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ARTICLE

Proposal of guidelines to assist managers to face pressing challenges confronting Latin American universities: a complexity theory perspective

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ABSTRACT

The Covid-19 pandemic exacerbated pre-existing problems in Latin America and posed unprecedented challenges for Latin American universities (LAU). These challenges can be characterised as complex problems that cannot be understood through reductionist approaches. This paper aims (i) to provide a complex system perspective of the challenges confronting LAUs and (ii) to propose guidelines for managers of LAUs to address them in practice. A multidisciplinary group was formed and conducted an iterative process of research, brainstorming and debate of potential solutions to the following problems considered particularly important by their universities: mental health issues in the university environment, student learning gaps, brain drain, and anti-science movements. Complexity theory and E/HF concepts are integrated to demonstrate that understanding what LAUs are experiencing in a fragmented manner is impossible, and that the interactions between the challenges should be at the centre of the managers' actions plans.

Practitioner summary: Managers of LAUs can benefit from the guidelines proposed to understand the pressing challenges confronting universities and develop systemic approaches to address them.

Abbreviation: E/HF: Ergonomics and Human Factors; ECLAC: Economic Commission for Latin America and the Caribbean; ESN: Erasmus Student Network; HEI: Higher Education Institution; IAU: International Association of Universities; IBE: International Bureau of Education; IESALC: International Institute for Higher Education in Latin America and the Caribbean; LAU: Latin American University; UN: United Nations; UNESCO: United Nations Educational, Scientific and Cultural Organisation

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1. Introduction: Latin America and its universities in the aftermath of a pandemic

Latin American universities (LAU) have always been at the forefront of critical and contentious issues in their countries (Menoni 2022; Vallaeys et al. 2022). With the Covid-19 pandemic, the role of LAUs for the recovery of nations has gained even more importance (IAU/ESN 2020; UNESCO/IESALC 2020).

Prior to the Covid-19 outbreak, the development model in Latin America was facing severe structural limitations, including high inequality, balance-of-payments constraints, exports concentrated in low-technology sectors resulting in recurrent exchange-rate and debt crises, low growth (United Nations 2020), high rate of informality in employment and poverty (UN/ECLAC 2022), vulnerability to climate change and natural disasters, and loss of biodiversity (Gonzalez-Perez et al. 2021). Also before the pandemic, public satisfaction with the quality of democracy in several Latin American countries was eroding (Congressional Research Service 2022), with broad political and economic factors contributing to the eruption of social protests in the region in the last decade (Mendoza 2020; Sigahi and Saltorato 2020, 2022).

In 2020, the first year of the pandemic, Latin America experienced 7% economic contraction, with many of the region's economies showing only modest recoveries in 2021 and pessimistic projections of economic growth for the coming years (Goldfajn, Ivanova, and Roldos 2022; International Monetary Fund 2021b, 2021a). After years of fluctuating around targets,

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inflation in Latin America's largest economies reached its highest level in 15 years in 2022 (Appendino, Goldfajn, and Pienknagura 2022). Furthermore, during the pandemic Latin America witnessed an increase in authoritarian practices, weakening of democratic institutions, politicisation of the judicial system, corruption, and high levels of crime and violence (Marquetti, Hoff, and Miebach 2020; Paulani 2022).

In the sphere of organisational and human behaviour, Covid-19 initiated an extensive, sudden and dramatic digital transformation of everyday life of people (Srisathan and Naruetharadhol 2022), businesses (Amankwah-Amoah et al. 2021), and HEIs (Watermeyer et al. 2021). The effect of the pandemic has speeded up and changed human intention to adopt digital technologies by several years (Soto-Acosta 2020) and has caused a vast digital divide between the poor and rich, the rural and urban areas, and the advanced and developing economies (Beaunoyer, Dupéré, and Guitton 2020).

The pre-existing problems in Latin America mixed with the effects of Covid-19 resonated in the LAUs. Several studies have shown a worsening of mental health issues in university students and staff, as in Brazil (Lopes and Nihei 2021), Chile (Salas et al. 2020), Colombia (Martínez, Valencia, and Trofimoff 2020), Ecuador (Mautong et al. 2021), Peru (Pedraz-Petrozzi et al. 2021), Venezuela (Parra 2020), Argentina, Bolivia, Paraguay and Uruguay (León-Manco et al. 2021). In the technological context, digital disruption has resulted in radical changes in the way people study, teach, and learn. Emerging evidence indicates that many students did not learn what was expected during the pandemic, and has experienced a loss of knowledge and skills as a result of lack of engagement with academic work (UNESCO/IBE 2022). The absence of adequate infrastructure and technical preparation of LAUs and socioeconomic inequality of the population of Latin American countries contributed to aggravate student learning gaps (García-Martín and García-Sánchez 2022; Paredes-Chacín, González, and Walles-Peñaloza 2020).

In the economic sphere, LAUs have faced severe budgetary cuts, threatening their ability to continue academic activities (Fajardo et al. 2020; Rosinger et al. 2022; United Nations and UNESCO/IESALC 2021). The deterioration of working conditions and the dramatic funding reduction primarily impacted researchers (Myers et al. 2020), particularly early-career researchers (Bansal et al. 2022; Herman et al. 2021). This has caused damage to career development in LAUs, fuelling the 'brain drain', i.e. the exodus of highly skilled professionals from developing to developed nations (Marchiori, Shen, and Docquier 2013; Artuc et al. 2015). The brain drain from Latin America is also influenced by the combination of poor policy implementation, mismanagement, corruption, and socio-economic and political conflict (Garcia Zea 2020; Latukha et al. 2022; Mao, Latukha, and Selivanovskikh 2022).

