Manuscript: Find Final Version Via Computers in Human Behavior at:
https://doi-org.ez.sun.ac.za/10.1016/j.chb.2017.08.030

In-lecture Media Use and Academic Performance: Does Subject Area Matter?

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Abstract

The current generation of university students display an increasing propensity for media multitasking behaviour with digital devices such as laptops, tablets and smartphones. A growing body of empirical evidence has shown that this behaviour is associated with reduced academic performance. In this study it is proposed that the subject area within which an individual is situated may influence the relationship between media multitasking and academic performance. This proposition is evaluated, firstly, by means of a meta-review of prior studies in this area and, secondly, through a survey-based study of 1 678 students at a large university in South Africa. Our findings suggest that little or no attention has been paid to variations between students from different subject areas in previous work and, based on our data, that subject area does influence the relationship between media use and academic performance. The study found that while a significant negative correlation exists between in-lecture media use and academic performance for students in the Arts and Social Sciences, the same pattern is not observable for students in the faculties of Engineering, Economic and Management Sciences, and Medical and Health Sciences.

Keywords: Media Multitasking, Academic Performance, Cognitive Control, Subject Area

1. Introduction

The current generation of university students are considered to be part of the net generation (Tapscott, 1998), a cohort displaying an unprecedented propensity for engaging and interacting with mobile digital devices such as laptops, smartphones and tablets (Cotten et al., 2011). They generally display a positive relationship with digital media, exhibiting significantly higher adoption and engagement rates than other generations (Dahlstrom and Bichsel, 2014). Extending from their significant engagement with digital media in the course of their general life (Junco and Cotten, 2011; Thompson, 2013; Moreno et al., 2012), studies

indicate that students are spending an increasingly larger proportion of their time engaging with media while performing academic activities (Leysens et al., 2016; Jacobsen and Forste, 2011; Fried, 2008; Junco, 2012a; Burak, 2012).

In the context of this study digital media are conceptualised as always-on, socially interactive, technologically mediated communication artifacts. Media facilitate access to the World Wide Web, providing opportunities for communication, collaboration and other forms of social interaction, from anywhere and with a minimal amount of effort (Wardley and Mang, 2015). They are characterised by an increased level of interactivity (Bolter, 2003), a hypertextual mode of operation (Conklin, 1987), increased individuality (Feenberg and Bakardjieva, 2004) and a deeper level of involvement in peoples' lives (Kennedy, 2006).

It has been argued that these characteristics contribute to increased levels of, not only media use, but media *multitasking* among individuals (Parry, 2017). Multitasking describes the purposeful, concurrent performance of independent tasks, each associated with distinct intentions (Salvucci and Taatgen, 2015). It can take place either as a result of environmental interruptions, or as a result of self-interruption. Such interruptions represent the re-prioritisation of goals, with cognitive control being directed to the goal currently possessing the highest priority (Clapp and Gazzaley, 2013).

Multitasking involves rapidly switching between various ongoing activities creating continuous attention shifts and disruptions (Fried, 2008; Small and Vorgan, 2009; Chen and Yan, 2016). While the ability to do this may be well-developed among certain individuals, "it has been broadly shown that rapid switching behaviour, when compared to carrying out tasks serially, leads to poorer learning results in students and poorer performance of the tasks being carried out" (Kirschner and De Bruyckere, 2017, p. 139). This has highlighted the importance of not equating *frequent* multitasking to *effective* multitasking. Kirschner and De Bruyckere (2017) argue that there is no evidence to support the pervasive belief that the net generation are better multitaskers than previous generations. This misconception, they believe, has lead to the adoption of various deleterious educational practices.

Logie et al. (2011) found that the ability to multitask is enabled by the interaction of multiple cognitive functions, including memory, planning and intent. Gazzaley and Rosen (2016), accordingly, argue that rapid switching between tasks will have a stronger impact on

the performance of individuals with underdeveloped or impaired cognitive function, "such as children, older adults, and individuals suffering from neurological and psychiatric conditions" (Gazzaley and Rosen, 2016, p. 5).

