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Demonstrating the Nexus Effects of Online Videos, Research Outputs, and Investments to Knowledge Absorption Using Linguistically Adapted Animations

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ABSTRACT

Given how educational videos on social media platforms like YouTube are changing how information and knowledge are delivered and accessed, understanding, and capitalizing on this innovation could potentially enable increasing knowledge absorption in populations able to access that information. This study sought to estimate that increase by applying logistic regression to model data and demonstrate the relationship of one YouTube educational channel—Scientific Animations Without Borders (SAWBO)—and Global Innovation Index 2019 for 79 developing and developing countries from 2011-2018. Results indicated that knowledge absorption was 7.69 and 1.85 times more likely to occur (1) with gross expenditures on research and development (GERD) and (2) the interaction (INNOV) between video views, ICT access, and science/technology publications, respectively. Importantly, qualities of governance indicators did not correlate significantly with tested variables in the model, a suggestion that GERD and INNOV maintain their increased odds of increased knowledge absorption, especially in developing countries and populations where governmentality is being impacted, e.g., by corruption, political instability, global pandemic like COVID-19, or simply national shortfalls of resources and/or infrastructure. Thus, INNOV represents a comparatively lower-cost pathway to promoting and achieving knowledge absorption, especially in many developing nations where GERD may be beyond their current financial means. Implications for research managers and policymakers—as well as recommendations for future research on linguistically adapted animations and educational online videos for increasing knowledge absorption, sharing, and content use—are also provided.

Keywords: online videos, YouTube, research and innovation, science animation, knowledge absorption, digital technologies.

INTRODUCTION

The Internet and its transformation have signaled the birth and exponential growth and use of YouTube videos. With an estimated 1 billion hours of video watched daily by some 63 million viewers worldwide, YouTube is now the leading access point on the Internet for information, especially for entertainment, marketing, education, news, and science [1-4]. This platform, now available in over 130 countries and over 80 languages, allows online sharing of user-generated videos. Today, it can be

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claimed that nearly everyone, especially younger generations across the globe has contributed to its widespread use.

Where Internet infrastructures are available, access to these videos has become possible. The YouTube platform reaches 95% of the Internet's population, and its top-performing countries reflect that global diversity [5]. ChannelMeter's YouTube's Top 25 Countries Ranked by Total Viewership & Subscribers provide a good proportion of developed and developing countries from across geographical regions. This report also forecasted a further increase in YouTube usage and statistics for developing countries, particularly for Southeast Asia in the coming years.

Videos shared on YouTube as digital resources are now increasingly used for teaching and learning in the classroom as well as seeking information [6-7]. Abstract science topics, for instance, that once seemed difficult to teach and learn are now more accessible and understandable due to the availability of videos (many of them animated) on these topics on YouTube. Within the academic field, YouTube—while still yet a niche endeavor—is increasingly reaching into a broad range of personal and professional activities among faculty, staff, and day-to-day institutional operations [8-10].

Despite some constraints, disadvantages, and criticisms on the use of social media in general, optimism about YouTube and similar digital technologies remains high and, when used effectively, can play a continuing role in the diffusion of knowledge, thus, enable local and global economic transformation [11-12]. This becomes critical given that the present knowledge-based economy assumes not only reading and writing but, also digital literacy as a core part of education [13-14]. With the advent of global coronavirus, which shifted many people onto online or virtual spaces, the role of digital/ICT for bridging physical distances and mobilizing more information, ideas, and insights that connect the world, is now more than ever receiving an intense emphasis.

While the use of YouTube online videos for knowledge and other content sharing has received a growing level of attention over the last few years, what are some other possibilities? While the Internet and YouTube videos have radically improved content delivery, altered the information access and exchange landscape, and shifted the potential for education and online learning, can online videos be accepted as an additional source to expand the knowledge base and can they provide other benefits outside of already established ones? Similarly, do YouTube videos play into the equation of research and innovation and their impacts? Can these new sources of knowledge and information, especially linguistic animated educational online videos, help in knowledge absorption, especially for developing countries? Addressing such questions, this paper establishes groundwork evidence that helps begin our understanding of the effect of digital and social media like YouTube, its interaction with other research and innovation metrics, and its influence on knowledge absorption. The notion of knowledge absorption refers to the various factors that affect the ability of any country, institution, or individuals to take advantage of technology developed abroad such as social and media technologies. This paper anticipates future research for identifying areas where countries can harness and maximize the potential of digital technologies like YouTube and its

educational content features for research and innovation, global development, and human progress. Through this research, we contribute to the little work done to date around understanding the impact of YouTube on research and innovation metrics and knowledge absorption at the national level. Specifically, the present study uses a modeling and statistical analysis of one channel owner's view count data—from Scientific Animation without Borders (SAWBO)—to measure its coupling influence on knowledge absorption when integrated with research and innovation metrics including ICT use, research investments, and scholarly S&T publication outputs.

Established in 2011 at the University of Illinois, and currently housed at Michigan State University in the United States, SAWBO through its YouTube channel shares educational videos as live-action or animated media, which is typically the most cost-effective approach to produce animations and communicate dynamic (scientific) ideas and processes in less abstract, more "digestible" ways [15]. A time-series analysis of the SAWBO channel covering the period 2011-2018 revealed that SAWBO's 450 scientific and linguistically adapted animations videos were watched by people around the world in more than 130 countries (mostly in United States, Mexico, Brazil, India, and Spain) and territories and across all age groups (from the youngest, age 13-17, group to the oldest, 65+ years).

