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Perceptions of Selected Nursing Students about the COVID-19 Pandemic: Investigations in Linear and Complexity Thinking

Brian Saludes Bantugan, PhD[1], Jennifer Joy Olivar, PhD, RN[2]. Maria Leah Sabayle, PhD, RN[3]. Portia Zoleta-Vitug, PhD, RN.[4]
[1,2,3,4]*St. Paul University Manila*

Abstract: The paper highlights the growing importance of complexity thinking in health education, emphasizing its role in understanding intricate systems, especially in healthcare. It differentiates between complex and complicated systems, highlighting the characteristics of complex systems, such as non-linearity and dynamic interactions. The COVID-19 pandemic serves as a case study of a complex system with various interdependencies and outcomes, contrasting it with linear thinking observed in public health measures, vaccine development, and public responses during the pandemic. The study conducted an 11-item online survey among nursing students to gauge their perceptions about travel during the pandemic. The results revealed a variety of perceptions, including some distinctions between ethics and responsibility, accountability for actions and consequences, and different understandings of the pandemic's complexity. The findings suggest the need for nursing students to better grasp the social dimensions of public health and the potential ethical challenges they may encounter in future healthcare decision-making due to variations in their perceptions.

Keywords: COVID-19 pandemic, travel and tourism, nursing students, linear thinking, systems thinking, complexity thinking

I. Introduction

"Complex adaptive system (CAS) science has aided the pursuit of understanding who we are, where we come from, and where we are going" (John Templeton Foundation, 2023, para. 1).Complex adaptive systems are phenomena that are greater than the sum of their parts (Crabtree, 2022). Healthcare teams, according to Pype, Mertens, Helewaut, &Krystallidou (2018), are complex adaptive systems that are interdisciplinary and can be better understood as resulting from "team members' interaction with each other than on the characteristics of individual team members" (para. 1). A CAS is composed of multiple intricately arranged parts that are shaped by learning from feedback emerging from its self-organizing non-linear interaction with its environment (Evans & Turner, 2017). Instances of complex adaptive systems encompass a wide array of phenomena, including but not limited to communities, political parties, the brain, the immune system, ant colonies, the stock market, ecosystems, developing embryos, and various human social collectives (Khalil & Boulding, 1996). Stevens, O'Donoghue, Horng, Tandon, & Tabb (2020, para. 4-5) distinguished between complicated and complex systems by writing:

> Complex adaptive systems are distinct from complicated systems. A complicated system is like an engine, with multiple, elaborate components that, when taken apart, are reduced to small, indivisible

> parts. Complicated systems are deterministic; they can be anticipated and predicted. Many health care processes that are easily measured and improved, such as placing a central venous line, are complicated. These types of systems are straightforwardly monitored with data systems; tracking incremental changes over time allows us to distinguish between meaningful variation and random noise… Complex systems have numerous *emerging and evolving connections* with individual agents and are largely *nondeterministic*--that is, there can be many possible outcomes for a given set of circumstances.

Pandemics as Complex Systems

Given the above, Fineberg (2020) asserted that a pandemic must be seen as a complex system (because it is) "by nature a complex system both in its cause and in its expression… (meaning) that the triggers and the consequences of a pandemic each have components with deep interdependencies: couplings that are loose or tight, direct or indirect; causations that are alternately necessary, joint, conditional, and relative; feedback loops that are amplifying or dampening; and indeterminacies that are partly stochastic features of the natural world and partly an expression of the limits of understanding. In sum, everything that makes a system "complex" (para. 2). The complexity of the COVID-19 pandemic, for example, was expressed as a disease, public health issue, medical health system problem, economic challenge, and a social crisis. Meanwhile, infections are linear phenomena. Smith & Karam (2018) pointed out that "linear causality was the primary structure for understanding the onset and development of… illness and distress" (para. 2). Braithwaite and associates (2021) argued healthcare management operate through linear thinking. They added:

> Many people do this: they imagine that the next policy or guideline or mandated change, or quality improvement programme, or procedure, or test result, or new IT system, will be taken up unproblematically on the front lines of care. Contrary to that kind of thinking, there are multiple layers to healthcare complexity (Braithwaite, Churruca, & Ellis, 2017, in Braithwaite et al., 2021).