The crisis of LAUs in the context of Covid-19 also includes political aspects. Anti-science movements were fuelled in Latin America by public figures and political leaders who consistently deny science and undermine public trust in universities in combating the pandemic (Daniels 2021; Lasco 2020; Malta et al. 2021). Brazil, Latin America's largest country, is an emblematic case in this regard, with the escalation of tensions between the federal government and the democratic institutions, directly affecting HEIs (Arrais, Corcioli, and Medina 2021; Ortega and Orsini 2020).

All of these challenges demonstrate that the situation of LAUs in the pre-pandemic period was already challenging and became even more complex after Covid-19. This scenario was the impetus for this study, which had as its starting point Brazil's State University of Campinas (Unicamp), where some of the authors of this paper are professors and work on the Board for Undergraduate Affairs (BUA) that advises the university's Chancellor.[1] The BUA identified several challenges imposed by the pandemic at Unicamp and considered the following particularly important within its scope of action: (i) mental health issues in the university environment, (ii) student learning gaps, (iii) the 'brain drain', and (iv) anti-science movements. The initial research conduct by the BUA found that, despite an increasing amount of empirical research on these challenges, there is a lack of studies that generate insights for managing them in practice.

Given the context presented, the purpose of this paper is twofold. First, it aims to provide a complex system perspective of the challenges confronting LAUs. Principles and concepts from complexity theory and ergonomics and human factors (E/HF) are used to develop a systemic view of the four aforementioned challenges. Second, it proposes guidelines for managers of LAUs to address these challenges in an integrated manner.

The remainder of this paper is organised as follows: Section 2 describes the methods used to conduct the research. Section 3 expands on the discussion of the four challenges within the scope of Unicamp's BUA by describing and considering their relevance to the LAUs more broadly. Section 4 introduces key concepts from complexity theory and relates them to the study

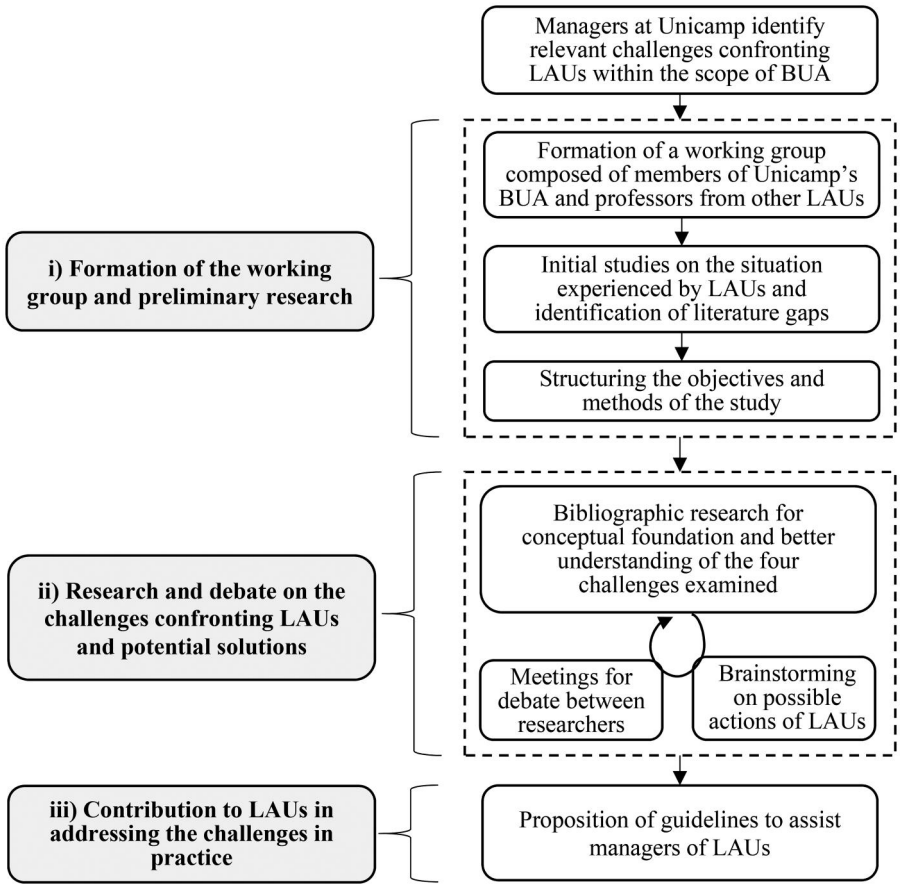

Figure 1. Research steps.

of E/HF systems. Section 5 discusses the challenges in an integrated manner and proposes a complex system view of the challenges confronting LAUs. Based on this, guidelines are proposed to assist managers of LAUs in dealing with the challenges analysed. Finally, Section 6 establishes the conclusions and limitations of the study, as well as proposals for future research, particularly how to move beyond theory to practical applications of complexity and E/HF in the context of management of LAUs.