Yet the study has its limitations and caveats, this study provided evidence on the relationship between R&D investments, and the interaction of ICT, innovation, and educational content in social media platforms like YouTube on knowledge absorption. Although we used data from one uniquely positioned educational YouTube channel, SAWBO, our study demonstrates the potential for future researchers to use other YouTube data for addressing questions of transfer of technology and knowledge sharing for global development. Beyond providing theoretical insights, the results could be useful for the design of national and institutional policies as well as strategies for enhancing the knowledge base and fostering research and innovation use through online video platforms.

LITERATURE REVIEW

Educational Videos and YouTube

Videos have long been considered an effective educational tool and fall into the broad field of multimedia instruction defined as "presenting words and pictures that are intended to foster learning" [16]. The visual and auditory nature of videos appeals to a wide audience and allows each user to process information in a way that is comfortable for them. The multiple benefits are noteworthy, including creating an immersive experience that affords more efficient processing and memory recall. Another important work demonstrated that a mix of audio and visual presentation increases recall of newly learned information and the construction of mental models [17]. Incorporating videos (e.g., as in-class activities) helps arouse interest, retain attention, improve interaction, and increase creativity and collaborative learning [18, 19]. The benefits of videos as instructional materials further expanded with the development of the Internet, which touches on most areas of human endeavors and other digital platforms. Digital forms, such as YouTube videos, are now often part of learning and instruction in the digital age.

YouTube, as a Web 2.0 technology, was designed as a content-sharing site, mostly for videos used for informal learning tasks and entertainment [20-21]. Since the founding of the platform over ten years ago, it has impacted society and the world in numerous ways, including supporting recognition of knowledge needs, knowledge-seeking and navigation procedures, and knowledge utilization and sharing. Given that access to YouTube and online videos has enabled a shift in information-seeking behavior and rapidly transformed the production, distribution, and consumption of knowledge and information in many parts of the world, educational videos posted on YouTube arguably have an increased potential for delivering additional benefits, which the literature to date has not addressed. As the Fortune cover story How YouTube Changes Everything indicates, as one of the fastest-growing social media technologies, YouTube has disrupted mainstream entertainment and is now used beyond its initial vision—now for everything from opening channels of communication and network building, to making a living, influencing the public (through information, misinformation, and disinformation), supporting DIY (do-it-yourself) ventures, social activism, a platform and gallery for the arts, and so on.

YouTube itself offers analytics and popularity and performance metrics that help to measure channel and/or video awareness (i.e., view count and subscribers), consideration (i.e., watch time), and action (e.g., likes, dislikes, comments, and shares). These analytics and metrics give channel owners such as for SAWBO, and researchers insights [22-24] into social video viewing and sharing. In a limited sense, YouTube data and metrics may suggest "success stories" around information delivery for these videos, and many studies have focused exactly on this potential. Illuminating how and when these educational videos were accessed and viewed by recipients, along with analyses of demographic patterns and trends at the channel level are helping to validate the relationship between user activity metrics and messages not just transmitted but also received [25-26].

Although still in a developmental stage, academic institutions (and others) are also paying significant attention to, and have adopted the social platform, YouTube as a potential channel for delivering information. The Australian-based search engine UniRank, which produces global rankings of universities based on their social media presence estimated that as of May 2020 more than 60% (8381/13723) has adopted an official institutional YouTube page [27]. Beyond student recruitment, these institutions are bolstering their educational and outreach programs and communicating research and innovations that are of global importance [28]. Similarly, some scholarly journals encourage authors, especially from academic institutions, of accepted scholarly outputs to submit video summaries of their research either available on YouTube or other platforms intended for a non-specialist scientific audience. Recently, the new reality of COVID-19 and the global pandemic is making a YouTube channel an indispensable component for most virtual conferences involving academicians and their research partners.

In another context, emphasized the potential of YouTube was emphasized as an emergency outreach platform, i.e., for Chinese Americans who underutilize mental health resources [29]. Due to its relative cost-effectiveness, YouTube is now actively used by businesses and other groups for video marketing and as a tool for assessing the sentiment(s) of customers towards products and services, for increasing sales,

and building and shaping their brands [30]. Moreover, after the 2010 Haiti earthquake, YouTube has been increasingly used as a communication channel for disaster (natural- or man-made) management processes, including one- and two-way information sharing, situational awareness, rumor control, reconnection, and insights and decision making [31-32]. Recently, YouTube has become an important venue for streaming content for a variety of health and medical-related topics related to COVID-19 [33-35]. Like any other major and quickly expanding technology that affects people's lives, YouTube has progressively attracted a polarized debate among scholars and experts on its numbers, uses, and impacts. Firstly, it is important to emphasize that the content available on the Internet is rarely properly expert reviewed and may be inaccurate/controversial. Another paradigm and branch of discourse on YouTube, however, is its role in promoting conflicts and violence - two drivers linked to elevating poverty and inequality in less developing countries, such as in West Africa [36]. Research also finds YouTube implicated in negative effects on the well-being of people, including depressive symptoms due to perceived or actual information overload [37]. Negative effects from social media platforms like YouTube, including behaviors by institutional leaders using the tool for public relations and consequent work-life conflicts, were also identified [38].

