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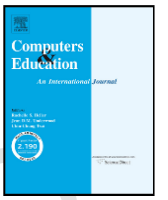

Can digital technologies improve students' efficiency? Exploring the role of Virtual Learning Environment and Social Media use in Higher Education

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ABSTRACT

Digital technologies, including Virtual Learning Environment (VL) and Social Media (SM), are well adopted in the Higher Education (HE) setting, yet little is known about the role these tools play in supporting students' achievement of HE goals. This research is the first to examine student efficiency by uncovering the direct links between HE inputs and outputs in consideration of technology use. Building on service productivity theory, a two-phase approach is adopted to empirically examine if VL and SM use enhances students' efficiency in HE goals attainment. The first phase identified a range of HE inputs and outputs perceived by HE students via structured interviews. Through questionnaires, the second phase revealed how technology use changed the input-output transformation. Our findings suggest that students are better off without relying on digital technologies. While VL can enhance students' HE goals achievement with additional inputs, students who use SM are the least efficient. This encourages further work to devise more diligent use of VL and SM under the HE setting.

1. Introduction

The latest Student Academic Experience Survey (2019) reveals that less than one in four Higher Education (HE) students perceive their HE experience to be better than expected, while over 65% of students report a mixed experience, and the rest remain rather underwhelmed by their HE experience. According to the survey results, one reason for such a poor evaluation is the limited support that students receive while working towards the attainment of HE goals. To enhance students' experience, HE institutions increasingly adopt digital technologies, such as Virtual Learning Environment (VL) and Social Media (SM), aimed at supporting students in their efforts to achieve specific HE goals (Selwyn, 2008, 2014; Tess, 2013; Waheed et al., 2020). Existing literature, however, presents a complex picture of the impact of these digital tools on students' learning and HE goals achievement (Lin, 2012; Hernandez-Lara et al., 2019; Kauppi et al., 2020). Although there is some evidence in favour of VL use in the HE context (Cho & Shen, 2013; Sobaih et al., 2016), its somewhat limited functionality is considered a significant weakness (Manca & Ranieri, 2013; Sobaih et al., 2016). While SM addresses some of the technological limitations of VL, research on SM use in HE is largely inconsistent, with some questioning its suitability to the HE context (Tess, 2013; Au et al., 2015; Lau, 2017). Finally, previous research indicates that students achieve HE goals with or without technology use (Margaryn et al., 2011), which questions the extent to which digital tools support students in their efforts to achieve HE goals.

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In light of those inconsistent views, Henderson et al. (2017) appeal to HE institutions not to rely on digital tools as '*better understanding of the realities of student encounters with digital technologies*' (p. 1567) is needed. With research seeking to identify the true potential of digital technologies in HE (Henderson et al., 2017; Manca & Ranieri, 2013), drawing from productivity theories, we aim to empirically examine if the use of VL and SM enhances students' efficiency in HE goals attainment, or if HE students are better off without digital tools.

2. Digital technologies in Higher Education

Digital technologies are well integrated in the HE setting (Bowe, 2015; Henderson et al., 2017; Hernandez-Lara et al., 2019). Their application in HE reflects not only the trajectory of technological advancements, but also a change in the means adopted by students working towards the attainment of HE goals, and HE institutions supporting students' efforts (Conole et al., 2008). For example, VL, traditionally used in HE, reflects a '*teacher-centred*' approach to teaching and learning, and aims to provide students with access to learning resources via a computer-based environment (Wilson, 1996). The recent trend of SM use in HE diverges the movement towards a '*student-centred*' approach (Evans, 2014; Manca & Ranieri, 2013; Selwyn, 2014; Tess, 2013; Wang et al., 2012). SM refers to '*a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of user-generated content*' (Kaplan & Haenlein. 2010, p. 61).

In the HE landscape, the introduction of technologies such as VL and SM attracted much research attention. Building on technology adoption theories, one stream of research explored determinants towards adoption and subsequent use of digital tools by HE students and staff alike (e.g. Lemay et al.,2019; Garone et al.,2019; Shen & Hi, 2020; Khechine et al.,2020). As VL and SM became a norm in HE, research attention moved towards an exploration of consequences of the use of those digital tools. In this most recent research stream, the positive impact of VL use is acknowledged (García-Martín & García-Sánchez, 2018; Waheed et al., 2020). It has been noted that VL use increases course enrolment (Nunes & McPherson, 2003; Wang et al., 2012), it supports course organisation, and the management of learning resources (Cantabella et al., 2018). Furthermore, VL use has been found to facilitate collaborative learning, prompting HE students' interaction with the faculty (Lonn & Teasley, 2009; Wang et al., 2012), which increases students' engagement (Gunuc & Kuzu, 2015). This subsequently improves education quality and enhances HE students' ability to learn, resulting in better academic performance (Cantabella et al., 2018; Cho & Shen, 2013). Similar to VL, the value of SM in HE is recognised (Lau et al., 2017; Sobiah et al., 2016). Specifically, the application of SM has been found to enhance communication, leading to a greater involvement and engagement among HE students (Evans, 2014; Irvin et al., 2012; Kaplan & Haenlein, 2016; McCarthy, 2010), which has enhanced their performance (Lee & Tsai, 2011).