2. Materials and methods

This paper aims to provide a complex systems view of the challenges confronting LAUs, contributing to the debate on how concepts from E/HF and complexity theory can be useful for managers to address them in practice. Figure 1 depicts the steps to conduct this study:

As previously mentioned, the study's motivation was the work of the Board for Undergraduate Affairs (BUA) at Unicamp regarding the problems affecting the university community. The BUA is one of Unicamp's 12 administrative bodies, which are responsible for the management of the university. It is worth mentioning that Unicamp was ranked top 3 among the best universities in Latin America (The World University Ranking 2022), which is important due to its representativeness in this region.

The BUA's preliminary research revealed that, while the problems caused by Covid-19 are numerous, the four challenges included in the scope of action of BUA – i.e. mental health issues in the university environment, student learning gaps, the 'brain drain', and anti-science moveverments – are representative of the current situation not only at Unicamp, but in LAUs in general (UN/ECLAC 2022; UNESCO/IESALC 2020; United Nations 2022). These challenges can be interpreted as complex problems because they involve economic, technological, and political aspects all at the same time (Décamps, Allal-Chérif, and Gombault 2021; Thatcher et al. 2018), and possible solutions require systemic approaches.

From the identification of target problems and the need for systemic approaches, an independent working group was formed, composed of members of Unicamp's BUA and professors from other LAUs, with the purpose of discussing possible actions to face

these challenges, which served as the basis for the development of this paper. In the formation of the working group, multidisciplinarity and work experience in management positions in LAUs were sought. Thus, the working group comprised researchers from Education, Administration, Economics, Ergonomics, Mechanical and Industrial Engineering (with focus on sustainability), and Chemistry (with focus on education). The variety of backgrounds and the diversity of knowledge was a crucial factor for developing a complex view of the challenges confronting LAUs. The working group included professors from universities in Brazil (State University of Campinas and University of São Paulo[2]) and Chile (Universidad Católica del Norte).

The working group conducted initial studies to deepen knowledge about the situation experienced by LAUs and to identify potential gaps in the literature. In this stage, the working group verified the relevance of the challenges for Latin American regions and universities, the need for systemic approaches to address them and the lack of practical proposals to support the managers of LAUs. Based on this, objectives and stages of the study were defined, and the actual research was initiated.

The working group dynamics consisted of an iterative process including bibliographic research to establish the conceptual foundation (i.e. complexity and E/HF) and to broaden the knowledge about the empirical reality of LAUs (mainly based on reports from United Nations, UNESCO and other relevant institutions); and meetings to generate and debate ideas on how LAUs could implement actions to address the challenges under investigation.

Finally, this iterative process of research, brainstorming and debate culminated in the development of guidelines to assist managers of LAUs as proposed in this paper.

3. Description and relevance of challenges confronting Latin American universities

3.1. Mental health issues in the university environment

Since the outbreak of the pandemic, one of the scientific community's primary concerns has been mental health. A search in the Scopus database using the keywords 'mental health' and 'covid' and considering only the 'article title' results in more than 4880 documents[3]. Over 480 studies are found when the same search parameters are used with the addition of the terms 'student*' OR 'professor*' OR 'faculty'.

A variety of mental health problems have been observed in higher education students, including insomnia, emotional irritability, emotional instability, anhedonia, depressed mood, physical headache, ocular tiredness, and backache (Michaeli et al. 2022). Indeed, studies have shown that being a student is a risk factor for having higher levels of depression, anxiety, and stress during the pandemic (Mautong et al. 2021). A meta-analysis of 62 studies with 196,950 participants in Latin America conducted by Zhang et al. (2022) reinforces this claim. The authors found that the prevalence of mental health symptoms in the general population, general healthcare workers, frontline healthcare workers and students in Latin America was 37%, 34%, 33% and 45%, respectively (Zhang et al. 2022).

Professors have also experienced mental health issues as a result of the abrupt change in teaching work caused by the lockdown (Araújo et al. 2020; Sigahi et al. 2021; Wang et al. 2020). Several challenges have been identified for professors at LAUs where support and infrastructure are less than that of rich-country HEIs (Freitas et al. 2021; Gomes et al. 2021). During the pandemic, professors faced challenges in the use of technological tools, digital platforms, and a lack of specific training; an increase in self-demand and pressure from HEIs; and frustration with the 'digital monologues' that some classes have become (Pucinelli et al. 2022; Santos et al. 2021). The lack of good internet access and adequate place for online teaching, difficulties in producing teaching materials, and housework roles had a significant impact on the quality of life and anxiety scores of LAUs professors (Pucinelli et al. 2022).

When considering the socio-economic context of countries, LAUs have to face challenges that go beyond campus boundaries. It has been suggested that despite quick action for the pandemic's containment and compliance with the protective measures, increased mortality in Latin American countries may be justified by the region's precarious healthcare system and poverty rates previous to the outbreak (Ruiz-Frutos et al. 2021). Another challenge for LAUs is that the global South, according to Martínez, Valencia, and Trofimoff (2020), is a region where information for policymaking and academic research is usually scarce. In fact, Boonroungrut, Saroinsong, and Thamdee (2022) conducted a bibliometric analysis of 2055 articles published between 2020 and 2021 and found that Latin American and African countries are the least productive in terms of research on student mental health.

There is consensus in the literature that the pandemic has influenced the personal, social, labour, and everyday lives of LAUs students and professors, affecting the mental health of this population. In this regard, public policies, strategies, and mental health surveillance systems are needed (León-Manco et al. 2021), in addition to psychological support and financial aid for low-income students (Silva et al. 2021).

