Collaboration and Communication in the Leadership of Educational Technology

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Abstract

The communication practices between educators, administrators, government officials, and students were key features of educational technology leadership in Western Canada. This paper presents the findings of an exhaustive study of all 75 large K-12 districts in Canada's three westernmost provinces: British Columbia, Alberta, and Saskatchewan. A data transformation model mixed methods triangulation design methodology was used in this study of over 1.1 million students across a geography of over 2.2 million square kilometres. Western Canadian K-12 relies heavily on cloud computing, and this approach enabled a successful shift to online education during COVID-19. What emerged from this research were several organizational collaboration practices that enabled inter-disciplinary communication [1]i. These practices produced this highly robust IT infrastructure. This paper will present these collaborative communication practices and the formalized organizational initiatives that enable them. The extent and impact of these interdisciplinary collaborative communication practices were so profound that they nullified differences in school district size and the locus of authority for educational technology decision-making.

Keywords: *K-12, cloud computing, educational technology, infrastructure, collaboration, communication*

1. Introduction

In the spring of 2019, the novel coronavirus (COVID-19) impacted all aspects of society (World Health Organization, 2020). In education, this impact was expressed through the rapid shift to online learning and remote instruction. This shift relied heavily on educational technology and was a test of school districts' IT systems. Schools in Western Canada, especially large K-12 districts, were exceptionally well positioned to make the necessary shifts required by COVID-19 by virtue of their existing cloud computing IT infrastructure. Schools in the provinces of British Columbia (BC), Alberta (AB), and Saskatchewan (SK) used cloud computing extensively. Large public school districts, defined as having 5,000 students or more, for many years already had a centralized IT infrastructure that made it possible for schools and students to connect to the districts' IT

[1] Important end note I, as editorial comment

services (Holowka, 2018). Prior to COVID-19, these IT services were accessed from schools; during the COVID-19 lockdown, these services were accessed from home. This cloud computing IT infrastructure made possible the rapid shifts in education necessary to continue teaching and learning within school districts.

The focus of this paper is on the communication and collaboration structures within these large Western Canadian K-12 districts that produced the cloud computing-first IT infrastructure that enabled these districts to respond to the challenges of remote infrastructure during COVID-19. Though the efficacy of remote teaching and learning is dependent upon multiple factors, such as access to devices by students, internet access at homes for both teachers and students, this paper's focus will be solely on the IT infrastructure of the K-12 districts and the decision-making processes by which it was developed. Though a confluence of factors is responsible for successful teaching and learning, should K-12 IT services have not been accessible through the internet by students and teachers, this would have produced a considerable impediment during the high of COVID-19 restrictions. Cloud computing is now widely accepted as a dominant modality for IT infrastructure, and Western Canadian K-12 schools were among the world leaders in its adoption (Holowka, 2018). This paper will briefly overview the extensive use of cloud computing in large Western Canadian K-12 districts. The paper will then explore in detail the organizational communication practices and collaborative structures which contributed to this wide adoption.

2. Cloud Computing IT Infrastructure in Western Canadian K-12

2. 1. Definitions of Cloud Computing

The formal definition of cloud computing according to the US Department of Commerce's National Institute of Standards and Technology (NIST) is as follows: "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics [on-demand self-service, broad network access, resource pooling, and rapid elasticity], three service models [SaaS, PaaS, and IaaS], and four deployment models [private cloud, community cloud, public cloud, and hybrid cloud]" (2011, p. 2).

For the purpose of this paper's discussion, a distinction must be made between cloud computing and traditional, on-premises-only IT infrastructure. Whereas cloud computing IT infrastructure provides access to computational resources through the internet, on-premises IT infrastructure is accessible only through a closed network such as a Local Area Network (LAN) or a Wide Area Network (WAN). Traditional, on-premises-only IT infrastructure is not accessible over the internet, whereas cloud computing IT infrastructure (i.e., private cloud or public cloud infrastructure) is accessible over the internet.

2.2. Extent of Cloud Computing Adoption

School districts in Western Canada were among the world leaders in the adoption of cloud computing IT infrastructure. At a time when the adoption of cloud computing by organizations varied widely, K-12 districts in this region had a 100% adoption rate of this technology infrastructure (International Data Group, 2015). Figure 1 illustrates this phenomenon, depicting the use of cloud computing and traditional, on-premises only IT infrastructure across the major domains of IT services delivered by K-12 districts. In instances where traditional, on-premises infrastructure was to continue, it was used in complement to the cloud computing IT infrastructure. This is why the categories in Figure 1 do not total 100%, such as with Student Information Systems (SIS) and the Learning Management Systems (LMS). The rationale for the on-premises systems was that it allowed a greater degree of flexibility/management at the school level, given that the majority of cloud computing systems were controlled centrally by a school district's central IT staff.