Despite more than 2,500 academic studies on YouTube as a video-sharing platform, however, the research community has yet to produce a "fair picture" of the actual additional benefits claimed for online educational videos that support peoples' or organizations' capacities for effective action. In addition, one of the key undocumented challenges recurrently facing informal Internet-based ICT educational videos platforms like YouTube is whether the information shared in those videos is retained and/or knowledge transferred, and/or acted upon appropriately by recipients—more precisely, that the knowledge is absorbed and that the videos contribute to knowledge and human progress.

Addressing the undocumented gap in the literature is both beneficial and necessary because it allows further understanding of any antecedents and subsequent benefits of YouTube educational videos while also identifying factors that can influence those videos' impacts on knowledge absorption. A fundamental motivation for this paper, then, is to investigate for the first time one of those additional benefits, knowledge absorption of educational content, and the factors or drivers that help facilitate this. These insights will potentially contribute to any country's research, innovation, and digital literacy efforts, in both the developed and developing world alike.

Technology and Other Drivers of Knowledge and Human Progress

Recent works reemphasized the importance of technologies and innovation for driving human progress [39-40]. As one major current symbol of the technological revolution, ICT and digital technologies have entered as a serious part of many economies and every country is now exhorted to maximize and tap the potential of these technologies. Given that one UNESCO document notes, "Understanding ICT and mastering the basic skills and concepts of ICT are now regarded by many countries as part of the core of education alongside reading and writing", achieving successful receipt and buy-in from would-be recipients becomes essential. In general, opportunities with ICT and digital technologies are greater than ever before

for expanding an organizations or individuals' reach worldwide. Being able to use these technologies and enhance knowledge and digital literacy is an important part of the growth strategies of developed and developing countries alike (with knowledge absorption as one such component of growth). However, as extensive research discloses, the extension of ICT and its influence on economic development/growth differ among nations [41-42].

These works highlighted a resultant digital divide, which the most recent UN report Digital Economy Report 2019 [43] corroborated. Many developing countries have not been able to take advantage of the opportunities offered by ICTs [44]. These limitations include developmental shortfalls (around technology, resources, and infrastructure), access barriers (particularly in remote or rural regions of countries), resistance to ICT practices or a failure to integrate them into education by educators and school administrations, linguistic barriers, and socio-historical hierarchies of dialects (particularly in highly multilingual regions, like Africa), and socioeconomic and cultural barriers that preclude access by certain people (often women and girls) even when developmental barriers have been overcome [45-46]. The widening of this digital divide threatens to leave not only developing countries—especially the least developed countries—even further behind [14] but also sectors within developed economies. The impact of ICT, modern innovation, and the digital economy, in general, will depend on (1) the level of development and readiness of countries to smartly embrace ICT and digital technologies, (2) greater intellectual leadership, (3) new and different skills among the workforce and citizens, and (4) adoption and enforcement of digital policies, especially from public sector institutions, public-private sector partnerships, and national investments [14].

The importance of ICT in promoting innovation and productivity is also an issue that has attracted increased attention in innovation studies. The use of ICT, which accounts for the largest share of R&D expenditures, in making knowledge available very rapidly on a worldwide scale [47- 48]. Other studies) focused on understanding the endogenous dynamics between R&D investment, ICT, and economic growth [49-50].

The key insight provided by these studies is that to attain sustained economic growth, policymakers, and the institutions they represent, especially in the developed economies should put in place an integrated framework that takes into consideration co-development policies about strategic use and intensification of R&D investment, ICT diffusion and economic growth-enhancing initiatives. This same framework is now promoted for other countries to emulate and adapt based on their unique national settings.

The relationship of technology, economy, and society—and the contribution of research, technological development, and innovation toward economic growth—point us to the Schumpeterian growth theory, the alternative model of endogenous growth [51]. This theory—which maintains that growth is a function of institutions, technology, and other growth components—has helped experts to understand and map the macroeconomic and microeconomic issues of technology and innovation, particularly around questions of who gains and who loses from technology and innovation, and what other determinants interact with growth within an economy

[52]. Taking a cue from limited yet pioneering studies that at least partly implemented an augmented Schumpeterian growth model that emphasized the interaction of ICT and innovation [53-54, 40], this study uses SAWBO's YouTube channel to investigate its connection to knowledge absorption and offers insights on how such a connection can occur. This research is based on the premise in that educational videos, complemented with causal conditions, can not only make people, institutions, and nations more knowledgeable but also change the state of knowledge generally [55]. Figure 1 diagrams our conceptual framework:

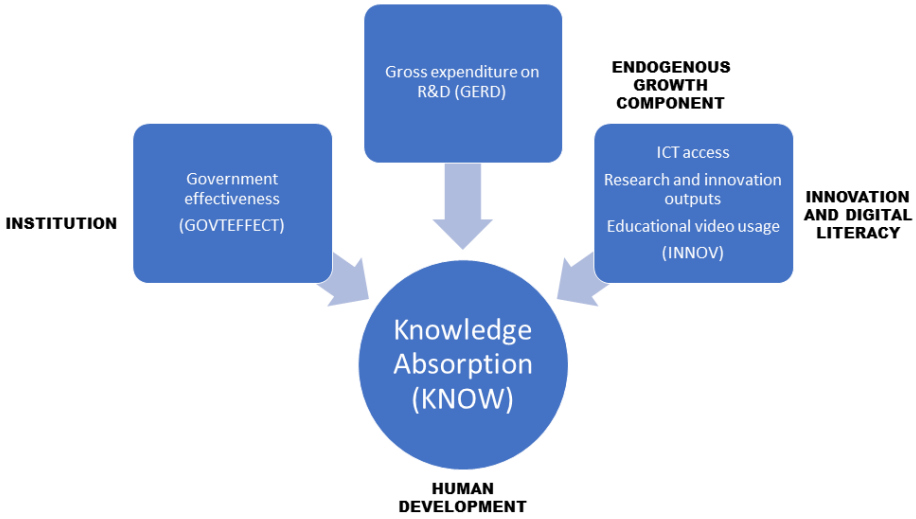

Figure 1. Conceptual framework and a priori expectation on the impact of educational online videos, research and innovation, and ICT linkage to knowledge absorption.

We test two hypotheses:

H1: The probability of knowledge absorption tends to be higher where good governance, R&D and ICT investments, production of R&D outputs, and use of social media are higher (e.g., YouTube) for sharing, communicating, and consuming knowledge and information, hence, contributing to innovation and digital literacy.

H2: The probability of knowledge absorption tends to be higher where R&D investments are higher and the nexus of ICT, R&D, and viewership of linguistically animated educational online videos are used more often for sharing, communicating, and consuming knowledge and information, hence, contributing to innovation and digital literacy.

METHODOLOGY

The purpose of this study was to provide empirical models (see below) demonstrating any interaction and co-influence of factors (such as ICT linking with R&D, its outputs, and ways to communicate them using a digital platform like YouTube and control variables) needed for growth (knowledge absorption) to occur. The models to statistically test hypotheses H1 and H2, respectively, are:

$$KNOW_i = \beta_0 + \beta_1 TYPE + \beta_2 ICT_i + \beta_3 PUBS_i + \beta_4 VIEWS_i + \beta_5 GERD_i + \sum GOV_i + e \quad (1)$$

$$KNOW_i = \beta_0 + \beta_1 TYPE + \beta_2 INNOV_i + \beta_3 GERD_i + e \quad (2)$$

Where INNOV captures the interaction between ICT, PUBS, and VIEWS. Table 1 details and defines the several variables in these models.

Table 1. Variables used in the study, their expected signs, and definition.

Variable (Metrics)	Sign	Definition	Nature of Variable
Dependent (response) variable			
Knowledge absorption (KNOW)		the capability of individuals, organizations, and nations to transfer, integrate and utilize new knowledge obtained from external sources; 1 with knowledge absorption effect for countries that are above the median knowledge absorption score, 0 knowledge absorption effect for countries that are below the median knowledge absorption score provided in the Global Innovation Index	Dichotomous
Independent (predictor) variable			
ICT access (ICT)	+	an index based on fixed telephone lines, mobile cellular phone users, internet bandwidth, households with a computer, households with internet access	Continuous
Scientific and technical publications (PUBS)	+	number of scientific and engineering articles sourced from Thompson Reuters and its publication database network	Continuous
Educational video usage (VIEWS)	+	number of times a video has been watched	Continuous
Gross expenditure on R&D (GERD)	+	an important endogenous growth component refers to the total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, university, and government laboratories, etc., in a country	Continuous
INNOV	+	the interaction of ICT, PUBS, and VIEWS and indicates that products of research and innovation are shared, communicated, and consumed using ICT and digital technologies	Continuous
Control variables			
Government effectiveness (GOVTEFFECT)	+	Represents the importance of an institution; an index that captures perceptions of the quality of public and civil services and the degree of their independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies	Continuous
Dummy variable			
TYPE		1, if the country is a developed country based on the definition of the World Bank; 0, otherwise developing country	Dichotomous

Sample data for 79 developing and developed countries were drawn both from the Global Innovation Index 2019 indicators [56]—which provide detailed metrics about the innovation performance of 129 countries and economies around the world—and from the SAWBO YouTube channel's view count data for the period 18 February 2011 through 9 October 2018. Designation of a country as developing or developed is taken from the Global Innovation Index data, and the 79 countries chosen were convenience sampled because SAWBO view count data exists for that country.

The data were presented and analyzed using descriptive statistics, correlation analysis, and binary logistic regression models using Real Statistics Resource Pack for Excel 365 and Tableau ver. 2020.1. Descriptive statistics characterized the independent variables in terms of central tendency measures (e.g., mean) and standard deviation (SD). The collinearity of predictor variables was checked using hierarchical cluster analysis with a Pearson correlation coefficient. Unequal variances of variables between developed and developing countries were compared using Student's t-test.

Logarithmic transformation linearized the relationship between the binary (e.g., 'successes or 'failure') dependent variable and independent variables. Binary logistic regression was tested for the impact of all significant predictor variables (Table 2) for predicting the probability of KNOW, H1, and H2. This allowed seeing how attributes affected the response of the dependent variable, KNOW while controlling other predictors. The effects from each variable on the dependent variable were expressed and evaluated in terms of the odds ratios, and regression diagnostics were also used to judge the goodness-of-fit of the model. These included the test for multicollinearity (i.e., variance inflation factors or VIF) and Wald Chi-square (χ^2) statistics for the regression model.