The phrase *media multitasking* refers to the simultaneous use of at least one type of media, while engaging in any number of other media or non-media activities (Jeong and Hwang, 2012). It follows that *media use* does not necessarily equate to *media multitasking*. However, it is our premise, based on previous work by ourselves and others (Judd, 2013; Carrier et al., 2009; Rosen et al., 2013; le Roux and Parry, 2017; Parry, 2017), that frequent rapid switching between multiple media and non-media tasks is, among members of the net generation, the norm. While this form of behaviour may create the illusion of tech savviness and effective multitasking, Kirschner and De Bruyckere (2017) warn that a broad range of evidence suggests that this is a myth.

1.1. Media Multitasking and Academic Performance

A recent meta-review of studies investigating media multitasking and academic performance indicates that there appears to be a negative correlation between media multitasking behaviour in academic contexts and academic performance (Van der Schuur et al., 2015). This outcome suggests that media multitasking implies some form of cognitive cost for learning, impeding the processing and encoding of information into long term memory (Oulasvirta and Saariluoma, 2004). We adopt the position that individuals possess an inherently limited capacity to pay attention to multiple simultaneous sensory stimuli (Ophir et al., 2009; Kahneman, 1973; Loh and Kanai, 2015; Gazzaley and Rosen, 2016; Kirschner and De Bruyckere, 2017). It follows that, for students, increased levels of media multitasking during academic activities reduce the cognitive resources available for retaining or making sense of academic content.

A number of studies involving students demonstrate how the learning process is negatively affected by media multitasking behaviour. In the majority of these studies academic performance refers to academic outcomes, such as course marks, test scores or year averages (GPA) (Van der Schuur et al., 2015). Within this line of research studies either adopt a correlational methodology, making use of self-administered questionnaires relating to use

frequencies, habits and academic outcomes or an experimental approach in which participants are generally exposed to media during an academic activity and their understanding and retention of content is measured.

Van der Schuur et al. (2015) reviewed a sample of studies ($n = 43$) that investigated the effect of media multitasking on academic performance. Of the 43 studies reviewed 17 indicate a significant negative correlation, four studies found no significant relationship and in the remainder of the studies the significance or direction of the relationship was not calculable. Negative correlations were found to exist in experimental as well as survey based studies. However, the correlations were small to moderate in strength, with no studies finding strong correlation. This should, of course, be interpreted with recognition of the wide spectrum of determinants of academic performance as a dependent variable.

Junco and Cotten (2012) examined the relationship between media use frequency while studying and academic performance through a survey of a large sample of students. The findings indicated that students' media multitasking behaviour was not curbed by academic tasks — students reported that they frequently engaged in technologically mediated, off-task activities whilst engaged in academic study. Upon analysis of the data, Junco and Cotten (2012) found that use of Facebook and texting activities were negatively correlated with indicators for academic achievement while talking on the phone, e-mail, instant messaging and web searching were not. It was concluded that the type as well as the purpose of the particular technologically mediated activity matters in terms of the educational impacts derived from multitasking.

In another study Risko et al. (2013) required participants to observe a pre-recorded lecture. While observing this lecture half of the participants were instructed to complete a series of online activities on laptops. Directly following the lecture students' recall of the presented content was tested. Through filmed observations of the lecture Risko et al. (2013) were able to determine that those students who engaged in the mediated tasks spent less time attending to the lecture than their peers. In addition to spending less time attending to the lecture, the participants in the mediated condition retained less information than those in the control condition. Risko et al. (2013) performed a mediation analysis to determine if the reduction in attention to the lecture mediated the effect of the laptop activities on retention.

The results are consistent with the authors' hypothesis that those in the laptop condition will achieve diminished performance because their attention is focused on the medium, not the lecture. Interestingly, 79% of the participants indicated that they felt their engagement with media during the lecture influenced their performance. Risko et al. (2013) found that there was no relation between this indication and the test outcomes.

While these studies and others (e.g. Rosen et al., 2013; Fried, 2008; Leysens et al., 2016) have reported negative correlations between in-lecture media multitasking and academic performance, other studies found no difference in performance outcomes as a result of media multitasking behaviour (Elder, 2013; Lee et al., 2012). This suggests that further research is required to enhance our understanding of the dynamics of the relationship between these constructs.

