponderance of off-task use behaviour. Modifying our view of the results as shown in table 4b, we see that under the restricted access setting off-task use is higher than on-task as measured by focus change ($p < .01$) and active time, although the latter comparison is not statistically significant. Thus, despite the technical constraints imposed by the CCS system, subjects continue to find ways to engage in off-task uses.

Also in the restricted access setting, inactive time is slightly higher for on-task over off-task. Thus, while subjects are spending more active time on off-task uses, they spend more inactive time on on-task uses. Assuming that inactive times coincide with periods of reading the display screen without any navigation or movement, this suggests that subjects are spending more time comprehending and interpreting information while on task.

Conclusions

We conclude that students will engage in more off-task than on-task uses by a significant margin. We also conclude that technical solutions alone are not sufficient to restrain off-task use, and that it may be advisable to augment these technical solutions with behavioural modification and reform efforts.

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