Despite the range of benefits outlined above, concerns about the application of VL and SM in HE have been raised (Monca & Ranieri, 2016; Rana et al., 2019; Sobaih et al., 2016). VL has been criticised for its limited functionality related to unidirectional information flow (Monca & Ranieri, 2016; Sobaih et al., 2016), and concerns related to SM use in HE have been widely debated (Au et al., 2015; Irvin et al., 2012; Shoaih et al., 2016; Tess, 2013). This is because, unlike VL, SM has not been created in the educational context, and as a result, it has '*very little educational use*' (Hew, 2011, p. 668). Hew (2011) for instance, noticed that students tend to adopt SM for social exchanges rather than collaborative learning. As such, although SM addresses some of the limitations of VL by enabling two-way synchronous as well as asynchronous communication (Kaplan & Haenlein, 2010), it does not encourage peer interaction and group-oriented learning (Ajjan & Hartshorne, 2008; Gao et al., 2012; Monca & Ranieri, 2016; Tess, 2013). Moreover, its use was found to lead to information overload which, in order to be processed, requires an unlimited amount of time spent on SM (Gao et al., 2012). Excessive application of SM may induce an undesirable impact on students' performance (Junco, 2012; Lau, 2017). Such an adverse effect on students (Meier et al., 2016; Paul et al., 2012), coupled with ethical concerns related to SM use including social exclusion, digital dividedness, and privacy concerns (Timmis et al., 2015), makes researchers question the suitability of SM in HE (Hew, 2011).

In light of these varying views, research cautions HE institutions from '*over-privileging*' technologies such as VL and SM in the HE setting (Selwyn, 2009; Henderson et al., 2017), and calls for more in-depth investigation over the consequences of those tools use in HE (Henderson et al., 2017). This assessment is particularly important in the context of students' HE goals attainment (Manca & Ranieri, 2013), since previous research questions the role of digital technologies in HE, claiming that students achieve HE goals without the use of technology (Margaryn et al., 2011). Thus far, however, there is a lack of empirical evidence concerning the role that VL and SM play in supporting students' HE goals attainment (Margaryn et al., 2011). With research seeking to identify the true potential of digital tools and the extent to which they can support students' in their efforts to achieve HE goals (Henderson et al., 2017; Manca & Ranieri, 2013), this paper aims to examine if the use of VL and SM enhances students' efficiency in achieving HE goals, or if HE students are better off without using digital technologies. To address this aim, we consult productivity theories.

3. Productivity theory

Productivity, simply defined as a ratio of inputs (i.e. resources needed to produce outputs) to outputs (i.e. product or service), is a strategic goal of every organisation, including HE institutions (Rana et al., 2019; Bodily et al.,2019). Productivity, and thus an input-output ratio, is calculated on the basis of efficiency (Johnston & Jones, 2004), which refers to the degree to which an activity generates a given quality of outputs within a minimum consumption of inputs (Gronroos & Ojasalo, 2004; Ismo et al., 1998; Xue & Harker, 2002). Although traditionally productivity has been examined from a product producer perspective (Johnston & Jones, 2004; Rust & Huang, 2012), an evaluation of inputs to outputs ratio is equally important for service producers, such as HE institu-

tions (Johnston & Jones, 2004; Rana et al., 2019; Sahney et al., 2004). The assessment of productivity, however, does not carry over in the same way to service producers (Johnston & Jones, 2004). One of the reasons for such a discrepancy is the type and nature of inputs and outputs, while another is a consumer role in service productivity. Specifically, service consumers do not only consume the service, but they are also engaged with service co-production (Anitsal & Schumann, 2007; Xue & Harker, 2002). This dual role of the consumer in service production is highlighted in the HE context, where Sahney et al. (2004) explicitly notes that HE students are consumers contributing to educational service provision. This is further confirmed by Gadrey (1988) and Jääskeläinen and Lönnqvist (2011), who state that HE institutions' outputs refer to education course provision, whereas HE students' outputs (i.e. service consumer outputs) concern learning. Although research urges more investigations over the consumer role in service provision (Anitsal & Schumann, 2007), with few exceptions (e.g. Anitsal & Schumann, 2007; Johnston & Jones, 2004; Xue & Harker, 2002), there is little empirical research exploring consumers' service inputs and outputs (Anitsal & Schumann, 2007). This is particularly evident in the HE context, as within HE literature there is a clear lack of productivity research in light of the student standpoint (Rana et al., 2019; Whitaker et al., 2016).

In order to account for an active role of consumers in service production, and particularly the assessment of outputs and inputs required in the co-production of service, the term '*consumer efficiency*' was coined (Xue & Harker, 2002). Consumer efficiency is the correlation between the service '*output experienced by the consumer*' and '*the inputs provided by that consumer as a participant in service production*' (Parasuraman, 2002, p. 6), or, in other words, the degree to which the consumer experiences the service outputs to service inputs they supplied (Anitsal & Schumann, 2007).