Linear Thinking Default

Siepe and Montgomery (2018) warned that "Linear thinking focuses on addressing 'symptoms' instead of looking for what is causing the symptoms to happen…(not recognizing) that it takes time for a signal to propagate through a system and so the result of an action can only be seen much later, making it harder to understand where the result came from in the first place. It induces us to concentrate on costs and not on how to maximize throughput and it confuses price with value" (para. 4). Linear thinking management is not able to foresee disruptions, as a result, and could fully account for what is truly happening in a business operating in a complex world. Spaeth (2011) dared to declare, thus, that "our current linear conception of biology and of health and disease is inadequate to explain many aspects of biology, health, and disease." Thus, Cornwall (2020) declared "Linear thinking no longer will work for life plans nor business plans." (para. 7).

Linear Thinking during the Pandemic

The assertion that public health mandates such as lockdowns, mask-wearing, and physical distancing can independently lead to the arrest of COVID-19 infections, and their simultaneous implementation were all that was needed to solve the COVID-19 pandemic show a lack of systems thinking and the proliferation of linear thinking, instead (Ayouni, Maatoug, Dhouib, *et al.*, (2021). These measures, following a series of steps to ensure public health, followed a linear approach. Similarly, the phasic return to normal business operations following criteria and timelines, also reveal a linear progression reflective of linear rather than complex thinking.

Similarly, vaccine development during the COVID-19 pandemic, ideally following a sequential and progressive multi-phase drug testing study design, implementation, and evaluation points to an institutionalized linear thinking template (Attwell, Rizzi, & Paul, 2022). Generalizations that stigmatized persons who refused to be vaccinated, asserting that they contribute to the continued spread of the COVID-19 virus, reflect a unidirectional and singular
solution to the pandemic, replete of complex thinking (Patary, 2023).

Since there was lack of adequate information about COVID-19 and uncertainty lingered in social spaces, more people became more disposed to linear thinking. Pietrangelo (2020), explaining the Yerkes-Dodson Law, wrote that people who are overcome with fear maybe be drawn towards linear thinking. Fear also impairs problem-solving because it limits creative thinking and can move a person to defer to tried-and-tested or default solutions. Theories like Cognitive Load Theory (Sweller, 1988), Working Memory Capacity (Constantinidis&Klingberg, 2016), Attentional Control Theory (Coombes, Higgins, Gamble, Cauraugh, & Janelle, 2009), Cognitive Interference (Sarason, Pierce, &Sarason, 1996), Emotional Regulation (Gross, 2014), and Perceptual Narrowing (Cashion & DeNicola, 2011) help explain this tendency towards linear thinking during times of distress.

Complexity Thinking and the COVID-10 Pandemic

Saurin (2020) wrote about the COVID-19 pandemic using the Complexity Thinking (CT) lens. CT, "concerned with understanding the dynamic interactions between the wide diversity of elements that form living systems" (Cilliers, 1998 in Saurin, 2020, para. 3), bring about emergent phenomena like pandemics. CT, defined by Braithwaite et al. (2018) as the application of systems thinking to complex systems (2018), is especially important when "the gap between complexity and human capabilities to cope with it has grown wider" (para. 4). Through the CT lens, the pandemic is defined as a "natural-socio-technical system" that is responding to a biological 'pathogen'. As such, it must be managed as a complex system using CT, wrote Saurin. While the COVID-19 virus is a relatively simple and predictable entity, the pandemic is "an extreme manifestation of non-linearity in complex systems" (para. 19) at three levels:

> In the pandemic, the micro level encompasses our personal lives and families, as well as the work of those at the front-line of the pandemic response, especially health workers and those that have kept essential businesses running. The meso level includes impacts on supply chains and organizations, such as hospitals, schools, and businesses in general. The macro level involves societies at the local, national, and international levels (Dekker, 2011; Song et al., 2006, in Saurin, 2020, para. 23).

CT has been gaining traction in the realm of health education, as health educators and professionals have become increasingly aware of the limitations associated with conventional linear approaches (Mennin, 2013). There is a growing trend toward interdisciplinary collaboration and the adoption of systems thinking to better address the intricate and interconnected nature of health (Rusoja et al., 2018). While certain health education programs have embraced adaptive strategies, they encountered obstacles such as resistance to change and resource constraints (Mirata, Hirt, Bergamin et al., 2020). The integration of complexity thinking has exhibited regional and institutional variations, often shaped by policy and institutional support, with some entities fully embracing it while others adhering to traditional models (Eray, 2021).