RESULTS AND DISCUSSION

Table 2 displays the parametric t-test results of mean differences between developed and developing countries for the non-interacting predictor variables (e.g., ICT, PUBS, VIEWS, GERD, and GOV). We note significant differences between both subsamples for most of these variables—indeed, developed countries measure higher ICT, PUBS, GERD, and GOV scores. On average, developed countries have lower VIEWS than developing countries but this result was not found significant.

Table 2. Descriptive statistics for variables explaining knowledge absorption. N = 79

	Developed Countries (n = 23)		**Developing Countries (n = 56)**		***t*-test**
	Mean	SD	Mean	SD	
ICT	82.1391	5.0567	54.1196	15.9469	11.7848***
PUBS	62.6796	18.8552	17.5038	18.0734	9.79071***
VIEWS	10192.4348	26815.3850	18708.6250	53241.6799	0.9411^{NS}
GERD	47.2365	20.0289	11.9086	14.8607	7.6394***
GOVTEFFECT	81.1665	13.6487	43.4141	13.7187	11.1519***

Note: *, **, and * indicate significant levels at 1%, 5%, and 10%, respectively.**

These results match intuitive expectations, given both the generally higher investment in ICT, generation, and diffusion of technology in more developed countries [56] and SAWBO's mission to disseminate knowledge-content on topics especially impacting people in areas (whether in developing or developed nations) with fewer technological resources [45]. Minimally, this suggests the relevance of SAWBO content for developing-country viewers, where such relevance is a necessary precondition for knowledge absorption itself, i.e., one must first perceive video (for whatever reason) as worth watching before absorbing any of its content.

Table 3 and figures 2 through 6 depict the results of the correlation analysis between the non-interactive predictor variables (ICT, PUBS, VIEWS, GERD, and GOV). Quality of governance (government effectiveness) shows considerable importance here with GERD, ICT, and PUBS all being significantly positively correlated at a 1% level. This resonates with studies linking government effectiveness to R&D investments [57], ICT investments [58], and production of science and technology publications or knowledge [59]. Expenditures on research and development (GERD) also significantly positively correlated at a 1% level with ICT and PUB, as did ICT and PUBS as well, which echoes previous studies on the relationships between these variables The Pearson coefficients of VIEWS with other variables were, however, not significant and VIEWS did not correlate with other variables.

Table 3. The correlation coefficients of predictor variables.

	ICT	PUBS	VIEWS	GERD	GOVTEFFECT
ICT	1.0000				
PUBS	0.5221***	1.0000			
VIEWS	0.0603	-0.1716	1.0000		
GERD	0.5717***	0.8174***	-0.0117	1.0000	
GOVTEFFECT	0.8457***	0.6098***	0.0612	0.6882***	1.0000

Note: *, **, and * indicate significant levels at 1%, 5%, and 10%, respectively.**

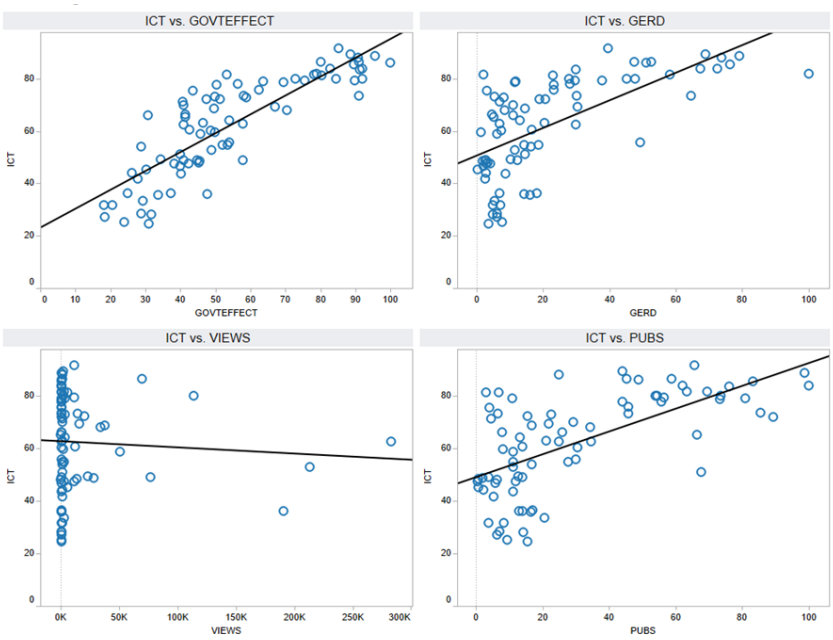

Figure 2. Correlation test between ICT and GOVTEFFECT, GERD, PUBS, and VIEWS.