Due to the nature of inputs and outputs which are perceived by the consumer (Anitsal & Schumann, 2007; Parasuraman, 2002), it is challenging yet beneficial to measure consumer efficiency. The application of digital technologies in service provision makes this task even more perplexing. This is because although technologies can reduce the number of service producer inputs to achieve a given output or outputs, the application of those tools to service may have a detrimental impact on consumer input-output ratio (Rust & Huang, 2012). Thus, although an incorporation of digital technologies in service production and delivery is attractive for service providers (Anitsal & Schumann, 2007; Baines & Lightfoot, 2014), it may have a negative impact on consumer efficiency (Gronroos & Ojasalo, 2004; Rust & Huang, 2012), which can be understood by the fact that improvement in one productivity type is invariably compensated by deterioration in another type (Parasuraman, 2002).

Technologies are transforming service provision including the HE sector (Rana et al., 2019*)* where digital technologies such as VL and SM have been increasingly adopted. HE institutions perceive them as solutions to growing pressures in order to offer a better HE experience with a reduced number of inputs (Whitaker et al., 2015). As evident from Student Academic Experience Survey (2019) however, despite the availability of VL and SM in HE, students do not feel supported while working towards HE goals attainment, which may indicate detrimental impact of those tools on students' efficiency. With this in mind, the impact of digital tools on HE students, and specifically student efficiency, has to be empirically examined. Thus, in order to gain an understanding of the impact of VL and SM on students' input-output ratio, and to assess whether VL and SM use enhances students' efficiency in HE goals attainment or if those tools are disturbing the student experience and distract from HE goals attainment (Henderson et al., 2017), we conduct two-phase research employing the research methodology described below.

4. Methodology

To achieve the research aim, a two-phase approach is adopted in which the first phase of the research is exploratory in nature, with the focus on the identification of HE students' inputs and outputs for measuring student efficiency (Xue & Harker, 2002). This took a form of structured interviews to identify a list of HE inputs and outputs, as opposed to gaining an in-depth understanding of inputs and outputs achieved, which is beyond the scope of this research. Specifically, structured interviews were conducted with students attending courses from across a range of faculties within a UK-based HE institution. To obtain a holistic view on the range of inputs and outputs, views of HE students were triangulated with that of the faculty and student support staff. In total, 25 structured interviews were conducted in early 2019, which allowed us to reach theoretical saturation and identify HE students' inputs and outputs. 8 undergraduate students, 8 postgraduate students, and one research student took part in the first research phase. Among them, 12 were male and 5 were female. The data triangulation was done between this student sample, 5 faculty members and 2 IT support staff.

According to Xue and Harker (2002) '*Consumer A is evaluated as more efficient than Consumer B if consumer A consumes fewer inputs to produce at least the same amount of certain outputs as Consumer B, or if Consumer A produces more outputs using at most the same amount of certain inputs as Consumer B*' (p.256). Therefore, to examine the number of inputs and outputs, quantitative assessment is required. In the second research phase, informed by qualitative research findings a questionnaire (as shown in the appendix) was developed and pilot tested. Using the 7-point Likert scale, respondents are asked to assess the importance of inputs and HE output in three different scenarios, i.e. in general – when digital technologies are not used, when VL is used, and when SM is used. The relative importance of each output was then normalised in each scenario in order to facilitate comparison, i.e. the sum of relative importance of all outputs is equal to 1 in each scenario.

A questionnaire was distributed to HE students across the UK via online channels. The final sample consisted of HE students who met the sample selection criteria by declaring that (1) during our study period they were registered on an undergraduate, postgraduate or research programme at a UK-based University, and (2) while conducting their studies, they were using VL and SM for HE learning and goals achievement. In total 229 fully completed responses were collected, all of which met the sample selection criteria. As shown in Tables 1 and 57.6% and 41% of respondents were female and male respectively. 59% of them fell into 18–22 age

Table 1
Quantitative research stage-demographic characteristics.

	Option	Count	%
VL use	YES	229	100
	NO	0	0
SM use	YES	229	100
	NO	0	0
Gender	Female	132	57.6
	Male	94	41.0
	Prefer not to tell	3	1.3
Age	18–22	135	59.0
	23–27	46	20.1
	28–31	14	6.1
	32–36	21	9.1
	37 and older	13	5.7
Faculty	Engineering	74	32.3
	Business School	82	35.8
	Humanities	26	11.4
	Science	47	20.5
Nationality	UK	143	62.4
	EU	34	14.8
	International (Non-EU)	52	22.7

group category; 20% were in the 23–27 age group; and 21% were 28 years old or older. The sample consists of HE students who studied at four main faculties; Business (35.8%), Engineering (32.3%), Science (20.5%), and Humanities (11.4%). 62.4% of respondents were UK nationals, 22.7% identified themselves as international students, and 14.8% of them were from the European Union.