Additionally, the study examined adoption satisfaction and the intention to continue or discontinue use of cloud computing. Another important finding was that once districts adopted cloud computing IT infrastructure, they intended to continue its use into the foreseeable future. Conversely, some of the limited instances of on-premises-only infrastructure were being considered for replacement with cloud computing infrastructure. These were universal phenomena, and unrelated to the other district characteristics such as size, leadership structures, decision-making level, etc.

2.3. Implications of Cloud Computing Adoption

The use of cloud computing has multiple advantages over traditional, on-premises-only systems. Cloud computing systems, hosted on a district's private cloud or in the public cloud, allowed the IT staff to manage the systems for multiple schools and thousands of students. This reduced or eliminated the need for IT staff to travel to schools to work on computer systems or to meet with users (students, teachers, support staff, etc.) as issues could be resolved at the data centre or remotely over the internet. Additionally, Software as a Service (SaaS) vendors such as Google and Microsoft have free tiers for education, which entirely eliminate the need for K-12 districts to manage certain domains of their IT infrastructure, such

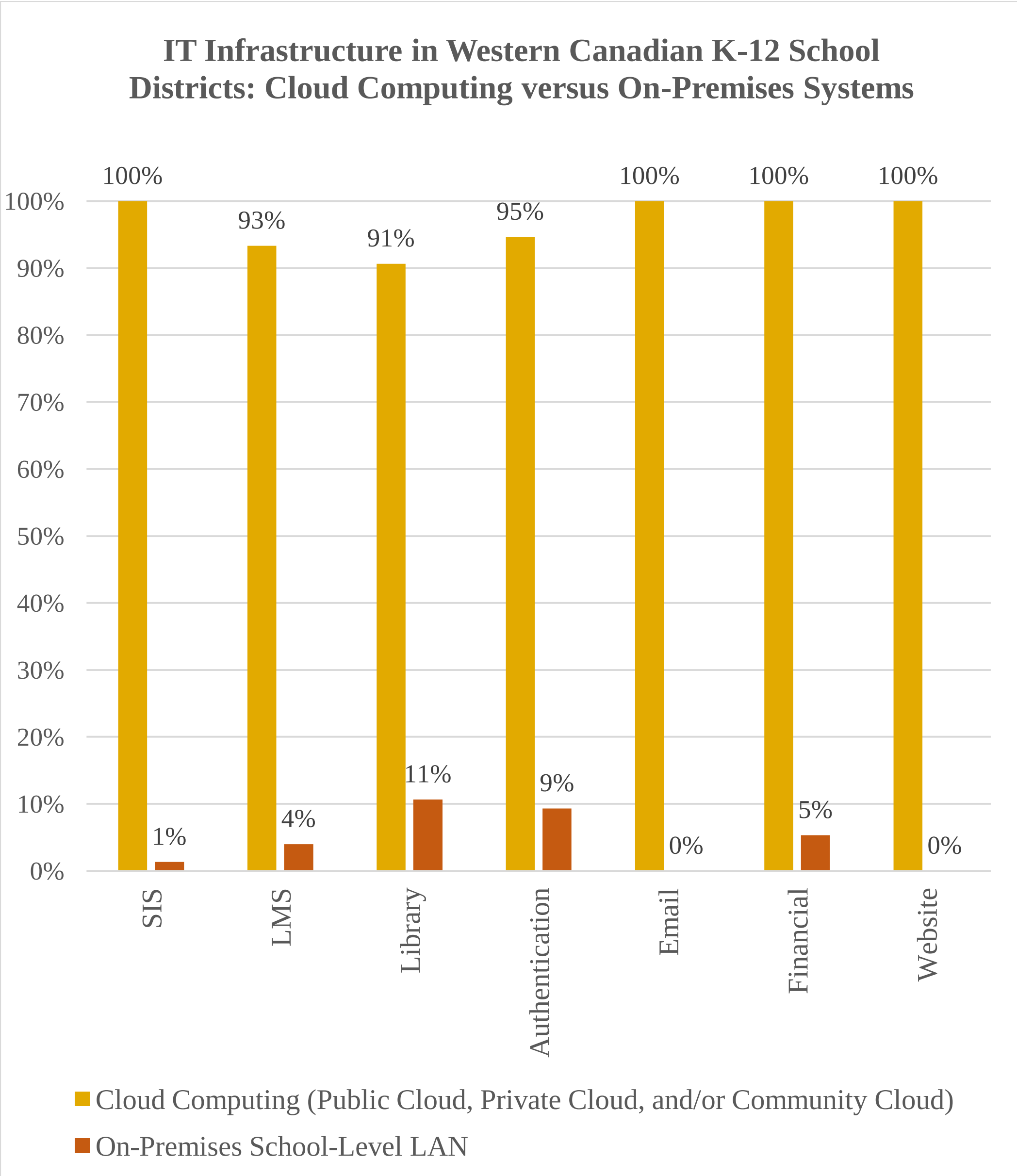

Figure 1: IT Infrastructure in Western Canadian K-12 School Districts: Cloud Computing Versus On-Premises Systems.

as email, file storage, etc. (Google LLC, 2020; Microsoft Corporation, 2020). The availability of SaaS solutions means that K-12 districts do not need to purchase, maintain, or secure the software and hardware required to deliver these IT services. This allows districts to redirect their IT staff towards other projects, such as end-user experience improvements and systems integrations, rather than low-level maintenance, such as replacing hard drives in email servers. These were advantages enjoyed prior to COVID-19, and the ability to manage cloud computing systems remotely was a critical enabling factor in the shift of schools to emergency remote online instruction during the pandemic.

3. Research Methodology

3.1. Study Scope and Scale

This paper examines the findings of the largest study ever conducted into IT infrastructure and leadership in Western Canadian K-12. The central question of the study was: "What factors influence district-level K-12 IT leadership on the adoption (or nonadoption) of cloud computing for district schools?" This study included all 75 districts in Canada's three western-most provinces, revealing the extensive use of cloud computing. This study encompassed over 1.1 million students within a geography of over 2.2 million square kilometers. In addition to examining all 75 districts in aggregate, the study examined the three provinces separately as well as through four size groupings. These four size groupings were school districts containing 5-9.9K, 10-14.9K, 15-24.9K, and 25K+ students. Combinations of province and size groupings were also analyzed. In total, the study's findings were examined through 18 different size and/or province groupings.