Study Framework

Table 1 below shows the application of the DSRP (Distinction, System, Relationship, and Perspectives) model used in a design process that facilitates understanding and definition of a situation, identification of leverage points, clarification of perspectives and their underlying preconceptions, and framing of a comparison

of "two design approaches in relation to complexity and the context of a wicked problem" (VilliusZetterholm& Jokela, 2023, para. 18). The model shows Perspective (P) manifested as an "awareness of different mental models" which is crucial in this paper in that it introduces the notion of disparity between an objective reality and mental models attempting to represent it for knowledge building

According to VilliusZetterholm and Jokela (2023):

> Epidemics and pandemics are defined by rapidly evolving and dynamic conditions, where the physical world changes (e.g., pathogens mutate) and, in parallel, our understanding and knowledge rapidly progress. This creates a multidimensional and complex situation that is challenging to grasp and approach.

Table 1
DSRP Model in a design process applied to a pandemic (VilliusZetterholm& Jokela, 2023)

Pattern	Pandemic
System (S)	Complex adaptive system. Root causes: pathogen–human interaction, human–human interaction. Subsystems and key parts in analysis: societal level; social level; pathogen, human hosts, preventive technologies.
Distinction (D)	Droplet spread of SARS-CoV-2 virus; infected and non-infected human hosts; contact tracing and nudging approaches.
Relationship (R)	Relations: human–virus; human–human; human–technology. Action–reaction: Primary prevention by nudging; secondary prevention by contact tracing.
Perspective (P)	Design perspective; awareness of different mental models; understanding the technologies.

Figure 1 below, taken from VilliusZetterholm and Jokela (2023) demonstrates that there is a knowledge variation continuum that exists between mental models and reality, and that users (people who attempt to manage realities through the solutions provided by designers) have limited access to understanding a problematic reality, and that, if any, are mostly influenced by mental models provided by current knowledge builders and designers who seek to solve it.