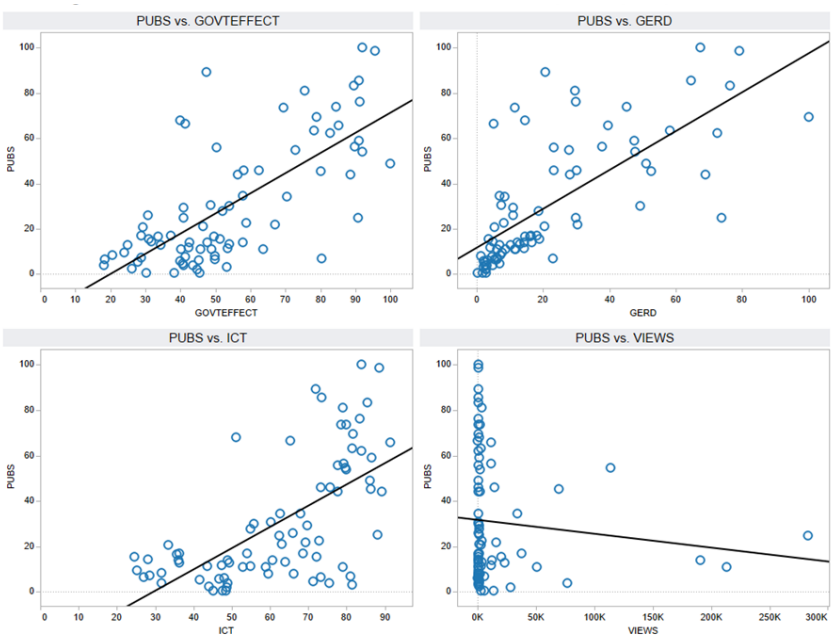

Figure 3. Correlation test between PUBS, and GOVTEFFECT, GERD, ICT, and VIEWS.

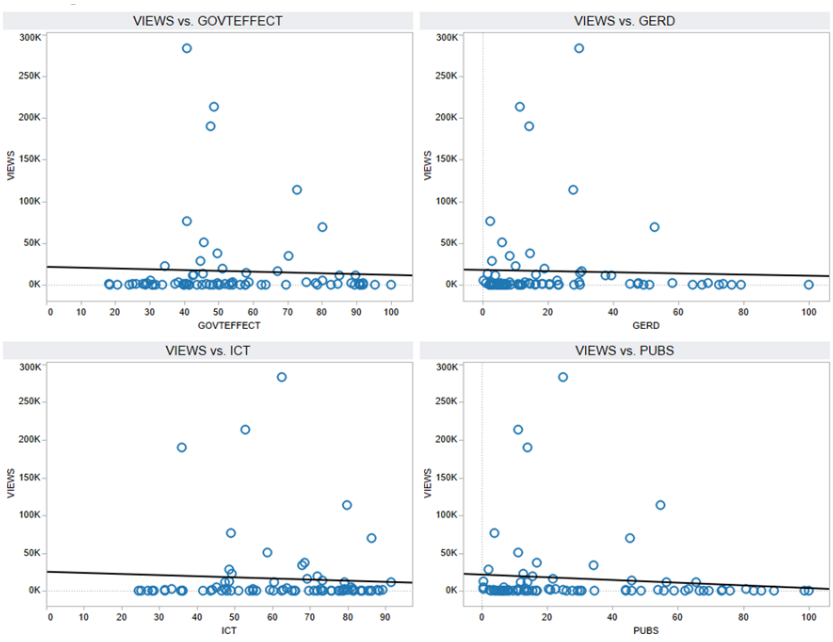

Figure 4. Correlation test between VIEWS, and GOVTEFFECT, GERD, ICT, and VIEWS.

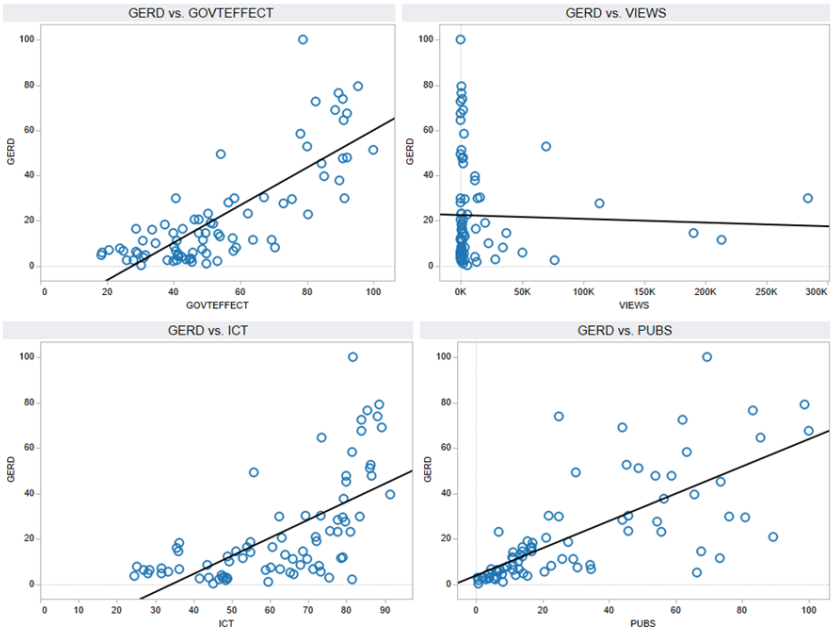

Figure 5. Correlation test between GERD, and GOVTEFFECT, ICT, PUBS, and VIEWS.