3.2. Data Transformation Model Mixed Methods Triangulation Design

The study employed a data transformation model mixed methods triangulation design methodology (Creswell, Plano Clark, Gutmann, & Hanson, 2003). The Frambach and Schillewaert conceptual framework was used to guide the investigation into innovation adoption by organizations (Frambach & Schillewaert, 2002). The study examined both the technical and non-technical, leadership aspects of cloud computing adoption within K-12 districts. A subquestion of the study, investigating the leadership and decision-making of districts concerning IT infrastructure was "What are the IT leadership structures and processes at the district level for large Western Canadian K-12 school districts?"

The data used in this study was primarily from document analysis and 80 semi-structured interviews of an average duration of 45 minutes with the senior IT leaders of K-12 districts from the 75 eligible large K-12 districts. Data was gathered over a twelve-month period. The participation rate was 100% as all 75 of the 75 eligible large K-12 districts participated. Though a detailed discussion of the research methodology and instruments is not possible in a paper of such limited length, the unanticipated high volume of participants made possible additional quantitative analysis, in addition to the qualitative analysis. Data from each of the 75 districts/cases were coded into bivariate data and analyzed for correlations using the 64-bit version of IBM SPSS Statistics 23.0.

3.3. Correlation Analysis

Correlation analysis provided additional insights into the study's many findings/variables, which included leadership structures, decision-making processes, IT infrastructure, and the priorities that shape IT infrastructure. Correlation analysis was essential given the large volume of variable combinations in this study. From a matrix of 223 by 223 variables, 49,729 possible relationship combinations exist. However, in addition to the aggregate study, an analysis was conducted for the three provinces, four size categories, and 10 province-size combination categories (18 size groupings in total). This resulted in 895,122 possible relationship combinations, underscoring the value of computer-aided quantitative analysis, as well as the value of the data transformation model mixed methods triangulation design methodology overall.