3.2. Student learning gaps

More than 1.5 billion students worldwide have suffered from education institutions closure since the beginning of Covid-19 due to confinement (UNESCO 2021). The pandemic transformed university teaching from models strongly anchored in the transmitting conception of training and the face-to-face teaching-student relationship to a situation strongly mediated by technology (Cabero-Almenara and Llorente-Cejudo 2020). For instance, medical professionals and students had to quickly adapt and respond to demands for social distancing, hygiene, new protocols, and the transition to online education, while educators were forced to engage in distance teaching and learning when the families they served lacked technological resources for online modalities (Atiles et al. 2021).

The situation experienced in the LAUs is directly linked to the low level of digital development in their respective countries (Antón-Sancho, Vergara, and Fernández-Arias 2021). In general, studies have identified an increased digital inequalities during the pandemic (García-Martín and García-Sánchez 2022), inadequate reliability of the technological resources for classes and the lack of training and development of digital skills for professors and students (Cabero-Almenara and Llorente-Cejudo 2020). Based on a sample of 298 students from Brazil, Colombia, and Peru, Quispe-Prieto et al. (2021) analysed their well-being, educational resources, learning experience, and satisfaction with virtual classes, and concluded that there are still unsatisfied needs regarding access to digital resources and socio-emotional needs. The study by Collazos et al. (2021) adds that existing online platforms are not conducive to support clear communication among academic staff.

In general, academic research on student learning gaps has emphasised two aspects of remote learning: technological and emotional. Regarding technological aspects, there is agreement on the importance of providing adequate professional training in the use of new technologies in online learning environments (Cabero-Almenara and Llorente-Cejudo 2020; Salas-Pilco, Yang, and Zhang 2022), but the problem is not limited to this. As proposed by Paredes-Chacín, González, and Walles-Peñaloza (2020), it is necessary to go beyond the exclusive use of technology for teaching and promote the dissemination of accessibility, visibility, and interoperability of technological platforms that respond to the requirements of an educational environment violated by Covid-19.

In terms of emotional aspects, the significance for HEIs to provide emotional support for students has been emphasised (Collazos et al. 2021). At this point, there is a clear connection between, on the one hand, the students' difficulty in learning and the teachers' difficult in teaching facing the restrictions imposed by the lockdown; and, on the other hand, broader issues such as mental health issues (see Section 2.1.1) and the socio-economic context of Latin American countries, most of which are characterised by precarious healthcare systems and high poverty rates prior to the outbreak (Ruiz-Frutos et al. 2021).

3.3. Brain drain

The Covid-19 pandemic, by slowing down or worsening various aspects of development in Latin America (UN/ECLAC 2022; United Nations 2020, 2022), has heightened a problem that countries in this region have been facing for a long time: the Brain drain, i.e. the exodus of highly skilled professionals who are vital human capital for organisations, communities, and nations (Garcia Zea 2020). As stated by Latukha et al. (2022) and Nourani et al. (2022), globalisation, increased knowledge intensity, and the growth of emerging economies have transformed talent into a unique resource and a driving force in the development of organisational sustainability and competitiveness.

Brain drain is experienced in particular in developing regions where employers offer restricted career growth opportunities, unbalanced workloads and poor incentives (Wanniarachchi, Kumara Jayakody, and Jayawardana 2022), and the wages and living conditions are less attractive for highly-skilled individuals than those in developed countries (Artuc et al. 2015; Marchiori, Shen, and Docquier 2013).

LAUs are particularly vulnerable to brain drain because researchers have been central figures in the brain drain movement (Toole and Czarnitzki 2010; Torrisi and Pernagallo 2020). The study conduct by Weinberg (2011) was very important to understand this scenario as it estimated that at that time one in every eight important scientists is born in the

developing world, with 80% working in the developed world. This author observed that with only 0.2% of scientists from developed countries migrating to developing countries, a developing country must both produce and retain important researchers to achieve scientific success (Weinberg 2011). Although recent studies of this amplitude are lacking in the literature, more focussed studies show that brain drain from developing to developed countries has increased over time (Mao, Latukha, and Selivanovskikh 2022; Nourani et al. 2022; Wanniarachchi, Kumara Jayakody, and Jayawardana 2022), thus worsening the data presented by Weinberg (2011).

It is important for LAUs and developing nations to understand that brain drain involves multiple challenges of different natures that go far beyond financial aspects (Latukha et al. 2022). Researchers have identified a variety of factors that influences the exodus of highly-trained professionals from developing countries such as high levels of corruption and inequality, low press freedom, and low trust in judicial systems (Beechler and Woodward 2009); low investment in research and development, industry competitiveness and innovativeness (Gibson and McKenzie 2014); and individual perception of social equality and diversity (Latukha et al. 2022). In this sense, while most of these factors can be identified in Latin American countries, there is no single approach to addressing them, and the complexities of each context must be considered (Mao, Latukha, and Selivanovskikh 2022).

3.4. Anti-science movements

Anti-science movements includes science denial, defined as the systematic rejection of empirical evidence in order to avoid personally and subjectively undesirable facts or conclusions (Liu 2012), as well as the denial or even alteration of clearly recognised historical or social facts (Allen et al. 2020).