2. Media Multitasking and Academic Performance in Different Subject Areas

In this study we propose that the subject area within which an individual is situated will influence the relationship between media multitasking and academic performance. We define the term subject area to refer to the general overarching category a particular academic discipline falls within. Findings described in previous studies (e.g. Saleh, 2001; Davis et al., 2004; Osterman, 2015) suggest that there exists a scope for personal and psychological differences between individuals studying different subject areas at university. Saleh (2001), for example, found a significant effect of brain hemisphericity on students' academic major, or subject area. The author found that arts/literature, education, nursing, communication and law students tended to be right brained while business/commerce, engineering and science students were left brained (Saleh, 2001, p. 196). Based on survey study of 101 subjects, Osterman (2015) found that, under certain circumstances, there exists a relationship between academic major, or subject area and, thinking style. His results indicated that students following a Humanities major generally demonstrated balanced linear/non-linear thinking styles, while students following a major in Business tended to demonstrate more linear thinking styles. Interestingly, while not directly associating thinking styles with particular subject areas, Chen and Ji (2015) found thinking style to interact with the use of educational media in determining academic performance. Their findings indicated that,

while thinking style did not predict overall media use, subjects who demonstrated abstract reasoning used non-educational media less frequently. They found, furthermore, that when subjects demonstrated concrete reasoning, educational media use was associated with improved academic performance. However, their data did not show support for the proposition that thinking style moderates the relationship between non-educational media use and academic performance. We propose that these differences may play a role in students' media multitasking behaviour, and, the subsequent implications for academic performance.

In a study specifically focusing on associations between students' in-class use of media and their academic success Gaudreau et al. (2014) examined differences occurring between four subject areas (Arts 14.5%, Social Sciences 37%, Health Sciences 28%, Sciences 20.4%) amongst a large sample ($n = 1129$) of Canadian students. Following analysis of self-administered questionnaires, Gaudreau et al. (2014) found small, but significant differences (Cohen's d from $-.25$ to $-.34$) in the media behaviours described by students across different subject areas. Science students were found to be less likely to: use their laptop for note-taking purposes, browse unrelated websites and visit social networking services. Despite finding differences in behaviour between students from different subject areas, Gaudreau et al. (2014) did not find significant differences between subject areas in terms of the relationship between media multitasking and academic performance.

2.1. Subject Area Analysis

To investigate, in more detail, the role of subject area in the relationship between media multitasking and academic performance we performed a systematic review of literature. A *general pool* of literature within this area was composed through a series of steps, conducted in an iterative manner. As a starting point a number of specialist journals[1] were selected. Through keyword searches relevant articles were located, considered and included in the general pool. Following this, a 'snowball' approach, as suggested by Webster and Watson (2002), was used to discover additional relevant sources. Two methods were employed: backwards search, and forwards search. Backwards search involved extracting literature

[1]Selected according to focus area and impact factor. Computers in Human Behavior, Computers & Education, Cyberspychology, Behavior, and Social Networking

from the sources cited in these initial studies. Forwards search involved finding studies that cited the literature already contained within the general pool.

Having finalised the general pool of literature ($n = 56$), a specific sample from this general pool was extracted using a non-probability sampling strategy as described by Berg et al. (2004, p. 35). Through purposive sampling a sample of literature displaying particular attributes was created. Literature were required to meet a number of criteria in order to be considered for the sample. These criteria include: either an experimental or a correlational methodology, publication post 2007[2], a focus on digital media *as defined in this study*, an attempt to determine the *correlation* between, specifically, media multitasking and measures for academic performance.

The sample of collected literature consisted of 35 ($n = 35$) peer-reviewed, primary studies matching the inclusion criteria specified (see Appendix A). Looking at the source location of these studies 11 appear in *Computers in Human Behavior*, eight in *Computers & Education*, one in *Cyberspychology, Behavior, and Social Networking* and 15 in other journals and conference proceedings. 20 of the studies sampled adopt a correlational methodology and 15 adopt an experimental methodology. 20 of the 35 studies were published within the last five years (from 2017), with the remaining 15 studies being published between 2008 and 2012 (inclusive).

Following the construction of the literature sample, the sample characteristics as well as the findings reported in each study were collected and analysed. If a particular subject area was mentioned it was classified accordingly. If no subject area was mentioned the study was classified as 'not specified'. Finally, if multiple subject areas were mentioned the study was classified as 'multiple'. Table 1 presents an overview of the literature sample in terms of the number of studies reporting the specific subject area of the participants, as well as aggregates of the direction of correlations with academic performance described in such studies. Upon analysis of the literature, it can be observed that the largest individual category of subject area reported is Arts and Social Sciences, with all 12 studies identified in this category showing a significant negative relationship between media multitasking and

[2]Following the widespread proliferation of social media services

academic performance. Interestingly, eight studies did not specify the subject area of their sample, while ten studies covered multiple subject areas without specifying the particular subject areas.