The Pearson's Chi-square and Fisher's Exact test were used to examine all of the variable combinations. A significance level of 5% ($\alpha = 0.05$) was used as there were no special circumstances applicable to this research which would necessitate a deviation from the conventions of educational research (Gay, Mills, & Airasian, 2009). Both Pearson's Chi-square and Fisher's Exact test were used in a complementary fashion as each statistical instrument has inherent limitations. With very few exceptions, Person's Chi-square test and Fisher's Exact test identified the same relationships. Supporting the statistics literature, the more conservative Fisher's Exact test failed to identify certain relationships that the Pearson's Chi-square test had (Freeman & Campbell, 2007; Lydersen, Fagerland, & Laake, 2009). From the subset of statistically significant relationships, phi coefficients were calculated. The phi coefficient describes the strength of each relationship on a scale between -1.0 and 1.0 (Davis, 1971). A 1.0 relationship means that when one factor occurs, the other factor always occurs; a -1.0 relationship means that when one factor occurs, the other factor never occurs.

Of the 895,122 possible relationship combinations in the study, just over 2,000 statistically significant relationships were found. These statistically significant relationships were nearly all IT infrastructure relationships that were purely technical in nature. Despite a comprehensive examination of leadership structures, decision-making processes, and organizational adoption priorities, these factors were not found to have a statistically significant effect on IT infrastructure within K-12 districts. A conclusion is of this study was that the collaborative and communication structures within districts were so extensive that they negated these factors. The following section presents the extensive collaboration and communication structures within large Western Canadian K-12 districts.

4. Communication and Collaborative Structures in IT Infrastructure

The findings of this study concerning the processes involved in IT decision making in K-12 districts reveal a highly collaborative approach that emphasizes communication. Information is gathered widely and includes input from technicians, consultation among various stakeholders, and formalized technology advisory committees that consist of multiple schools. These collaborative approaches limit the impact of differences in the IT leadership structures on the resulting IT infrastructure. The collaborative process helps bring forward the concerns/needs of many of the district stakeholders. Consequently, concerns and ideas do not exist in silos. This collaborative decision-making process helps to have contributions incorporated into the broader district's IT strategy. The lack of statistically significant relationships involving leadership/decision factors support this assertion.

4.1. District Awareness of IT Needs

End-users and network support staff are typically the first to identify the IT needs of a K-12 district. These needs emerge during the day-to-day activities of the district's users, which include teachers, students, school office staff, etc. District IT staff resolve these issues and/or communicate them to the higher levels of the IT department. During meetings, both formal and informal, the IT department and the district's IT leadership share information concerning IT matters such as ageing, deteriorating, and/or failing systems. This is the foundation for planning future IT upgrades to mitigate problems, and is emblematic of extensive collaboration and communication practices.

4.2. Technology Advisory Committees

In many K-12 districts, a technology advisory committee informs the IT infrastructure decision-making process by engaging a broad group of stakeholders. Although the district needs that IT support staff identify are important in addressing existing issues, technology advisory committees make possible a more proactive, inclusive, and forward-looking decision-making process. Whereas the focus of K-12 district IT departments is often on maintaining and upgrading existing systems, the technology advisory committees help districts to look beyond their existing systems to explore more dramatic changes/improvements. The following quote exemplifies this:

> We also have a technology council which I chair, and the technology council is an advisory group to the superintendent's team, and the advisory council is made up of representatives from all the major

> stakeholders in the organization, so it's an internal advisory and it's made up of members of the 5 areas of our schools, principals sit on that advisory, from our elementary, middle, and senior high schools, and then we have representatives through all of our superintendents and service unit teams. So it's a table of about 16 people and all major technology decisions, we have a process for bringing them forward, a project approval process, and a discussion format. We meet twice a month and all technology decisions go through - initially - that advisory council. (Ami, p. 1)

Technology advisory committees can be comprised of teachers, elementary principals, high school principals, superintendents, associate superintendents, Chief Financial Officers, and Directors of IT to maintenance forepersons, and so on. The committees often meet several times a year to discuss IT needs and set future technology direction for their districts. Due to the diverse nature of the technology advisory committee's membership and concerns, this group facilitates a richer assessment of needs for district planning purposes.