5. Findings

The first research phase uncovered a number of inputs and outputs which are deemed important in the HE setting (Author1 & Author2, 2019). These HE outputs include LEARNING, which comprises of aspects such as grades and degree, and COGNITIVE outputs, which refer to students' gaining domain-specific knowledge. In line with Jääskeläinen and Lönnqvist's (2011) research, KNOWLEDGE TRANSFER outputs related to networking opportunities, are also recognised as an important HE output obtained by students. The prominence of skills development, termed as SKILLS, was highlighted, with the focus on a range of transferable skills including communication and team-building skills. The importance of skills as the HE outcome has been recently confirmed by Tseng et al. (2019). Finally, participants in the qualitative research phase noted that PSYCHOLOGICAL outputs are also the outcomes of students' HE experience, which includes confidence building, feelings of satisfaction, and a sense of accomplishment.

Quizzed on the inputs needed to accomplish the above listed HE outputs, respondents revealed that TIME, FINANCIAL RESOURCES as well as RESOURCES (non-financial such as computer, Internet access), are crucial to obtain HE goals. In addition to those three fundamental inputs, prior skills and knowledge, termed as SKILLS and COGNITIVE inputs respectively, are needed to succeed as an HE student. Finally, respondents acknowledged the role of SUPPORT inputs (such as family and faculty support), and PSYCHOLOGICAL inputs (such as resilience and motivation), in their efforts to accomplish specific HE goals. Table 2 outlines all identified inputs and outputs.

Following the qualitative research phase, Partial Least Squares Structural Equation Modeling (PLS-SEM) using SmartPLS 3.27 (Ringle et al., 2015) was employed in the quantitative assessment. A variance-based approach was deemed appropriate since the

Table 2
HE inputs and outputs.

HE Input	HE Output
TIME (T_I)	LEARNING (L_O)
RESOURCES (R_I)	KNOWLEDGE TRANSFER (KT_O)
FINANCIAL RESOURCES (FR_I)	COGNITIVE (C_O)
COGNITIVE (C_I)	SKILLS (SK_O)
SKILLS (SK_I)	PSYCHOLOGICAL (P_O)
SUPPORT (SU_I)	
PSYCHOLOGICAL (P_I)	

core focus of this research is to explain the impact of multiple inputs on multiple outputs that together define consumer (i.e. HE student) efficiency (Hair et al., 2016). Before the assessment of the quality of the three measurement models explaining the inputs and outputs ratio under three scenarios; in general, VL use and SM use, data reliability and validity were confirmed.

Reliability captures the degree to which a given measure generates consistent outcomes under similar conditions, and is typically assessed through both composite reliability (CR) and Cronbach's Alpha coefficients. Validity reflects the degree to which a group of indicators jointly measure input or output, and is assessed through items' loadings and the Average Variance Extracted (AVE) coefficient to capture convergent validity, and the square roots of AVE to capture discriminant validity (Hair et al., 2016). In this study, all indicators displayed loadings exceeding 0.5, CR and Cronbach's Alpha estimates were above the cut-off value of 0.7 (Schmiedel et al., 2014), AVE scores exceeded the 0.5 threshold, and square root of AVE of each construct was greater than the correlations involved in the remaining constructs (Fornell & Larcker, 1981). Therefore, reliability and validity can both be established as reported in Table 3. Lastly, multicollinearity issues were also examined through the variance inflation factor (VIF). In this respect, no major issues of collinearity emerged as all VIFs values ranged between 1.6 and 6.8 for the three measurement models.

Next, the three structural models for all three scenarios (i.e. in general, VL use, and SM use) were assessed. Table 4 shows the explained variances, in terms of coefficient of determinations (R^2), for all output dimensions under all three scenarios. Explained variances show the extent to which the dependent variables (outputs) are predictable by the independent variables (inputs). In the general scenario, 12.5%–20.5% of the variances in all outputs were predictable by all inputs; with VL use, 8.2%–18.5% of the variances in all outputs were predictable by all inputs; and with SM use, only 4.2%–9% of the variances in all outputs were predictable by all inputs. Based on the R^2 we note that technology use tended to dilute the impact of inputs on outputs. In other words, efficiency of output attainments decreased when VL was used, and declined further when SM was used.

Table 5 shows the correlations, with path coefficients and significance levels, between all inputs and all outputs under three scenarios (i.e. in general, VL use and SM use). To reinforce the findings reported in Table 4, it is noted that the total number of significant positive correlations (at least $p < 0.05$) between inputs and outputs dropped from 9 (in the general scenario), to 7 (VL use) and finally 3 (SM use).

In addition to the reduction in the total number of significant positive correlations, technology use appears to change the landscape of student efficiency by altering and removing the correlations between inputs and outputs. For example, one of the inputs, TIME (T_I), was deemed to be a significant driver to an output, SKILLS (SK_o), in the general scenario. When VL was considered, T_I was found to be an insignificant driver to SK_o but significant to LEARNING (L_O). T_I did not have a significant impact on any outputs when SM was considered. For ease of presentation, all significant ($p < 0.05$) positive input-output correlations under the three scenarios are visually presented in Fig. 1, and discussed in detail below.