Anti-science movements are neither new nor exclusive to Latin American countries. In fact, it has a long history of causing harm in contemporary society including the denial of climate change, relativity theory, evolution, the origin of life, AIDS, tobacco disease, the flat-Earth (Fackler 2021), and more recently, the Covid-19. Thus, anti-science movements are neither new nor exclusive to Latin American countries, but it had a huge impact on pandemic management in countries in this region, such as Brazil where the denialist government resulted in one of the worst response to the pandemics (Daniels 2021; Malta et al. 2021; Ortega and Orsini 2020).

The study of Safford, Whitmore, and Hamilton (2021) is important to understand how the science denial in the context of Covid-19 impacted directly the LAUs. These authors explained that 'follow the science' became the mantra for responding to the COVID-19 pandemic, which for the general public also meant 'follow the scientists', which caused concern because some people viewed scientists as untrustworthy. In this sense, public political figures have cast unfounded doubts about the role of LAUs in combating the pandemic (Arrais, Corcioli, and Medina 2021).

Although the study by Hansson (2017) have been conducted before the Covid-19 pandemic, it is essential for understanding how anti-science groups operate. This authors identified a series of actions that comprise the modus operandi of these groups, including considering the target theory as a threat (e.g. evolution theory as a threat to traditional religion) and giving a false impression of having support in the scientific community (denialists create institutes, conferences, and journals to impress the public).

To combat these actions of anti-science groups, the LAUs have assumed a role in promoting vaccine and drug research, as well as in solidarity actions directed to local and socially vulnerable populations (Lima and Nascimento 2022). Several examples can be cited, for example, such as in Peru, LAUs worked on the manufacturing of mechanical respirators to assist the country's health system; in Mexico, a network of 28 hospitals and university laboratories was established to conduct Covid-19 diagnosis throughout the country; in Argentina, the government collaborated with universities by providing financial support for pandemic response efforts as well as funding for social and human sciences research projects (Arrais, Corcioli, and Medina 2021); and in Brazil, where researchers have launched a project offering science advice to policymakers (de Oliveira Andrade 2019) and 68 HEIs organised to provide direct care to the population, including Intense Care Units for the treatment of people infected by Covid-19, as well as more than 3000 public university hospital beds, over 1000 research initiatives, and 500 voluntary solidarity actions to assist local populations (Arrais, Corcioli, and Medina 2021; National Association of Directors of Federal Institutions of Higher Education 2022a, 2022b).

Lima and Nascimento (2022) summarised the scientific community's warning, stating that the pandemic has demonstrated that scientific trust, as well as how society – including LAUs – should respond to collective danger, must be decided now and cannot be

postponed any longer (as it seemed in the case of climate change).

4. Complexity and E/HF: key concepts for a systemic approach

Complexity sciences refer to the studies of complex systems in a broad way (Castellani and Gerrits 2021). There are numerous approaches and theories of complexity with distinct epistemological, ontological and conceptual foundations (Yolles 2019), but they all have in common the central idea that a complex system cannot be understood solely through the study of its parts and/or the whole; it is fundamentally necessary to know the *interactions* that comprise it (Byrne and Callaghan 2014).

This idea emerged from the perception that reductionist approaches were insufficient for understanding real-world problems, characterised as complex or wicked problems (Sahin et al. 2020; Yearworth 2016). In this regard, complexity-based approaches are increasingly being used in the modelling and investigation of E/HF systems (S. W. A. Dekker, Hancock, and Wilkin 2013; Salmon et al. 2017; Thatcher et al. 2018, Thatcher, Nayak, and Waterson 2020; Walker et al. 2010). In this research, we build on the concepts of complexity thinking developed by Morin (2010, 2015) and systems E/HF approaches (Dul et al. 2012; ILO and IEA 2021; Read et al. 2018; Salmon et al. 2022; Thatcher and Yeow 2016; Walker et al. 2010; Wilson 2012, 2014).

4.1. Moving from Cartesian to complexity thinking

Classical science is characterised by the principles of reduction and separation (Morin 2010); it rejects all subjectivity and uncertainty as if they are side effects of ignorance, and considers that 'the clarity and distinction of ideas are criteria of truth' (Morin 2011, 279–280). These principles reflect the Cartesian thinking, which holds that any problem can be solved by breaking it down into its constituent parts and analysing them separately; the underlying idea is that the sum of the solutions to each of the subproblems would be the answer to the whole problem (Morin 2015). This strategy is also Machiavelli's to dominate the city and Taylor's to rule the worker's operations in the firm (Morin 2011).

On the one hand, it is important to acknowledge that much of the scientific advancement that we know today was made possible by Cartesian thinking; on the other hand, it can be problematic when dealing with complex, real-world systems (Sigahi et al. 2022; Weber et al. 2021). From the standpoint of complexity, a new way of thinking is required to move beyond the concept of system as 'sum of parts' or 'whole' (Byrne and Callaghan 2014). In this sense, developing complex thinking implies overcoming 'reductionist blindness (only seeing the parts)' and 'holistic blindness (only seeing the whole)' (Morin 2016, 142).