4.3. Collaboration among Senior Leadership

In an effort to more fully understand the adoption decisions concerning cloud computing in K-12, the study that this paper is based on examined the leadership structures within a K-12 district that determined its IT infrastructure. This included a breakdown of both the vertical hierarchy of responsibility within a district/organization, as well as an examination of the different horizontal branches of a district/organization, such as instruction, finance, facilities, IT systems, etc. An important finding was the extensive collaboration and consultation across the various branches of a district. District leaders consistently described their decision-making process as highly collaborative, where they would consult with teams within their branch of responsibility, as well as across to other branches. For example, the instructional branch would consult with the financial branch regarding IT infrastructure plans and decisions. This collaboration was evident consistently across the study and is depicted in Table 1 through representative quotes from the district IT leaders. A key finding from this study of the adoption of cloud computing within Western Canadian K-12 districts is the high degree of consultation and collaboration that occurs within an organization prior to and during the decision-making process. Not only did this process apply to the cloud computing adoption decision, but it also was practiced for the majority of IT and IT infrastructure decisions (Holowka, 2018).

5. Conclusion

A recommendation of this paper is that school districts, and organizations more generally, adopt, continue, and/or expand upon their existing collaborative decision-making processes. In the area of IT infrastructure in K-12 in Western Canada, the result of these collaborative practices was a cloud-first IT infrastructure which positioned large public school districts exceptionally well for the COVID-19-induced situation of emergency remote instruction online. Similarly, as society prepares for a post-COVID-19 world of remote work and increased online activity, the cloud-first IT infrastructure and the collaborative practices already present within Western Canadian K-12 districts will continue to be of benefit.

As this paper has demonstrated, many K-12 districts already have extensive collaboration among stakeholders on the development of IT infrastructure. These districts should continue this practice. Moreover, organizations, those within K-12 and beyond, should adopt such a collaborative approach if they are not already doing so. Technology advisory committees are effective mechanisms to gathering input from a diverse group of stakeholders. The use of a technology advisory committee can be used as a long-term planning complement to the more immediately-oriented information that comes from the IT support department. Districts, and organizations in general, should also collaborate across organizational branches of responsibility. The extensive collaboration within and across branches by the K-12 districts in Western Canada helped to produce a similarly robust IT infrastructure across provinces and district size categories. This collaboration across branches is beneficial as it helps overcome technical-knowledge limitations by non-technical stakeholders, and, conversely, broadens the perspective of the technology leaders with regard to non-technical considerations (e.g., educational implications, financial implications, etc.). The implication of this is that high levels of collaboration and communication better equip organizations for known and unknown future challenges. Future research could perhaps examine the delta in performance between organizations that have adopted such communication and collaboration structures.

Table 1. Collaboration of senior leadership

Province	Representative quotation
BC	The manager of technology reports to the assistant superintendent. It's an interesting arrangement, but the decisions are usually made almost on a team basis, so even though on the chart we have the assistant superintendent on the top who ultimately has the decision making powers, but the way we operate here, the team of usually the three of us will make the decision as a group. (Blair, p. 1)
BC	Now, if we talk about IT type projects, that affect the district, we do have an advisory committee, and we may get to that later, but that's the district technology advisory committee, DTAC, is what we call it. And that includes the superintendent, secretary treasurer, director and myself, but also director of Ed Services, educational services. So that committee really brings in all areas of business and the educational side of the district. (Brook, p. 1)
BC	Now we have a technology committee that meets maybe a couple times a year that consists of the assistant superintendent, the one I report to, the CFO, a handful of principals, one from every family school group, so one elementary principal, one middle school principal, one secondary school principal. Our tech coordinator that works out of our department, and probably one of the people, one of our programmer analysts or systems analysts from our own department, so maybe 7 people maximum. All with a very good overview of the system. (Brandyn, p. 4)
AB	We like to work to a consensus model at the superintendent's team, and superintendents are made up of 7 corporate decision-makers who bring a variety of perspective to the decision-making role. So we have legal services, communications, finance and supply chain, facilities and environmental services, education - we have two educational superintendents who look after programs, and program requirements, and ... I'm missing one. Oh! Superintendent of HR, and then we have our chief and we have a deputy chief. So that superintendent's team is a multiple perspective team made up of a variety of those stakeholders. (Ami, p. 1)
AB	We have a fairly flat hierarchy in our division and in our department anyways, in that in as often as possible we try to use collaborative decision-making to come up with answers to our needs. (Amari, p. 1)
AB	We try to work these processes very collaboratively, uh, I think in some organizations, that same committee that I just described would be meeting without IT people, and they would be bringing the decision to the IT team to say, now you design it and implement it. (Anstice, p. 5).
SK	And then there's the, there's also an admin council that I report to, and that's a group of ten superintendents and one director, and the priority there is also learning, and technology is, is . . . sometimes partly a solution and sometimes it's seen as not a solution as well. So, it's an area of debate, and it's . . . I think that's healthy, rather than people are just gung-ho to spend money on technology without addressing the learning. (Saffi, p. 1)
SK	Anything that would be impacting how we deliver our services would pretty much all go CIO to the secretary treasurer. One thing to just clarify, when we're looking at delivering something, say, a SIS, and we're looking at it being cloud-based type of thing where the parties who are going to be affected are going to be involved, so if we were to be looking at a new SIS and I'm not implying that we are, that would definitely involve the deputy director of schools, because the decision to make these moves would not be done in isolation without the parties that are involved. Not at all. (Sam, p. 4)
SK	We do have regular meetings as a group, about once every six weeks we'll all sit down again with our superintendent and just sort of round-table ideas and discussions, talk about what's been going on. I update them in terms of what we're doing as a department from the technology side in terms of infrastructure upgrades or whatever it might happen to be, and then they discuss ideas that they would like the IT department to look into in terms of, you know, some sort of possibility for execution on. (Stacey, p. 3)