Table 3
Cronbach's alpha, CR and AVE.

	Dimension (Construct)	In general			VL			SM		
		Cronbach's Alpha	CR	AVE	Cronbach's Alpha	CR	AVE	Cronbach's Alpha	CR	AVE
Output	L_O	0.933	0.948	0.751	0.873	0.899	0.600	0.878	0.907	0.619
	KT_O	0.827	0.920	0.852	0.857	0.933	0.874	0.839	0.925	0.861
	C_O	0.835	0.924	0.858	0.662 #	0.849	0.739	0.800	0.909	0.833
	SK_O	0.938	0.951	0.763	0.917	0.935	0.706	0.884	0.906	0.618
	P_O	0.961	0.967	0.786	0.951	0.959	0.747	0.942	0.952	0.714
Input	SK_I	0.909	0.907	0.668	0.909	0.869	0.574	0.909	0.932	0.733
	SU_I	0.885	0.924	0.801	0.885	0.925	0.806	0.885	0.926	0.806
	P_I	0.961	0.967	0.808	0.944	0.959	0.854	0.961	0.968	0.811

Cronbach's Alpha is generally sensitive to the low number of items.

Table 4
Explained variance of all output dimensions.

	R^2		
Output	In general	VL	SM
L_O	0.143	0.180	0.090
KT_O	0.138	0.185	0.057
C_O	0.125	0.082	0.084
SK_O	0.205	0.105	0.042
P_O	0.177	0.082	0.064

Table 5
Structural Models showing correlations between inputs and outputs.

Input	Output														
	In general					VL					SM				
	L_O	KT_O	C_O	SK_O	P_O	L_O	KT_O	C_O	SK_O	P_O	L_O	KT_O	C_O	SK_O	P_O
T_I	0.28	0.289	0.264	0.288*	0.193	0.559***	0.257	0.146	0.194	0.24	0.343	0.165	0.088	0.099	0.092
R_I	0.037	−0.025	−0.124	0.042	0.24	0.016	0.217*	−0.034	0.154	0.071	0.255	−0.074	0.382**	0.22	0.258
FR_I	0.127	0.253**	0.164*	0.200*	0.150*	0.118	0.174*	0.066	0.011	0.046	−0.133	0.105	−0.12	−0.072	−0.07
C_I	0.028	−0.182	−0.01	−0.176	−0.271**	−0.274*	−0.138	0.181	−0.027	−0.178	−0.273	0.154	−0.107	−0.254	−0.217
SK_I	−0.217	−0.05	−0.215	−0.231	−0.323	0.093	0.252	0.079	0.09	0.046	0.057	0.188	−0.217	0.032	0.054
SU_I	0.230*	0.169	0.312**	0.393***	0.360***	0.198*	0.084	0.202*	0.250**	0.244**	0.185	−0.049	0.253*	0.132	0.200*
P_I	−0.552***	−0.413*	−0.343	−0.434**	−0.22	−0.568**	−0.654***	−0.534**	−0.570**	−0.342	−0.352*	−0.293	−0.158	−0.085	−0.173

Significance level: * 0.05, ** 0.01, *** 0.001.

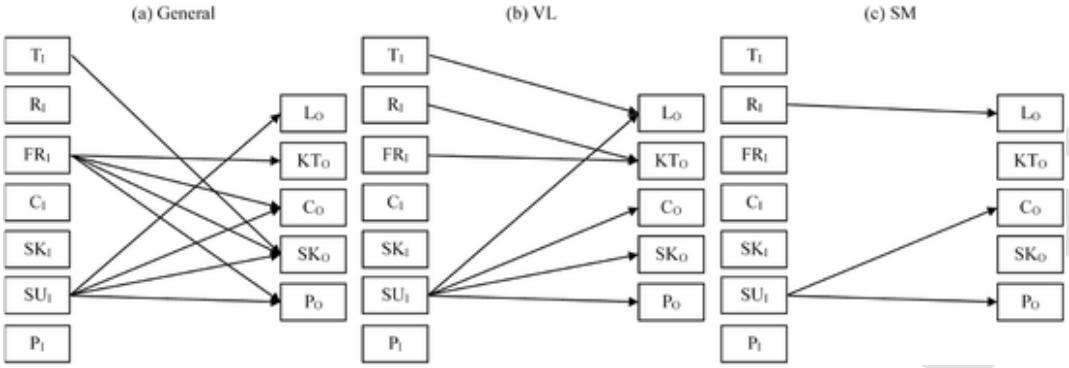

Fig. 1. Input-output correlations under (a) in general; (b) VL use; and (c) SM use.