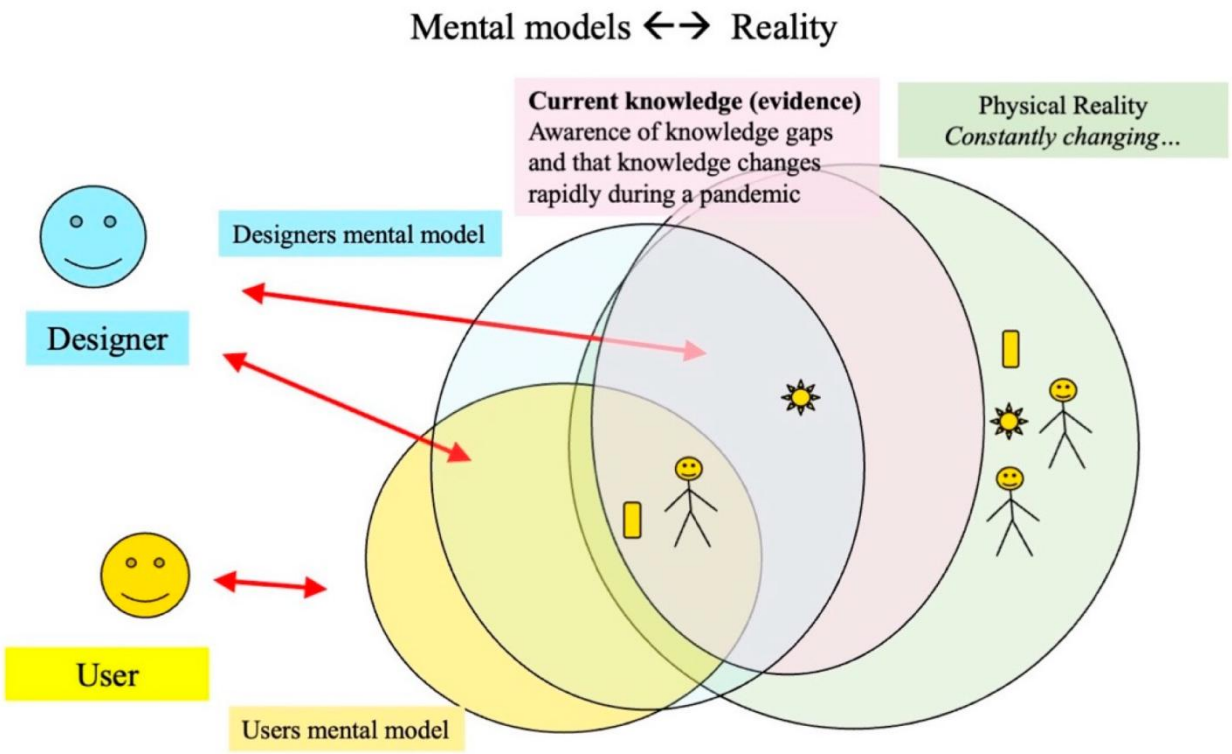

Figure 1. Continuum of knowledge of physical reality (VilliusZetterholm& Jokela, 2023)

In this study, the user is operationalized as nursing students and the designers are their respective teachers (learning designers). The COVID-19 pandemic, being a transdisciplinary subject matter that can be discussed in any course, is most relevant as an academic content to health science students. Figure 1, applied to this context, demonstrates that understanding of the COVID-19 pandemic among health science students are likely influenced in the school setting by their teachers, and that whatever perceptions they have about the pandemic, reflective of complexity thinking or otherwise, is a consequence mainly of their formal learning in the university. Their perceptions, hence, are reflective of the complexity thinking and/or the lack thereof, in their academic programs.

Statement of the Problem

This study investigates the perceptions of selected nursing students of St. Paul University Manila on COVID-19 pandemic-related issues. Knowing their perceptions would lead the researchers to identify gaps between their perceptions and systems thinking which is becoming more and more important in the healthcare system which they intend to penetrate and serve.

II. Methodology

An 11-item online survey via Google Forms (composed of two items on demographics and nine items on psychographics) were administered to 55 volunteer nursing students from first year to fourth yearin the College of Nursing and Allied Health Sciences of St. Paul University Manila during the second semester of academic year 2022-202, constituting majority (56%) of the college's student population. The latter items were about the respondents' perceptions on travel during the first year of quarantine mandate in the Philippines. Descriptive statistics were used to analyze the data and discussions were constructed based on the relationship of the results to complexity thinking. Perception gaps (PGs) were computed as the difference between two

response distribution percentages being compared. PGs were converted back to head counts to establish more tangible connections between perceptions and persons. Evidence of linear thinking were derived from expected alignments between closely related perceptions based on established logical relationships. PGs were interpreted as complexities inherent in respondent responses.

III. Results

Data are presented in the following sequence: (1) Linear Thinking; (2) Inherent Complexity in Responses; and (3) Alignment with Complexity Thinking Statements.

Linear Thinking

During the first year of the quarantine period in the Philippines, only front liners and essential workers were allowed to leave home. Students were doing online classes so there was no need to violate quarantine mandates implemented in communities by the government. Majority (85.5%) of the respondents rarely or never left their homes in compliance with government policy. It must be noted that students were not the most at-risk populations so they could opt to go outside given the proper documents and following strictly the health protocols, if needed.

Because quarantine was understood as a means to minimize risk of infections, the government's promotion of local tourism, despite the increasing infection rates during the first (Bantugan&Manguerra-Mahusay, 2021) and second (Bantugan, San Juan, Villanueva, Dumagat. &Ramagapu, 2023) trimesters of the first year of lockdowns, were found inconsistent with the principles in support of community quarantines. Hence, majority (78.2%) of respondents perceived that "it was not right for the national government to promote tourism and travel during the first year of the quarantine period of the pandemic in the Philippines" and most of them (74.5%) perceived that "quarantine mandates helped reduce COVID-19 infections".

As such, most of the respondents (76.4%) perceived that they "would not have considered traveling locally for tourism during the first year of the community quarantine policy even if the Department of Tourism encouraged them to do so". Further linear thinking was found when majority of the respondents (61.8%) perceived that "public health first before economy" was the stance that their discipline requires them to take. It is not surprising, then, that most respondents (65.5%) perceived that "the government promoting local tourism during the quarantine period of the first year of the pandemic in the Philippines should be held accountable for the increase in infections during that time", especially because they (69.1%) abide by the belief that "travel has something to do with the spread of the COVID-19 virus" and, consequently, "promoting travel and tourism during the community quarantine period is irresponsible action (56.4%).