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i ***Editorial Note:*** Inter-Disciplinary Research, thinking, doing, and/or Communication are more rigorous than any of the disciplines involved in achieving the objective. This is especially true when the objective is the solution of a real life problem. Because in such a case it does not depend on theoretical interpretations, Solutions of real, life problems are ***facts***, which by nature are not disputable, even if the degree of achievement may be perceived on different levels. Bur, the achievement in itself is not questionable, what may be questionable is the degree of the effectiveness and, hence, of the achievement. This why we think that Peter F. Holowka's research, design and implementation is more rigorous than any of the involved disciplines in his inter-disciplinary reasearch, thinking and communication.

Let us, now, provide few and short details about what we just affirmed. Intellectual Rigor has not been treated as a theme. Its meaning depends on the context it is used. Scientific Rigor is usually defined in the context of some sub-, or sub-sub-, or sub-sub-disciplinary semiotic system. This reductionism is even worst when it is defined as "***following a pre-established method"*** of a discipline, or sub-, or sub-sub-, or sub-sub-disciplinary. Anyone would wonder where is the originality or the creativity in following a ***pre-established method*** to prove that a hypothesis is false or correct. If it false, 1) other scientists would avoid wasting time trying to prove that the hypothesis is correct and 2) may trigger a learning process. If the hypothesis is proven to be correct then the creativity was in the analogical thinking process that triggered the formulation of the hypothesis and in the design of the experiment with which to follow the pre-specified methods.

Elsewhere we provided details regarding the following definition (or short description) of Intellectual Rigor, as directly proportional to the effectiveness in 1) ***achieving a purpose***, and objective, a goal while 2) being *subject to restrictions.* These restrictions are 2a) principles (e.g. axioms, in mathematics, ethical/moral principles, legal laws, consensually accepted scientific theories, etc), 2b) disciplinary semiotic systems, and 3b) environmental (including economical, financial, technological, and temporal constraints). ***This is why, scientists and professionals in developing countries, may require more rigorous thinking in solving the same problem.*** *The* ***urgency (temporal restriction generated by the unexpected COVID-19, which is the case of Dr. Peter F. Holowka, required more rigor in the thinking and doing of the people involved in the solution of the problem, which is described in this article.***

Inter-Disciplinary Research, Education, and/or communication require more rigor than each one of the disciplines involved because it has the restrictions of all the disciplinary semiotic systems involved (not just one of them) plus the objective and restriction of effective translating among these different semiotic systems, which frequently is the respective Natural Language Semiotic System, which, in turn is one the most trans-disciplinary semiotic system, with its own three semiotic level: Syntactical (Grammar), Semiotic (which is confusing because the different senses a word has in the different disciplinary semiotic systems involved) and pragmatics (confusing because the implicit purpose of each of the disciplinary semiotic system, which may interfere with the problems at had that required the specific Inter-Disciplinary Research and Communication).

In any case, it is evident that is more rigorous to comply with each kind of rigorousness of each one of the involved disciplines. Add to that, the temporal urgency and emergency and any one can notice that achievements made in the situation created by COVID-19 required more rigorous thoughts and/.or actions. (Nagib Callaos)