Table 1: Correlational and experimental studies arranged by subject area

	Correlational			Experimental			
SA	Number	DP	ns	Number	DP	ns	Totals
ASS	4	4[10, 23, 24, 26]		8	8[4, 8, 9, 18, 19, 28, 30, 31]		12
EMS	1		1[3]	2	2[7, 17]		3
EDU				1	1[5]		1
N/A	6	6[1, 13, 14, 15, 25, 29]		2	2[34, 35]		8
Multiple	9	7[6, 11, 16, 20, 21, 22, 27]	2[12, 33]	2	2[2, 32]		11
Totals	20	16	3	15	15		

Note. SA= Subject Area, ASS = Arts & Social Sciences, EMS = Economic & Management Sciences, EDU = Education, N/A= the faculty was not specified DP = Decreased performance, ns = no significant correlation found.

The numbers in superscript indicate the specific studies considered, details of which are available in the attached appendix.

2.2. Conclusions

From this brief analysis we conclude that little or no attention has been paid to variations in the relationship between media use and academic performance across multiple subject areas. Specifically, it appears that most studies consider students from social science programs or fail to specify subject area. In studies where students from a wider range of subject areas participated, variations in results were mostly not reported. Finally, when multiple study areas exist within the sample, the interplay between this factor and other outcomes achieved are not explored. One exception in this regard is Gaudreau et al. (2014) who compare academic performance outcomes to specific subject areas, finding no significant difference. However, Gaudreau et al. (2014, p. 246) concede that their samples were not entirely representative of students across faculties.

We propose that subject area may moderate the relationship between media multitasking and academic performance. This proposition is based on two premises. The first concerns the notion that different subject areas tend to attract students with different thinking styles (concrete/abstract or linear/non-linear) (Saleh, 2001; Osterman, 2015; Chen and Yan, 2016). We contend that such differences may influence the utilisation of cognitive control functions such as working memory and attentional control which, as has been found (Pollard and Courage, 2017; Chan et al., 2008), will influence multitasking performance in an individual. Our second premise concerns differences in the nature of academic work performed in different subject areas. We propose that the performance costs for learning resulting from media use during lectures may be higher in some subject areas than others. This effect can result, for example, from differences in the degree to which learning requires the effective utilisation of a cognitive process such as working memory. It follows, under this premise, that the processes of knowledge acquisition in particular academic areas may more sensitive to interference than others.

3. Research Design

To address the problem outlined in the preceding section we pose the following research question:

Do statistically significant differences exist between the correlations of in-lecture media multitasking and academic performance amongst university students from different subject areas?

To address the question a web-based survey was designed to collect data at a large, residential, South African university.[3] The first section concerned subjects' media use in general as well their media use in structured academic contexts (i.e, lectures, practical classes or tutorial classes). After investigating previous studies of media use among South African students we identified six forms of online media typically used by the target population. These included:

[3]The university is ranked inside the top 500 on the 2016/2017 Times Higher Education World University Rankings Times Higher Education (2017).

1. Social Networks (SN)
2. Micro-blogs (MB)
3. Online encyclopedic (or structured data) browsing (ENC)
4. Instant Messaging (IM)
5. Search (engine) activities (SE)
6. The university's e-learning platform (EL)

For each medium two Likert-type questions were used to elicit frequency of use - one for general use and one for in-lecture use. For general use five indicators were provided ("Not at all"; "Sometimes (at least once per month)"; "Often (at least once per week)"; "At most once a day"; "Multiple times per day"). For in-lecture use the indicators were "Not at all"; "Once or twice"; "Every 10 minutes"; "Every 5 minutes"; "Constantly".

The survey also elicited demographic variables including age, gender, language, highest qualification of parents and subject area. Subject area was elicited by asking students to indicate, using a drop-down list, in which of the university's 10 faculties their degree program was located. The university's 10 faculties are:

1. Agricultural Science (AGR)
2. Arts and Social Science (ASS)
3. Economic and Management Science (EMS)
4. Education (EDU)
5. Engineering (ENG)
6. Law (LAW)
7. Medicine and Health Science (MHS)
8. Military Science (MIL)
9. Natural Science (NAT)
10. Theology (THE)

Finally, respondents were asked to report their general level of academic performance in the previous academic year through a series of indicators ranging, in 5% intervals, from

"Below 40%" to "96%-100%"[4].