Table 2
Statements reflecting linear thinking

Item #	Perceptions	%
01	It was not right for the national government to promote tourism and travel during the first year of the quarantine period of the pandemic in the Philippines	78.2
02	I would not have considered traveling locally for tourism during the first year of the community quarantine policy even if the Department of Tourism encouraged him/her/them to do so.	76.4

03	Travel has something to do with the spread of the COVID-19 virus	69.1
04	The government promoting local tourism during the quarantine period of the first year of the pandemic in the Philippines should be held accountable for the increase in infections during that time	65.5
05	Public health first before economy	61.8
06	Promoting travel and tourism during the community quarantine period is irresponsible action	56.4
07	Community quarantine mandates helped reduce COVID-19 infections	74.5
08	Community quarantine mandates did not make me feel mentally healthier during the first year of the pandemic	61.8

Inherent Complexity in Responses

The perceptions above also present inconsistencies (reflected in the percentage distribution) that reveal lesser agreement between perceptions than expected. The response distribution variations show that the respondents' uncertainties and disagreements with two normally coherent statements come from underlying complexities. They are as follows:

Doing something not right (Item 01) **is not necessarily being irresponsible** (Item 06). The perception gap (PG) between the former (78.2%) and the latter (56.4%) reveal 21.8% or 12 nursing students who do not judge one as irresponsible simply because of his/her/their not doing the right thing or unethical action. In theory, one's sense of responsibility is not always reflected in one's actions. In particular, the respondents' responses show a distinction made by 12 nursing students between ethics and sense of responsibility.

One need not be accountable (Item 04) **for the consequencesofdoing something not right** (Item 01). The PG between the two items (12.7% or 7 respondents) indicates seven nursing students who perceive that accountability for the consequences of unethical action is unnecessary. Thus, accountability is presented here as potentially dissociated from ethical action.

One need not be accountable (Item 04) **for the consequences of being irresponsible** (Item 06). The perception gap between the two items (9.1% or 5 respondents) uncovers nursing students who will not expect accountability for the consequences of one's irresponsibility. This means that acts of irresponsibility are sometimes dissociated from the need for accountability.

When before one's ethics and accountability are tightly woven into the fabric of one's sense of responsibility, the perceptions of the respondents reveal an unweaving between the three for at least five out of the 55 (almost one in ten) nursing students. While the perceptual gaps seem low, the inherent uncertainties and/or disagreements in their responses, point to a veering away from a simpler linear thinking. This is further elaborated by the items below:

Perceiving that travel has something to do with the spread of the COVID-19 virus (Item 03) **does not always mean perceiving travel promotion during quarantine is irresponsible** (Item 06) - Seven nursing students (equivalent to 13.3% PG) dissociates participation in the promotion of a perceived cause of viral spread from lack of responsibility.

Perceiving travel promotion during quarantine is not right (Item 01) **is not always associated with perceiving that travel has something to do with the spread of the COVID-19 virus** (Item 03) - While majority of nursing students perceive travel promotion during a quarantine period as unethical, five nursing students (equivalent to 9.1% PG) do not associate this with the perception that travel contributes to viral spread.

Perceiving that the government must be accountable for the consequences of promoting virus spread through travel (Item 04) **is not always associated with the perception that public health should come first before the economy** (Item 05) - Similarly, while most nursing students perceive that the government has to be accountable for the increased spread of COVID-19 because of its travel promotion during a quarantine period, five nursing students (equivalent to 9.1% PG) does not relate this need for accountability with the perception that public health must rank highest among government priorities during the pandemic.

Perceiving public health should come before the economy (Item 05) **does not always reflect the perception that promoting the economy through travel during the quarantine is irresponsible** (Item 06) - Approximately three nursing students (equivalent to 5.4% PG) who perceive public health should be first priority do not perceive travel promotion during a quarantine period to be irresponsible.

Perceiving community quarantine mandates helped reduce COVID-19 infections (Item 07) **does not align completely with perceiving community quarantine mandates were making people feel mentally healthier** (Item 08). Approximately seven nursing students (equivalent to 12.7% PG) who perceived quarantine mandates as being helpful in the reduction of viral spread did not perceive it to be helpful in promoting mental health. This presents quarantines as necessary sacrifices that must be taken to stop the pandemic and prevent the further extension of quarantines (a decrease in mental health is a necessary adverse event of reduced viral spread).