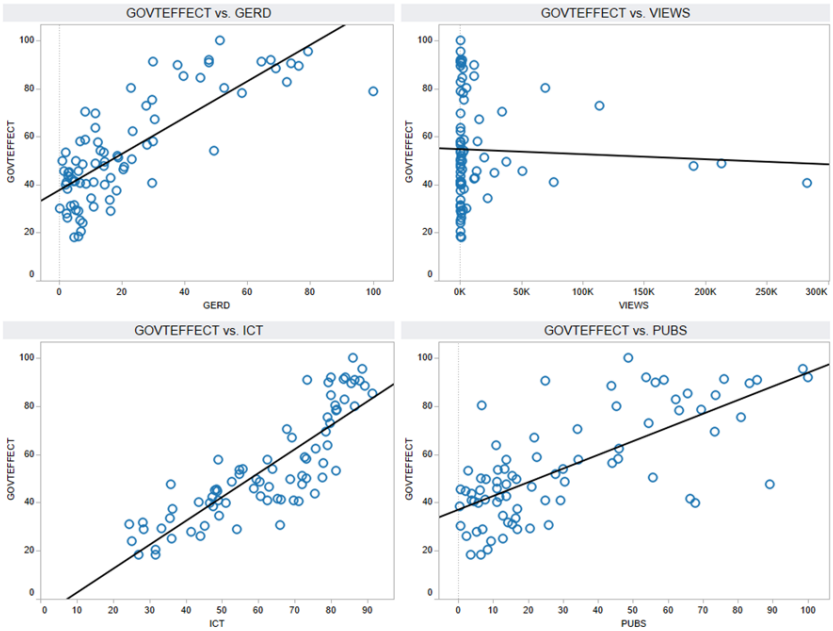

Figure 6. Correlation test between GOVTEFFECT, and GERD, ICT, PUBS, and VIEWS.

The correlation coefficients between the predictor variables ICT, PUBS, GERD, and GOV generated multi-collinearity in Model 1 (inflation factors ranged from 2.5-5.0). Logistic regression analysis similarly confirmed this effect with no significant relationship found among the variables (see Table 4). This suggests a lack of support for H1—i.e., that ICT, PUBS, VIEWS, GERD, and GOV lack an additive effect on the response variable, KNOW.

Table 4. Estimated coefficients and odds ratios for the binary logistic regression model containing the determinants of knowledge absorption.

Variable	B	S.E.	Wald X^2	df	P-value	Odds Exp (B)
Dependent Variable: KNOW						
Independent Variables:						
TYPE	2.4204	1.19297	4.11654	1	0.04247**	11.2509
GERD	2.0400	0.91596	4.96061	1	0.02593**	7.69118
INNOV	0.6162	0.27075	5.18001	1	0.02285**	1.85191
Constant	-6.2956	1.79578	12.2905	1	0.0005***	0.00184
Model	47.0888			3	0.0000***	
-2 Log Likelihood	0.4300					
Cox Snell R Square	0.4490					
Nagelkerke R Square	0.5987					

Note: ***, **, and * indicate significant levels at 1%, 5%, and 10%, respectively.

For the second model, TYPE (χ^2 = 4.1165, p = 0.0425), GERD (χ^2 =, p = 0.0259), and INNOV (χ^2 = 5.1800, p = 0.0228) were found to have a strong relationship with knowledge absorption (KNOW). While the dummy variable, TYPE, had the highest log-odds among the predictors (showing that KNOW is 11 times more likely to occur), KNOW is 7.69 more likely to occur with GERD, and 1.85 more likely to occur with INNOV. These results imply that having a significant level of social and economic development of the country—which is the basis in the Global Innovation Index 2020 for country classification—provides greater odds of knowledge absorption than only the country's expenditure on R&D.

While GERD and INNOV have positive effects on knowledge absorption, these variables are statistically significant and have a more positive effect in developing countries (see Table 5). KNOW is 6.9037 more likely to occur with GERD and 1.9122 more likely with INNOV. This relationship suggests that these factors can serve as major predictors of knowledge absorption, especially in developing nations. These results support H2—that there is an association between TYPE, GERD, and INNOV—and a rejection of the null hypothesis.

Table 5. Estimated coefficients and odds ratios for the binary logistic regression model containing the determinants of knowledge absorption and effects to developing countries.

Variable	B	S.E.	Wald X^2	df	P-value	Odds Exp (B)
Dependent Variable: KNOW						
Independent Variables:						
GERD	1.9321	0.9269	4.3452	1	0.0371**	6.9037
INNOV	0.6483	0.2817	5.2958	1	0.0214**	1.9122
Constant	-6.3786	1.8738	11.5881	1	0.0007***	0.0017
Model	15.3000			2		0.0005
-2 Log Likelihood	0.2176					
Cox Snell R Square	0.2391					
Nagelkerke R Square	0.3343					

Note: *, **, and * indicate significant levels at 1%, 5%, and 10%, respectively.**

Of some interest in this result are the increased odds for knowledge absorption without the absence of GOV as a factor, although collinearity with GERD may explain this. Future research is needed to test this possibility, but it is potentially a very promising potential that it may not be necessary to "solve" the quality of governance issue as a prerequisite or necessary condition for knowledge absorption. This would be especially promising where institutional capacity remains less developed or in situations where political instabilities compromise GOV.