A single round of invitations to complete the survey was sent, by e-mail, to 14 122 registered undergraduate students at the university. Because subjects' academic performance in the previous academic year was elicited, first-year students were excluded from the list of recipients. Completion of the survey was incentivised by offering recipients a chance to win a ZAR 1 000 (roughly USD 80) gift voucher through a separately-managed lucky draw. Recipients of the invitations were asked to provide informed consent to participate in the study prior to completion of the survey. As part thereof they were informed that their participation would be both voluntary and anonymous. A total of 1 678 completed surveys were submitted within a three-week period following the invitation. The collected data was analysed using IBM SPSS Statistics version 24.

4. Findings

4.1. Overview of the Sample Population

Of the 1 678 students which comprised the sample population 82% were between 20 and 23 years of age at the time of survey completion, 7% did not disclose their age and the rest were older (predominantly 24 or 25 years of age). 51% of respondents are female, 49% are male and two respondents indicated "other". In terms of first language, 48% of respondents indicated Afrikaans, while 43% indicated English. The remaining 10% indicated isiXhosa (2%), Zulu (2%), Sepedi (1%), other African language (3%) or other European language (2%). Just under 60% of respondents indicated that at least one of their parents has a university qualification. This includes Bachelor's degrees (31%), Honours and/or Master's degrees (25%) and Doctorates (4%). 38% of respondents' parents' highest qualification is a high school certificate.

Table 2 provides a summary of the subject areas of the sample and the sizes of the populations[5] they represent. The larger faculties including Engineering ($n = 402$), Economic and Management Science ($n = 353$), Medical and Health Science ($n = 263$), Arts and Social

[4]Within the South African university system a mark of 50% represents a fail, and a mark above 75% refers to a distinction

[5]Populations were calculated as all non-first year undergraduate students in each faculty.

Science ($n = 223$) and Natural Science ($n = 196$) were well represented enabling margins of error of 6% or smaller for a 95% confidence level. However, the smaller faculties were not well presented in the sample obtained and, for a 95% confidence level, margins of error of 9% or greater were found for Agricultural Science ($n = 107$), Law ($n = 63$), Education ($n = 40$), Theology ($n = 19$) and Military Science ($n = 10$). For this reason these faculties are excluded in the remainder of the analysis.

Table 2: Respondents per home faculty.

Faculty	Male Count	Female Count	Total Count	Percent	Population	MOE
ENG	310	92	402	24.0	1 880	4%
EMS	188	170	353	21.0	3 303	5%
MHS	60	212	263	15.7	1 606	6%
ASS	68	155	223	13.3	2 306	6%
NAT	88	107	196	11.7	1 397	6%
AGR	58	49	107	6.4	987	9%
LAW	25	38	63	3.8	283	11%
EDU	9	31	40	2.4	653	15%
THE	11	8	19	1.1	153	21%
MIL	6	4	10	0.6	353	31%
Missing			2	0.1		
Total	818	856	1678	100	100	

4.2. Frequency of Media Use for Different Subject Areas

To analyse media use frequency we calculated six use frequency scales:

1. General use (GU) calculated as the aggregate of general use across all six channels.
2. General social media use (GSM) calculated as the aggregate of general use across social networks, instant messaging and micro-blogs.
3. General utilitarian use (GUT) calculated as the aggregate of general use across encyclopedias, search engines and the e-learning platform.

4. In-lecture use (LU) calculated as the aggregate of in-lecture use across all six channels.
5. In-lecture social media use (LSM) calculated as the aggregate of in-lecture use across social networks, instant messaging and micro-blogs.
6. In-lecture utilitarian use (LUT) calculated as the aggregate of in-lecture use across encyclopedias, search engines and the e-learning platform.