As can be seen in Fig. 1a, there are nine significant correlations in the general scenario. Three inputs, T_I, FR_I, and SU_I, collectively lead to all five outputs. In particular, T_I leads to SK_O; FR_I results in KT_O, C_O, SK_O, P_O; and SU_I leads to L_O, C_O, SK_O and P_O. When VL is considered (see Fig. 1b) T_I leads to L_O but its impact on SK_O disappears; we also observe that FR_I becomes less influential - it leads to KT_O only. The impact of SU_I on outputs is the same as in the general scenario, specifically SU_I leads to L_O, C_O, SK_O and P_O. Moreover, when VL is used, RESOURCES (R_I) are needed as an input, which lead to KT_O. Finally, Fig. 1c depicts correlations of inputs and outputs when SM is considered. It appears that T_I and FR_I do not lead to any output, SU_I leads to C_O and P_O, which is consistent with the other two scenarios, and R_I appears to impact L_O which is specific to outcomes attainment when SM is used.

Based on the results of correlation analysis of inputs-outputs in the three scenarios, it is evident that the same set of productivity outputs can be achieved when HE students do not use technology and when they use VL. In both scenarios, the following HE outputs can be achieved: L_O, C_O, SK_O, and P_O. In order to achieve these outputs, however, fewer inputs are required when technologies are not used, than when VL is used. Following Xue and Harker's (2012) assertion, therefore, HE students who do not use technologies to achieve HE goals are more efficient than students who use VL to achieve the same set of HE goals. The results of the analysis reveal that HE students are the least efficient when they use SM. This is because although they use fewer inputs, they also obtain fewer outputs in comparison to the general scenario.

To reveal if technologies enhance achievement of HE outputs, the strength of correlations between inputs and outputs is considered next (see Table 5). As evident from Fig. 2, when VL is considered (Fig. 2a), five input-output correlations (solid lines) remain the same as in the general scenario, i.e., $FR_I \rightarrow KT_O$, $SU_I \rightarrow L_O$, $SU_I \rightarrow C_O$, $SU_I \rightarrow SK_O$, and $SU_I \rightarrow P_O$. Among these five correlations, L_O and KT_O can be enhanced through VL use. This, however, requires the presence of new inputs (T_I and R_I) as depicted by the two new correlations (dotted lines), i.e. $T_I \rightarrow L_O$ and $R_I \rightarrow KT_O$. In other words, there is no improvement in student efficiency when VL is used, as the enhancement of HE outcomes relies on additional inputs, i.e. T_I and R_I. When SM is considered (Fig. 2b), only two correlations remain, i.e. $SU_I \rightarrow C_O$ and $SU_I \rightarrow P_O$. The two outputs (C_O and P_O) are not enhanced when SM is used. A new correlation is noted between R_I and L_O, although there is no sign of efficiency improvement unlike when VL is in use.

In conclusion, this research reveals that the application of VL and SM in the HE sector has no positive impact on student efficiency. This finding greatly contradicts our understanding that the use of technology can improve HE goals attainment. This study

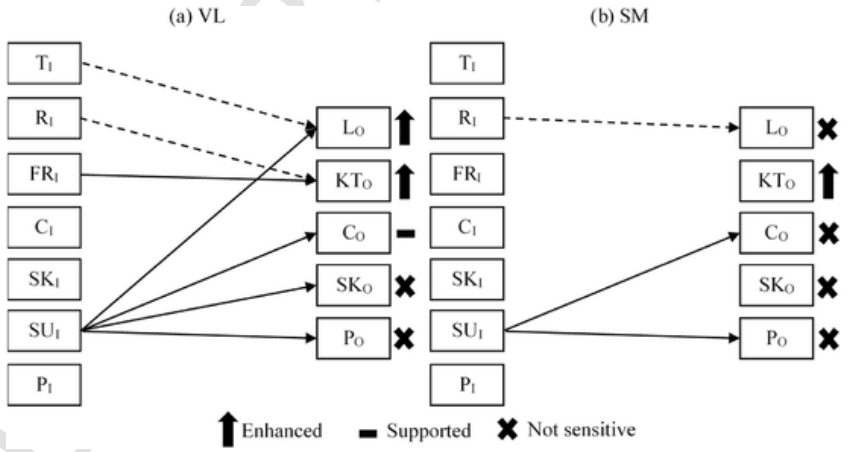

Fig. 2. Impact of (a) VL use and (b) SM use on student efficiency.

reveals that HE students are the most efficient in the process of achieving HE goals if they do not use digital tools such as VL and SM.

6. Discussion and conclusion

Although digital technologies are well integrated in the HE setting, their impact on students' HE goals attainment has not been empirically verified. Building on the productivity theory and consumer efficiency, this study aims to empirically examine if technologies such as VL and SM support students in HE goals attainment. By doing so, this research complements the recent work of Laurell et al. (2020), which revealed that SM improves academic productivity – we aim to assess if SM, as well as VL, impact productivity of students. To accomplish this aim, we first carried out qualitative investigation, through which a range of inputs and HE outputs, as perceived by HE students as service consumers, were identified. We also reveal a set of inputs students need to accomplish HE goals. To the best of authors' knowledge, this is the first study addressing students' inputs and HE outputs.