Also, the effect of R&D expenditures in Model 2 complements the study which observed how R&D expenditures, often used to encourage innovation, also favor the absorption of knowledge [60]. This insight into R&D expenditure's role in new knowledge generation, technology, and thinking is leading towards the acceleration of R&D investments in developing countries. While we anticipate that R&D expenditure will continue to play an important role in generating new knowledge, technology, and thinking for driving innovation like digital technologies, it must be clear that such gains only happen in (developing) countries that have the resources to do so. While BRICS countries, in the interstice between developing and developed countries, likely have much greater access to resources [56] most developing nations will not.

At the same time, while GERD shows higher odds for knowledge absorption than INNOV, this does not mandate an exclusive focus on GERD, again especially given that not all contexts have the needed resources. For example, Vietnamese students have tested at a world-class level for STEM education [40] particularly in areas of mathematics and computer programs, neither of which require the kind of extensive infrastructure investments that other STEM disciplines require. In this context, whether national or international support for GERD was available, developmental efforts could amplify INNOV to support knowledge absorption in Việt Nam (and other similar national contexts).

While this study may be the first to specifically use the predictor INNOV (i.e., the interaction of ICT, science and technology publications, and educational video usage), the results corroborate other research highlighting the significant role of the interaction of ICT and technical knowledge in general for influencing the outcome of human development [40, 61]. This insight, and the relationship of ICT, science and technology publications, and educational video usage, has clear implications for global (South-North, developing/developed) educational and collaborative contexts through higher education specifically but remains relevant for individual researchers at institutional and national levels even in contexts with fewer resources [45]. This echoes research with similar findings for knowledge absorption in both higher education institutions and extension services learning in developing nations [62- 63]. As laid out in this study, the modern innovation of the YouTube platform, all else being held equal, has shown in its educational aspect a good potential for contributing to knowledge diffusion, information sharing, and learning—and, thereby, directly, or indirectly economic productivity improvements. Its continuing contribution to knowledge diffusion, information sharing, and learning specifically are contingent on certain drivers (as maintained by the Schumpeterian growth theory). Inspiring knowledge absorption, creativity, and curiosity, as well as novel idea and knowledge generation, will depend on causal conditions that include access and use of ICT infrastructure, research, and

development, and skills enhancement [13, 14]. Furthermore, the knowledge absorption capacity affordance of YouTube—whether at the country, organizational, or individual levels—will depend on an ability by viewers to recognize valuable knowledge in the (digital) environment and then align it with existing capabilities to promote its utilization. Additional support from organizations, in the form of institutional policies, can further facilitate and enhance knowledge absorption and other benefits in countries that utilize ICT and digital innovations [64- 65]. The complex interactions of these many drivers toward a desirable level of knowledge absorption all become tractable through an enhanced Schumpeterian growth model [66, 40]. We also urge institutions and individuals that are producing research outputs to reflect on the type of approaches used to disseminate and reinforce findings in layman's language. Peer-reviewed research, while essential for scientific validity, can be difficult to locate, access, interpret, and/or understand for lay audiences. Moreover, the several benefits of popularizing science discourses notwithstanding (Ruse, 2013), these can also often risk key or fatal distortions and/or omissions out of a greater commitment in the writing to "epistemic certainty, news-worthiness, and subjectivity" [67]. To make scientific research easier to understand, then, journals have begun encouraging the use of video-based content that allows authors to explain their research in a simplifying but not distorting or inaccurate manner [68]. Also, the recent shock due to the COVID-19 global pandemic has accelerated how ICT is used for knowledge and information sharing, virtual collaboration, and generating research ideas. Per this study's findings, while increased expenditures would indeed increase pandemic-related research, this would come also at the opportunity cost of tightening other financial conditions globally. In places less able to justify this approach, INNOV offers a less costly approach still able to cross the finish line of influencing knowledge absorption.

CONCLUSION AND FUTURE RESEARCH

Two key predictors—GERD (gross expenditures on research and development) and INNOV (the product of ICT, science and technology publications, and educational video viewership)—demonstrated both positive and significant effects on knowledge absorption, especially for developing countries. While GERD showed stronger knowledge absorption odds, such that it remains a recommendation that developing countries actively promote this interaction, financial constraints (or the opportunity costs of decreased social well-being associated with such spending) can rationally preclude this pathway. Even in such contexts, however, INNOV remains a less costly alternative pathway for knowledge absorption. Future research should measure and compare GERD- or INNOV-based strategies in different socioeconomic contexts.

This research also provides the groundwork for larger-scale studies both on more extensive data sets of linguistically adapted, educational animated videos on other or multiple social media platforms and more granular demographics. In particular, a replication study confirming that qualities of governance (GOV) have no statistical significance for knowledge absorption in this study's second model suggests that educational knowledge absorption (on online platforms like YouTube) can still be achieved despite elements like corruption, political instability, natural and/or man-made disasters, or disease pandemics temporarily or ostensibly permanently

affecting the qualities of governance at the institution and national levels. What factors might confound this effect remain to be studied. Follow-up qualitative studies would also help document, complement, and assess the impact of knowledge absorption both generally and in specific area topics, such as COVID-19 prevention in communities and among individuals. However, as the success of development projects are often influenced by the qualities of governance of countries where they are being enacted, diminishing their effectiveness with poor governance, where programs such as SAWBO can be impactful independent of qualities of governance has the potential to reshape how we think about investments in human development and economic growth.

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