Alignment with Complexity Thinking Statements

Respondents were most aligned with the statement that "government pandemic action should be evaluated for future improvements" (81.8%). This, at immediate glance, seems to reflect linear thinking as evaluation is normally expected after the implementation of a program. However, if it were to be considered a statement that is foundational to establishing a complex reality (i.e. the evaluation can establish that the actions were insufficient and simplistic; hence, the problem is more complex than linear), the above statement is a window to complexity thinking.

Following closely at 74.5% alignment with respondents is the statement "The pandemic is a complex problem requiring complex solutions" which is clearly a statement declaring the complexity of the phenomenon of the pandemic. On the flip side of this data is 25.5% of nursing students or 14 persons who have yet to acknowledge complexity in the pandemic. This is directly related to the fourth most aligned statement "The pandemic is not just a medical issue but a social issue" (63.5%) which, unfortunately, points to 20 nursing students who have not seen the pandemic as a social issue at the time of the survey. In third highest placement at 69.1% is the statement "Travel has something to do with the spread of the COVID-19 virus" which is an established fact (Cetin & Kara, 2020). This means that 30.9% or 17 nursing students have not learned of this reality.

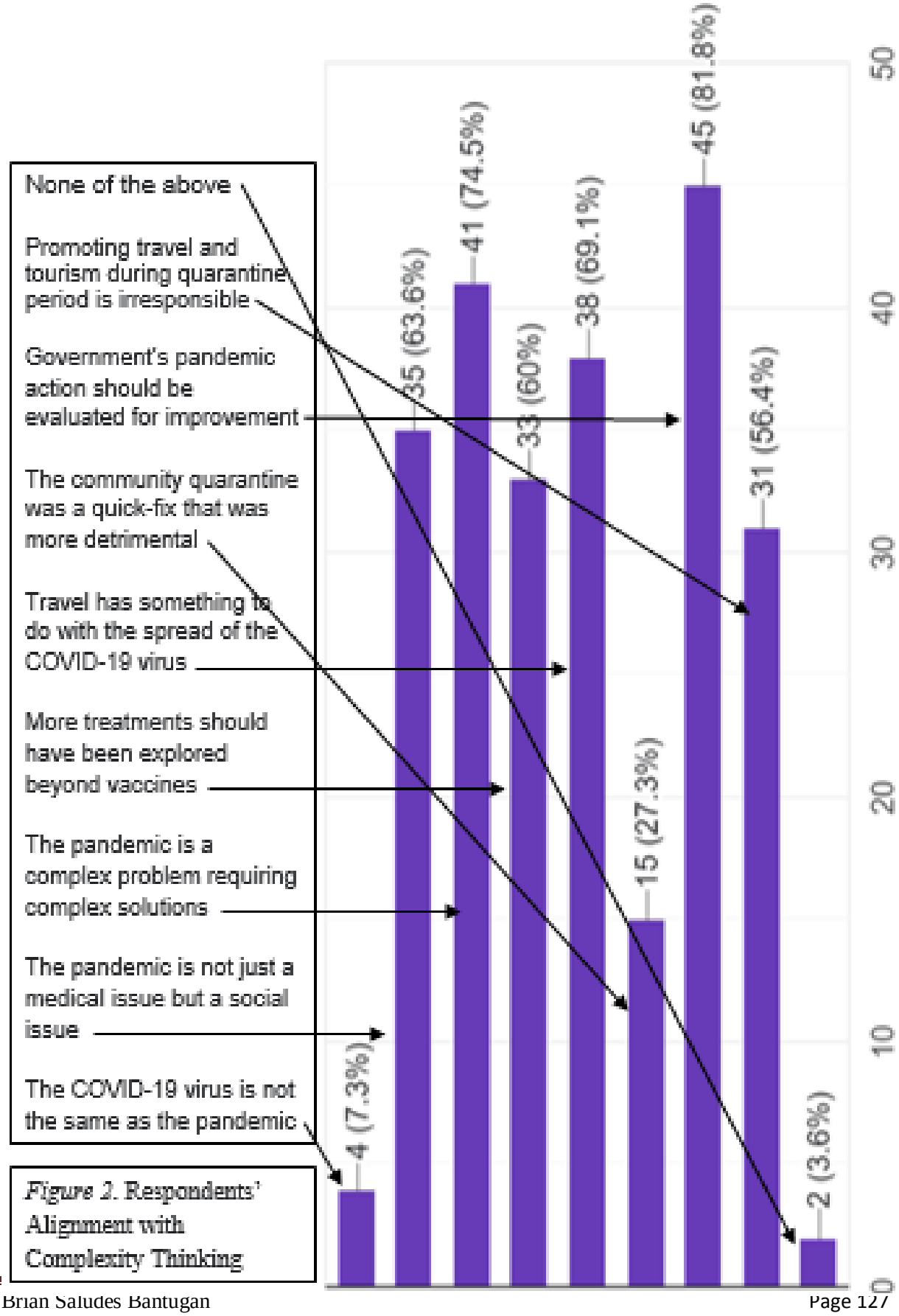

Figure 2. Respondents' Alignment with Complexity Thinking

Given that at least 17 nursing students admitted to not having connected the spread of COVID-19 beyond on-contact viral transfer, it is not surprising to find 40% of the respondents (or 22 nursing students) not agreeing with the statement "More treatments should have been explored beyond vaccines". Likewise, it was found that 24 nursing students not in alignment with the statement "Promoting travel and tourism during quarantine period is irresponsible". It seems that nursing students have truly yet to learn about meso-level pandemic spread. With only four students perceiving the pandemic as distinct from the COVID-19 virus reveals that 96.7% of nursing students do not understand the micro-level complexity on which they are expected to be trained.

IV. Discussion

Data under 'Linear Thinking' suggest that while most of the selected nursing students agree with statements based on linear thinking, as likely influenced by their formal academic learning, a few disagree. This means that academic learning either fails to convince those few to think with the majority or that individually they have found contradictory statements to be more convincing. In this scenario, it is evident that the formal education of nursing students has no complete control of nursing students' perceptions related to the COVID-19 pandemic, especially those that are mostly governed by linear, seemingly logical, thinking.