Employing PLS-SEM, we are the first to uncover the direct relationship between inputs and outputs in three scenarios; in general when student efforts are not supported by digital technologies, when students use VL, and when SM is used to achieve specific HE goals. The findings of our quantitative examination reveal that students are the most efficient in achieving a range of HE outputs if they don't use digital technologies in their effort to achieve HE goals. We also show when students use VL they are able to gain the same set of outputs, but the achievement of those outputs requires additional inputs, which has a negative implication on their efficiency. We find that the use of VL supports COGNITIVE outputs and enhances the accomplishment of both LEARNING and KNOWLEDGE TRANSFER goals; however, such enhancement requires additional inputs, specifically TIME and RESOURCES, which according to productivity and consumer efficiency theories (see Xue & Harker, 2002) makes HE students less efficient while working towards HE goals attainment. Our research findings suggest that HE students are the most efficient without relying on digital tools use; the use of VL requires additional resources to accomplish HE goals. Based on those results, we echo Henderson et al., (2017, p. 1577) who mention that digital technologies are apparently not '*transforming*' but '*disrupting*' the HE teaching and learning. This finding is supported by Margaryn et al. (2011) who advises moderate use of technology in teaching and learning. Specifically, we note positive role of VL in HE setting, which Waheed et al. (2020) notes, has positive impact on students.

Our research also reveals that students who use SM are the least efficient in HE goals achievement. This is because SM use results in an achievement of fewer outputs. This finding reinforces the assertion of Selwyn (2008) and Au et al. (2015), who suggest that SM does not enhance formal studies. Additionally, it also supports Hew (2011) and García-Martín and García-Sánchez (2013), who note that SM has very little educational application and that of Lau (2017) who notes that SM use does not impact student performance. We note, however, that SM use is deemed effective while developing network connections through KNOWLEDGE TRANSFER, as it assists HE students in identifying business opportunities (Benson & Filippaios, 2015), and therefore SM fulfils its core role of facilitating social exchanges (Hew, 2011) as well as social development (García-Martín & García-Sánchez, 2015).

There are a number of theoretical and practical implications derived from our research findings. First, the current research offers empirical evidence to support the gaps between students' experiences and institutions' expectations when using digital technologies (Henderson et al., 2017). This paper is the first to examine the impact of VL and SM use on students' HE goals attainment. Specifically, we are the first to investigate the correlation between adoption of digital technologies and student efficiency by first uncovering a range of inputs and outputs as perceived by HE students, and then uncovering direct links between inputs and outputs in the HE setting to reveal HE students' efficiency.

Second, we show that HE students are better off not using technology while working towards HE goals attainment. The findings of this research therefore contradict the popular view that digital technologies support students in those efforts. We are the first to reveal that HE students are the most efficient without relying on digital tools such as VL and SM.

Third, although VL is believed to be outdated and does not meet the expectations of 21st century students, its use can enhance LEARNING and KNOWLEDGE TRANSFER goals, yet this requires students to utilise additional resources. Finally, our research reveals that use of SM does not support students in HE goals achievement and nor does it enhance their efficiency while working towards HE goals. On the contrary, HE students who use SM are the least efficient. We therefore question the role of SM in the HE setting. We note, however, its value for networking purposes, and therefore we acknowledge its role in establishing connections.

In addition to the theoretical implications, our research derives a number of practical implications, which HE institutions should find particularly useful post-COVID-19. We note that students are capable of achieving a range of HE goals efficiently without using technologies, and we therefore caution HE institutions from what Henderson et al. (2017) refers to as '*over-privileging*' digital tools in HE. This is particularly important post-COVID-19 when many HE institutions will rely on digital tools for teaching and learning. We believe that students' HE experience can be enhanced by offline interaction, rather than through digital means. We therefore highlight the importance of face-to-face interaction. Post-COVID-19, HE institutions may find themselves facing paradoxes related to technology use outlined by Kauppi et al. (2020). Next, we acknowledge the value of VL in the HE setting, and we encourage HE institutions to support students with the additional resources required to use VL efficiently. While preparing for teaching delivery post-COVID-19 therefore, HE institutions should consider if students have all necessary rescues to be able to use VL. These resources include computers, other electronic devices, software and network connections, which enable HE students to use VL. Finally, we discourage HE institutions from using SM as a tool supporting HE goals attainment, as our research reveals that SM does not help students achieve HE goals. HE students should be encouraged to use SM to develop networked connections instead.