It should be emphasised that complexity-based approaches do not seek to eliminate or replace reductionist and holistic thinking, but to complement and integrate them (Zilbovicius, Piqueira, and Sznelvar 2020). Morin (2016) proposes that complex thinking can integrate the partial truths found in reductionist and holistic approaches by making sense of the *interactions* between parts and the whole. The central idea is that the part-whole relationships must necessarily be mediated by the concept of interaction because systems are not made up of parts, but of interactions between them (Morin 2015). For example, an organism (system) is not made up of cells (parts), but of the actions that are established between cells (interactions), and the set of these interactions constitutes the organisation of the system (Morin 2010). The chain of interactions between the parts that produces a system, and the organisation ensures relative strength to these interactions, thereby promoting the system's resilience (Morin 2016).

Finally, it is important to note that complexity thinking does not argue against reductionism *per se* (Sigahi and Sznelwar 2022). It is necessary to *reduce* complexity to a point where the world becomes intelligible to us (Human and Cilliers 2013). Thus, applying complex thinking requires us to set boundaries, excluding certain aspects of the system from the model; in other words, we cannot understand the world in its totality, and there must be limits for a system to exist (Human 2016).

4.2. Complexity and systems E/HF approaches

S. Dekker, Cilliers, and Hofmeyr (2011) stated in their study of the implications of complexity theory for safety investigations that mainstream ergonomics advocates a reductionist philosophical stance, whether explicitly acknowledged or not. Salmon et al. (2017) added that whilst E/HF systems have arguably been complex since the dawn of the discipline, the shift towards the systems thinking paradigm revealed the reductionist tendencies of many ergonomics methods. Notwithstanding the issues E/HF addresses are

Table 1. E/HF domains, principles and stakeholders applied to the situation experienced by LAUs.

E/HF	Example of relevant topics/concepts	Example in the context of the challenges confronting LAUs
Domains (IEA 2019)		
Physical	Workplace layout, physical safety and health	Adequate environments for distance teaching and learning
Cognitive	Mental health, work stress, and training	Abrupt changes in study and work routine
Organisational	Communication, work design, telework	Clear communication between HEIs, faculty and students
Principles (ILO and IEA 2021; Read et al. 2018)		
Humans as assets	Ensure worker safety, health, and wellbeing in the optimisation of work systems as a top priority	LAU's leadership commitment to protect students and workers
Technology as a tool to assist humans	Design and manage work systems to ensure organisational and worker alignment	Use of technology tools and platforms to enhance learning
Promotion of quality of life	Create a safe, healthy, and sustainable work environment	Work-home equilibrium
Respect for individual differences	Account for individual differences and organisational contingencies in the design of work systems	Consideration of different home dynamics and family routines
Responsibility to all stakeholders	Make use of collective, transdisciplinary knowledge and participation of workers for designing systems, detecting problems, and creating solutions	Engagement of all stakeholders to face the challenges that Covid-19 imposes on LAUs
Stakeholders (Dul et al. 2012)		
Systems influencers	Competent authorities such as governments and regulators	Federal government and policy makers
Systems decision makers	Employers and managers	Managers of LAUs
Systems experts	Professional who contribute to the design of systems	Support staff of LAUs (e.g. IT experts)
Systems actors	Workers and product/service users who are directly or indirectly affected by its design	Professors, researchers, students, community

typically systemic in nature (IEA 2019), and it has long been claimed that the field of E/HF must be systems-oriented in order to be useful (Wilson 2014).

Complexity thinking and E/HF concepts can be integrated to develop a powerful lens to study systems (S. W. A. Dekker, Hancock, and Wilkin 2013; Sigahi and Sznelwar 2021; Walker et al. 2010). Salmon et al. (2022) emphasise that systems E/HF is well suited to addressing major global and societal issues, such as Covid-19 pandemic, because it allows for the description of entire systems, their component parts, and, importantly, the *interactions* between these parts. From this perspective, E/HF domains, principles and stakeholders can be related to the study of challenges faced by LAUs (Table 1).

Complexity thinking warns that recognising the different E/HF domains is just as important as integrating them. In this sense, it is critical to look into the interactions between physical, cognitive, and organisational issues in the context of the challenges facing LAUs. As an example, it can be considered how workspace adequacy (Cuerdo-Vilches, Navas-Martín, and Oteiza 2021) is related to stress and mental health (Zhang et al. 2022), and how this can be mediated by effective communication between students, professors, and institutions (Sasangohar et al. 2020).

E/HF principles can be enhanced by complexity thinking as it helps us to see how different levels of systems impact each other (Thatcher and Yeow 2016). Instead of analysing central elements of the systems separately, such as worker wellbeing, technology, and work environment, complexity shed light on the interaction between first- (e.g. home dynamics and family routines) (Ayyildiz and Taskin Gumus 2021), second- (e.g. LAU's leadership) (Dennerlein et al. 2020) and third-order systems (e.g. government response to pandemic) (Fu et al. 2020).

Finally, complexity thinking assists in comprehending how the challenges posed by Covid-19 interact between each other and how they affect directly or indirectly all E/HF systems stakeholders (Dul et al. 2012), since it changes the way people study, learn and teach (Srisathan and Naruetharadhol 2022); the development of researchers' careers (Myers et al. 2020); and the decisions to be made by managers of LAUs, policy makers and governments (Saurin 2021).

5. A complex system view of the challenges confronting LAUs

Based on the concepts of complexity and E/HF presented, an integrated approach capable of recognising the interactions between the challenges confronting the LAUs under study can be proposed (Figure 2).