It should be noted that Table 2 revealed eight linear thinking statements in the survey that were highly agreeable to the respondents. This indicates that majority of the selected nursing students truly align with linear thinking in the context of the pandemic and travel and tourism to varying degrees. Variations in alignment point to variations in perception that were quantitatively recorded as PGs manifesting individuated perception within a linear thinking-oriented discipline. Although systems thinking, arising from complexity thinking, is now becoming a significant part of the nursing and healthcare systems, linear thinking remains more dominant in ways of perceiving the pandemic. It must be pointed out that meso-level systems thinking is quite unfamiliar still to some of the respondents in the context of understanding the spread of diseases; hence, learning about the spread of diseases within countries and globally have yet to introduce and/or emphasize the social dimensions of public health, specifically in St. Paul University Manila among the selected respondents.

Data under 'Inherent Complexity in Responses' reveal perceptions that do not follow normal linear-logical assumptions and train of thought. Ethics, social responsibility, and accountability, often aligned and discussed as a cluster of related concepts were found disjointed in some respondents, indicating an autonomy in perceiving the world, independent of this conceptual clustering. Whether such is a result of a independent thinking, complexity thinking, or misinformed thinking is something that must be invested more in-depth. However it is, the data revealed emergent uncertainties and disagreements that are normally associated with complex phenomena.

Data under 'Alignment with Complexity Thinking Statements' showed that the selected respondents perceive complexity in the pandemic; however, almost all students failed to distinguish the difference between a virus and a pandemic, which one can assume contributed to greater confusion about the pandemic at the meso- and macro-levels. The pandemic, assumed a natural and not a social phenomenon, renders the government capable only of reacting, albeit ignorantly, to its unfolding. As such, one can possibly not hold them accountable for wrong actions taken, especially if motivated by good intentions. Its sense of responsibility, then, must be dissociated from usual sense of accountability people expect from them during non-pandemic times. This, consequently, presents an ethical crisis, given that much of what people know about life were rendered not useful, including assumptions about what can and cannot be done to address the pandemic, for which nursing

students with individuated perceptions should be trained to humanely decide on competently together with other healthcare professionals as future pandemic front liners.

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