The means and standard deviations of the six variables for each of the subject areas are reported in table 3. An analysis of variance test (Oneway ANOVA) was performed to determine the variance between the use variables between the faculties. For general use (GU) the test revealed no significant variation between faculties, $F(4, 1432) = 1.594, p = 0.173$. However, significant variation was found for general social media use (GSM), $F(4, 1432) = 18.402, p = 0.000$, general utilitarian media use (GUT), $F(4, 1432) = 13.238, p = 0.000$, in-lecture use (LU), $F(4, 1432) = 6.212, p = 0.000$, in-lecture social media use (LSM), $F(4, 1432) = 4.215, p = 0.002$, and in-lecture utilitarian media use (LUT), $F(4, 1432) = 6.326, p = 0.000$.

To investigate these variations a post-hoc Tukey HSD test was performed to compare the faculties based on each of the use variables. The data suggests statistically significant lower general social media use among ENG students than students in MHS ($p < 0.01$) and students in ASS ($p < 0.01$). Converserly, ENG students use utiliterian media more frequently than their peers in ASS ($p < 0.01$), MHS ($p < 0.01$) and EMS ($p < 0.01$). Similarly, NAT students use utilitarian media significantly more than students in EMS ($p < 0.01$) and MHS ($p < 0.01$). Students in ASS have significantly higher levels of in-lecture media use, than their peers in NAT ($p < 0.01$), and MHS have significantly higher in-lecture media use than their peers in ENG ($p < 0.05$) and NAT ($p < 0.01$).

Table 3: Means and standard deviations for the six use frequency variables for the different subject areas.

	GU		GSM		GUT		LU		LSM		LUT	
Faculty	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
All	23.73	2.62	11.52	1.94	12.20	1.63	11.69	3.35	6.17	2.11	5.52	1.97
ASS	24.10	2.88	11.98	2	12.12	1.69	12.16	3.91	6.42	2.39	5.74	2.29
EMS	23.77	2.43	11.75	1.79	12.02	1.51	11.87	3.18	6.44	2.2	5.43	1.65
ENG	23.56	2.51	10.94	1.97	12.63	1.72	11.40	2.44	5.98	1.94	5.42	1.04
MHS	23.84	2.79	11.95	1.75	11.89	1.89	12.25	3.62	6.34	2.21	5.91	2.23
NAT	23.81	2.46	11.25	1.93	12.56	1.44	10.97	3.08	5.65	1.88	5.32	1.87

4.3. Media Use and Academic Performance

Table 4 presents a frequency table of the academic performance categories. Within the South African higher education systems a mark of greater than or equal to 50% is required to pass a module. The mean (based on selected category) was 6.16 with a standard deviation of 1.69.

Table 4: Frequency table for academic performance categories.

		Frequency (Valid Percent)					
Category	Range	All	ASS	EMS	ENG	MHS	NAT
1	Below 40%	0.1	0	0.3	0.2	0	0
2	40 - 45%	0.4	0	0.6	0.7	0	0.5
3	46 - 50%	1.7	0	3.1	1.7	1.1	1.0
4	51 - 55%	14.0	7.7	20.2	19.2	6.8	10.7
5	56 - 60%	24.2	23.4	25.3	28.9	18.3	25.0
6	61- 65%	20	21.2	17.3	20.7	20.2	21.9
7	66- 70%	17	18.9	11.6	12.5	23.6	19.4
8	71 - 75%	13	17.1	12.2	8.2	18.3	12.8
9	76 - 80%	6.6	8.1	6.0	6.0	8.7	4.1
10	81 - 85%	2.2	3.2	2.6	1.5	2.7	3.1
11	86 - 90%	0.5	0	0.9	0.2	0.4	1.0
12	91 - 95%	0.1	0.5	0	0	0	0.5
13	96 - 100%	0	0	0	0	0	0
Mean		6.16	6.54	5.9	5.77	6.63	6.26
Std. Deviation		1.69	1.59	1.8	1.63	1.56	1.67

Table 5 presents bivariate correlations (Spearman's rho, two-tailed) between the six use frequency variables for the full sample and each of the subject areas. For the full sample significant negative correlation was found between in-lecture media use across all media and academic performance ($\rho = -.055, p < 0.05$). The correlation was slightly stronger and also significant ($\rho = -.081, p < 0.01$) when only the use frequencies of the three social media, as presented by LSM, were considered.

Table 5: Correlations between academic performance and media use.