In order to avoid reductionism and holism (Morin 2016), it is not possible to understand the situation

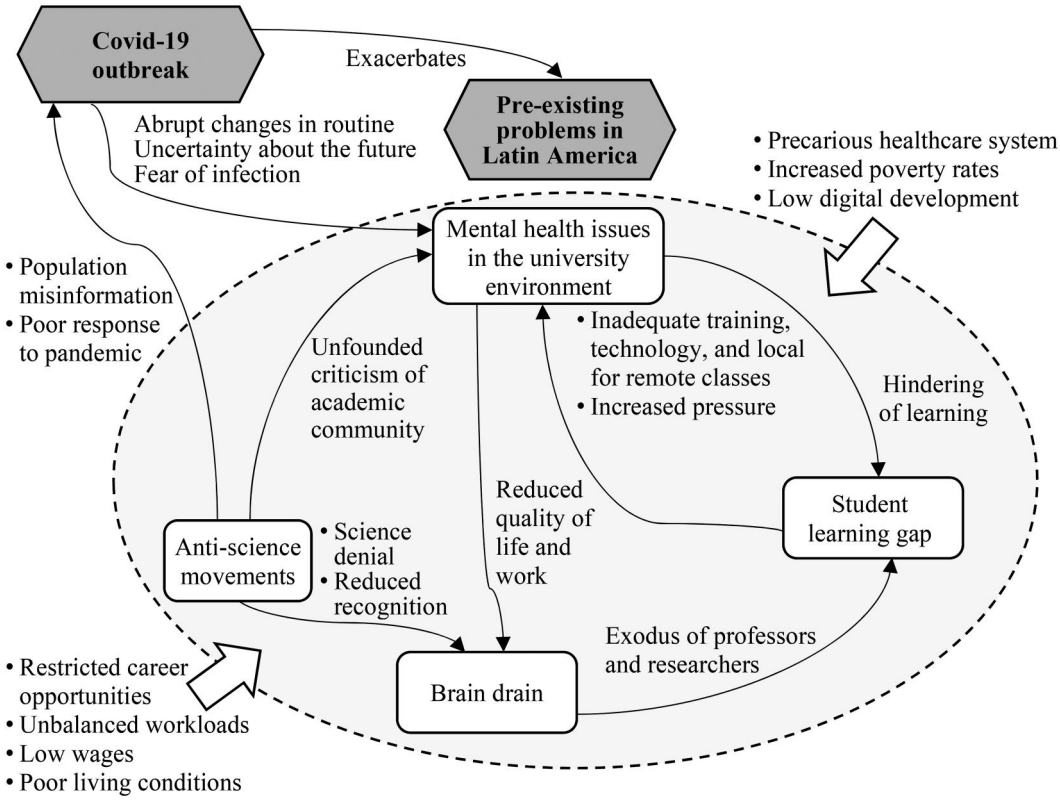

Figure 2. A complex view of the interactions between the challenges confronting LAUs.

faced by LAUs (the whole) by understanding each of the challenges (the parts) independently, just as it is not possible to comprehend such challenges by considering the university as a whole. Following complexity thinking and E/HF principles, the interactions between the challenges should be investigated.

The Covid-19 pandemic has abruptly changed the dynamics of the university environment, causing profound changes in people's lives and work, which is a starting point for developing a complex view of the challenges confronting LAUs. Furthermore, the pandemic has brought the threat to everyone's life, as well as uncertainty about the future of friends, family, and society. Such issues affect mental health of students and faculty (Michaeli et al. 2022; Zhang et al. 2022), which resonates in other areas.

The incidence of mental health issues has increased with Covid-19 among students and faculty, negatively impacting both learning (Collazos et al. 2021; Quispe-Prieto et al. 2021) and teaching (Cabero-Almenara and Llorente-Cejudo 2020). In addition, contextual issues in Latin America, such as the precariousness of health systems (which increases fear and uncertainty about the pandemic's evolution), the high rate of poverty (which worsen mental health of the population as a whole) (Ruiz-Frutos et al. 2021), and low digital development (Antón-Sancho, Vergara, and Fernández-Arias 2021), affects remote classes and culminate in gaps in student learning.

The student learning gap exposes the inadequacy of academic staff training in LAUs (Cabero-Almenara and Llorente-Cejudo 2020; Salas-Pilco, Yang, and Zhang 2022) as well as of technological and physical resources for remote classes (Paredes-Chacín, González, and Walles-Peñaloza 2020), putting additional strain on students and professors (Pucinelli et al. 2022; Santos et al. 2021) and negatively impacting their mental health.

When researchers and professors notice a decline in the quality of life and work, they are more likely to look for opportunities outside of the country (Latukha et al. 2022; Mao, Latukha, and Selivanovskikh 2022). Working conditions at LAUs, such as low salaries and limited career opportunities in comparison to other professions (Artuc et al. 2015; Marchiori, Shen, and Docquier 2013; Wanniarachchi, Kumara Jayakody, and Jayawardana 2022), cause an exodus of qualified professionals from HEIs, with a negative effect on student learning.

The brain drain is further intensified by the actions of anti-science groups (Fackler 2021; Liu 2012), which deny science and thus reduce the recognition of researchers' work. Associated with these issues, the criticism directed to the academic community (Safford,

Table 2. Relationship between guidelines and interactions.