Finally, we acknowledge that this study suffers from some limitations, which provide directions for future research. First, the aim of our qualitative investigation was to identify HE students' inputs and outputs, and we did not aim to obtain in-depth examina-

tion of the inputs and outputs identified. This is a subject of future work. Second, although our sample consisted of HE students using VL and SM for educational purposes, we did not measure the frequency of use or the engagement level of students. We also did not examine the type of learning activities performed by students when using VL and SM, both of which were beyond the scope of the present work. Further research could evaluate the moderating impact of these variables on HE outputs. Finally, with the focus on consumer efficiency, this study ignored other HE stakeholders (e.g., staff, faculty, organisations, parents, and society) and their inputs and outputs. In order to develop a more holistic view of HE productivity, future work should account for a larger number of HE stakeholders. In addition to the holistic perspective on the use of technologies in HE, we encourage case study research which would explore HE institutions' as well as individual teachers' strategies for VL and SM use. Such research could explore not only technology use, but also functions of those technology tools and how students and HE staff are using them.

Credit author statement

Ewelina Lacka: Conceptualisation, Methodology, Investigation, Writing – Original Draft. **T.C. Wong**: Conceptualisation, Methodology, Writing – Review & Editing, Visualisation. **Mohamed Haddoud**: Software, Formal analysis.

Appendix.

As a university student, you are invited to take part in this study that aims to assess productivity of UK universities. Performance of the organisation can be measured by productivity, which is achieved via the process of transforming inputs (what is required to produce a product or service) into outputs (a product or service produced).

First you will be asked a set of questions about your background, next you will be asked some questions regarding productivity of your University. Your answer will be completely anonymous and used for the purpose of this study only.

Thank you for your participation.

Part 1. Demographic Characteristics

1. Age
   - Under 18
   - 18-22
   - 23-27
   - 28-31
   - 32-36
   - 37 and above
2. Gender
   - Male
   - Female
   - Prefer Not to Tell
3. Are you a current university student?
   - Yes
   - No
4. Are you studying at XXX University?
   - Yes
   - No
5. What is your current level of study?
   - Undergraduate degree
   - Postgraduate degree
   - Research degree
6. In which faculty do you undertake your courses?
   - Engineering
   - Humanities and Social Science
   - Science
   - Business School
7. Are you UK, EU or an international student?
   - I am a UK student
   - I am an EU student
   - I am an International student

Part 2. From the perspective of university student, please rate the importance (1- least important; 7-most important) of each of the following OUTPUTS that you can achieve in THREE different scenarios, (i) In general (digital technologies are not used), (ii) Using Virtual Environment (VL), and (iii) Using Social Media (SM).

Overall learning oriented outputs	**1**	2	3	4	5	6	7
Degree/qualifications	**1**	2	3	4	5	6	7
Grades	**1**	2	3	4	5	6	7
Work portfolio	**1**	2	3	4	5	6	7
Feedback	**1**	2	3	4	5	6	7
Employability	**1**	2	3	4	5	6	7
Career prospects	**1**	2	3	4	5	6	7
Overall knowledge transfer oriented outputs	**1**	2	3	4	5	6	7
Internships	**1**	2	3	4	5	6	7

Industrial connections	**1**	2	3	4	5
Cognitive outputs	**1**	2	3	4	5
Knowledge/understanding	**1**	2	3	4	5
Experience	**1**	2	3	4	5
Overall Skills	**1**	2	3	4	5
Project management skills	**1**	2	3	4	5
Team work/team management skills	**1**	2	3	4	5
Problem solving skills	**1**	2	3	4	5
Interpersonal skills	**1**	2	3	4	5
Practical skills	**1**	2	3	4	5
Presentation skills	**1**	2	3	4	5
Overall psychological outputs	**1**	2	3	4	5
Confidence	**1**	2	3	4	5
Satisfaction	**1**	2	3	4	5
Professionalism	**1**	2	3	4	5
Effort	**1**	2	3	4	5
Patience	**1**	2	3	4	5
Enthusiasm	**1**	2	3	4	5
Willingness	**1**	2	3	4	5
Independence	**1**	2	3	4	5
From the perspective of university student, please rate the importance (1-least important; 7-most important) of each of the following INPUTS that can be t the outputs that you can achieve in THREE different scenarios, (i) In general (digital technologies are not used), (ii) Using Virtual Environment (VL), an cial Media (SM).					
Time	1	2	3	4	5
Resources (facilities)	1	2	3	4	5
Financial resources (money)	1	2	3	4	5
Overall cognitive inputs	1	2	3	4	5
Knowledge	1	2	3	4	5
Overall skills	1	2	3	4	5
Time management skills	1	2	3	4	5
Organisation skills	1	2	3	4	5
Work-life balance	1	2	3	4	5
Social skills	1	2	3	4	5
Work ethics	1	2	3	4	5
Overall support	1	2	3	4	5
Staff support	1	2	3	4	5
Peer support	1	2	3	4	5
Family support	1	2	3	4	5
Overall psychological inputs	1	2	3	4	5
Motivation	1	2	3	4	5
Engagement	1	2	3	4	5
Persistence	1	2	3	4	5
Enthusiasm	1	2	3	4	5
Curiosity	1	2	3	4	5
Critical thinking	1	2	3	4	5
Effort	1	2	3	4	5
End of Questionnaire. Thank you.					

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