Subject Area	N	GU	GSM	GUT	LU	LSM	LUT
All	1672	-.029	-.031	-.013	**-.055***	**-.081****	-.013
ASS	222	**-.143***	-.096	-.112	**-.239****	**-.174****	**-.226****
EMS	352	.046	.022	.064	.030	.014	.050
ENG	401	**-.113***	**-.127***	-.047	-.056	-.096	-.002
MHS	263	-.064	**-.123***	.026	-.060	-.113	-.008
NAT	196	.045	-.009	.080	-.117	**-.157***	-.054

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

For students in Arts and Social Science ($n = 222$) negative correlations with academic performance were found between general use across all media ($\rho = -.143, p < 0.05$), in-lecture use across all media ($\rho = -.239, p < 0.01$), in-lecture use of social media ($\rho = -.174, p < 0.01$) and in-lecture use of utilitarian media ($\rho = -.226, p < 0.01$). For students in Engineering ($n = 401$) negative correlations were found between academic performance and general use across all media ($\rho = -.113, p < 0.05$) as well as general use of social media ($\rho = -.127, p < 0.05$). For Medical and Health Science ($n = 263$) general use of social media correlated negatively with academic performance ($\rho = -.123, p < 0.05$) and for Natural Science ($n = 196$) in-lecture use of social media correlated negatively with academic performance ($\rho = -.157, p < 0.05$). For the faculty of Economic and Management Science ($n = 352$) no significant correlations were found between any of the six use variables and academic performance.

Finally, to address our primary research question, we performed the Fisher r-to-z transformation to determine the significance of the differences between subject areas in terms of the correlations found between in-lecture use (LU) and academic performance. The results are shown in table 6. Statistically significant differences were found between ASS and EMS, ASS and ENG, as well as ASS and MHS.

Table 6: Significance of differences between correlations for in-lecture media use and academic performance calculated using the Fisher r-to-z transformation.

	ASS	EMS	ENG	MHS
EMS	**-3.18****			
ENG	**-2.23***	1.17		
MHS	**-2.00***	1.1	-0.05	
NAT	1.28	-0.98	-0.7	-0.6

*. Difference is significant at the 0.05 level (2-tailed).

**. Difference is significant at the 0.01 level (2-tailed).

5. Discussion

Our findings suggest that the influence of general and in-lecture media use on academic performance among university students differs depending on subject area. Previous studies have relied predominantly on data obtained for students in Social Science programs and, as confirmed by our own data, there is evidence of a negative correlation between in-lecture media use and academic performance for this subject area. There is also evidence of weak correlation between in-lecture social media use and academic performance for students in Natural Science. However, this study has found that in-lecture media use is not a predictor of academic performance in other subject areas. In terms of general media use we found that the use of social media is a predictor of academic performance for students in Engineering and Medical and Health Sciences.

From these findings emerges the question of why these differences exist. More specifically, which aspects of a particular subject area may influence the relationship between students' level of media use and their academic performance. Identification of such aspects would be an important step towards understanding the possible mechanism(s) by which media use may influence academic performance. We briefly propose three (not mutually exclusive) interpretations of our findings.

1. Perhaps the most obvious interpretation is that students from a particular subject area demonstrate, as found by Chen and Ji (2015) and Osterman (2015), a degree

of similarity in terms of *thinking style*. It should be acknowledged that, while this effect may result from the preferences of students when selecting their major subjects, thinking styles may also be nurtured by nature of content and pedagogical styles of different subject areas. This point is well articulated by Kolb (2014, p. 241) who states that: "For students, education in an academic field is a continuing process of selection and socialization to the pivotal norms of the field governing criteria for truth and how it is to be achieved, communicated and used, and secondarily, to peripheral norms governing personal styles, attitudes and social relationships". It follows, that our observation of differences between subject areas may actually reflect differences between various thinking styles, represented by the proxy variable of faculty.

This interpretation suggests that thinking styles, through their dictation of the utilisation of cognitive processes, impact multitasking performance during the learning process. Some thinking styles, accordingly, may be more or less resilient than others to the costs associated with media use during lectures. In the context of our findings this would suggest that the non-linear, abstract thinking style generally associated with students of the social sciences/humanities (Spink and Park, 2005; Osterman, 2015; Chen and Ji, 2015) involves cognitive processes which are more susceptible to the costs of interference during learning.