	Guidelines									
Interactions between the problems confronting LAUs	GD1	GD2	GD3	GD4	GD5	GD6	GD7	GD8	GD9	GD10
Unfounded criticism directed at the academic community					✓		✓		✓	✓
Science denial							✓		✓	✓
Reduced recognition of research contribution							✓	✓	✓	
Reduced quality of life and work	✓		✓	✓	✓	✓	✓			
Exodus of professors and researchers	✓			✓	✓		✓		✓	
Inadequate training, technology, and local for remote classes	✓	✓				✓	✓			
Increased pressure on students and professors	✓	✓	✓	✓	✓	✓	✓			
Hindering of learning of the students	✓	✓	✓	✓			✓			
Abrupt changes in routine of students and professors	✓			✓	✓					
Uncertainty about the future			✓	✓	✓	✓				
Fear of infection			✓							
Population misinformation									✓	✓
Poor response to pandemic						✓			✓	✓
Restricted career opportunities							✓	✓		
Unbalanced workloads	✓		✓	✓			✓	✓		
Low wages							✓	✓		
Poor living conditions						✓		✓		
Precarious healthcare system						✓		✓		
Increased poverty rates						✓		✓		
Low digital development		✓				✓		✓		

Whitmore, and Hamilton 2021), as well as questions about the role of LAUs in facing the pandemic (Arrais, Corcioli, and Medina 2021), contribute to the worsening of mental health in the university environment. The actions of anti-science groups have affect pandemic management, due mainly to public misinformation. As the pandemic worsens, a complex cycle of exacerbation of existing problems in Latin America begins again through the network of connections between them.

A complex view can greatly assist the managers of LAUs in understanding and proposing solutions to existing problems; however, as postulated by complexity theory (Human 2016; Human and Cilliers 2013), any representation of reality (such as Figure 2) excludes certain aspects of the systems, which is necessary so that the complex interactions between the challenges become intelligible to us.

5.1. Proposal of guidelines for managers of LAUs

Based on the results and discussions, 10 guidelines (GD) were developed to assist managers of LAUs in addressing the issues they face:

- GD1: Train academic staff to perform activities in virtual environments;
- GD2: Promote the accessibility, visibility, and interoperability of technological platforms;
- GD3: Strengthen emotional support for students and professors;
- GD4: Monitor the mental health of students, professors and other workers of the HEI;
- GD5: Develop policies that aim to improve the resilience of the university members;
- GD6: Provide financial aid taking into account sociodemographic aspects;
- GD7: Develop policies, programs, and activities for the purpose of enhancing the quality and quantity of talent within and across LAUs;
- GD8: Engage with governments for the implementation of investments in local institutions, youth policies and programs of retention of talents;
- GD9: Strengthen communication channels between university and society;
- GD10: Establish partnerships with public and private organisations for the dissemination of science.

The guidelines were created in accordance with the principles of complexity, which focuses on interactions (between the problems) rather than parts (the problems separately) and the whole (the situation of the LAUs in its totality). The relationship between guidelines and interactions is summarised in Table 2:

6. Conclusions

The challenges confronting LAUs are not easy to manage, and the purpose of this paper is not to present solutions to them. Instead, it sought to contribute to the debate on how concepts from complexity theory and E/HF can be integrated to assist managers of LAUs in understanding the problems they face.

At first glance, the challenges confronting LAUs discussed in this paper – mental health issues in the university environment, student learning gaps, brain drain, and anti-science movements – may appear

unrelated. However, the complex systems view provided in this paper, while excluding certain aspects of the systems, demonstrates that understanding what LAUs are experiencing in a fragmented manner is impossible. In addition, a complex systems view helps us to see that HEIs are subsystems of larger, more complex systems (e.g. nature, society), which requires their needs to be interdependently regulated taken into account all the E/HF system stakeholders.

It is important to note that most managers of LAUs were trained with a Cartesian perspective, as this underpins classical science and education systems (Morin 2010; Sigahi et al. 2022; Sigahi and Sznelwar 2022). Therefore, these professionals can tend to break down a complex problem into smaller, simpler problems, losing important information from the interfaces. Complexity thinking and systems E/HF teaches us that uncertainty is an inherent aspect of real-world problems, and in order to incorporate (rather than eliminate or ignore) it to the solution, the *interactions* between the problems should be at the centre of the actions.

7. Limitations and future studies

This study has several limitations. First, as previously discussed, applying complex thinking requires us to set boundaries, excluding certain aspects of the system from the model. Future studies can identify neglected interactions and integrate them into the complex view proposed in this paper. Second, the challenges studied were limited by the scope of action of the Unicamp's Board for Undergraduate Affairs. Many other pressing challenges affecting the LAUs can be investigated in future research, such as budgetary cuts, cost inflation, and digital disruptions. Third, this study was based on the perception and experience of professors working at universities in Brazil and Chile. It is necessary that further studies are conducted not only in other universities in these countries, but also in other regions of Latin America. Finally, the use of theoretical lenses that add to E/HF and complexity theory, as well as other qualitative and quantitative research methods, can greatly enrich the complex view of the challenges confronting LAUs.

Notes

1. The institutional website of the Unicamp's Board for Undergraduate Affairs is https://www.prg.unicamp.br/.
2. State University of Campinas and University of São Paulo were considered the top 2 best universities in Brazil and were included in the top 3 in Latin America, while Universidad Católica del Norte was ranked 13th in Chile (The World University Ranking 2022).
3. The search was conduct in August 2022.

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