Closely related to this interpretation is the argument that students from different subject areas may demonstrate different personality traits which, in turn, influence information seeking behaviour. Previous studies suggest, firstly, that thinking style and personality traits are related (Zhang, 2002) and, secondly, that these traits influence information seeking behaviour (Heinstrom, 2006). Heinstrom (2006) found that individuals with an "energetic personality, high motivation, and positive emotionality" are more likely to find useful or interesting information while not consciously looking for it (incidental acquisition) (Heinstrom, 2006, p. 588). Our data does not justify conclusions to be drawn in this regard, we suggest future research to consider both thinking style and personality measures in relation to multitasking performance.

2. A second interpretation concerns the nature of the content being taught/learned as opposed to attributes of the learners. This view considers the possibility that certain

attributes of the content being taught during a lecture make the effectiveness of the learning process more/less susceptible to subjective media-induced interferences. Our data suggest that media-induced distractions may be more influential during the teaching of content associated with social science subject matter than during the teaching of other subject areas. The oft-used distinction between soft and hard disciplines provides a high-level indicator of the epistemological differences between subject areas. While hard disciplines are characterised by "the quantitative nature of knowledge", which requires numerical calculation and experimental skills, the soft disciplines are characterised as "free-ranging and qualitative, with knowledge-building a formative process and teaching and learning activities largely constructive and interpretative" (Neumann et al., 2002, p. 408). Our findings suggest that the effective acquiring of knowledge during lectures in a soft discipline may be more sensitive to media-induced interference.

3. Finally, the use of academic performance as dependent variable implies that comparison across subject areas will be influenced by the existence of differences in academic assessment policies and norms between areas. Accordingly, the finding that social science students' performance correlates negatively with in-lecture media use may suggest that assessment methods used in this subject area are more sensitive to students' receptiveness during lectures as opposed to, for example, their time spent preparing for tests. This is, of course, reflected in the *assessment* styles adopted by different disciplines. Neumann et al. (2002, p. 408) found that "science-based subjects are more likely to utilise assessment tasks that emphasise the acquisition of knowledge blocks in a cumulative process, whereas in the humanities and social sciences, together with the social professions (soft pure and soft applied fields), assessment tasks emphasise knowledge application and integration, usually in essay or explanatory form". Unlike the assessment of, for example, a mathematical calculation that enables objective verification of correctness, the assessment of essays is, in principle, influenced by assessor subjectivity. One may expect, accordingly, a degree of correspondence between the assessor's interpretation of content, implicitly communicated through his/her teaching, and the assessment standards applied. This correspondence, in turn, would be reflected

in association between attentiveness during lectures and academic performance.

Our findings imply that the relationship between media multitasking and academic performance may be more nuanced than suggested by earlier work on this topic. The bias towards students of the social sciences observed in previously published studies may have obscured the complex interplay between the nature of knowledge, the cognitive processes by which it becomes acquired and assessed, and the role of media induced interferences in these processes.

Educators should be mindful in their interpretation of our findings. Specifically, we do not reject Kirschner and De Bruyckere (2017)'s argument that members of the net generation have no particular aptitude for multitasking. Our data do not provide sufficient evidence that media use during lectures only impact the learning performance of students in arts and social sciences, while their peers in other subjects are not susceptible to these effects. We propose, rather, that attention be paid to the role that subjective attributes like thinking style and personality type play in determining learners' sensitivity to interference. In addition, we encourage careful attention to the role of the nature of content in a particular discipline and the implication thereof for learning.

From a research perspective we believe more studies are required that investigate the underlying cognitive processes that result from media-induced interferences. We suggest that future research be undertaken to investigate, firstly, whether the subject area differences reported here also exist at other learning institutions. Secondly, we call for studies to test the validity of the three interpretations we propose by considering thinking style, nature of content and forms of assessment as independent variables.

Finally, we have to acknowledge a number of limitations in our research design. The first is that all our data, including respondents' academic performance, are self-reported. Secondly, the use of students' home faculty as a proxy variable for subject area may imply an oversimplification of the construct. The use of faculty assumes a degree of correspondence in the nature of academic work performed in programs and courses presented by a particular faculty. We acknowledge, however, that some overlap exists in this regard. More textured data (e.g., academic performance in particular courses) may provide better insight into how the nature of content moderates the correlation between media use and academic

performance.

6. Funding Sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Appendix A. Articles used in the subject area review

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