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Space without Time and Time without Space in Educational Paradigm Shifts?

ABSTRACT

Aims: The aim of the article is three-fold: first, to show that space and time are interrelated when teaching and learning is considered, creating the need to examine space and time in an integrated and inter-dimensional framework; second, to propose an integrated approach to the concept of space-time as a useful teaching and learningissue, allowing us to unmask the true time-space consideration in education; and third,to argue for the relevance of analyzing the concept of space-time as a paramount issue in the research on teaching and learning.
Studydesign: Due to the ongoing societal and technological changes, the space-time concept is changing extremely fast,and new conceptualizations are requiredin order to examine how such evolving space-time approaches can operate as a tool for teaching and learning. This paper provides such a conceptualization.
Methodology: This article should be considered as a theoretical contribution ~~of~~ tohow the existing conceptualization of space-time in education should be redefined to address emerging teaching and learning paradigm shifts, which have an impact on its consideration and use.
Results: It has been established: first, that in education the spatial domainis**not** defined by the classroom, while the temporal domain is**not**defined by the lessons' timing; second, space and time are multi-dimensional, which have an impact on how space-time should be considered; and third, the concept of space-time has evolved from a four-dimension concept consideration to a multi-dimensional and later on to an inter-dimensional concept,demandingan integrated and inter-dimensional approach to teaching and learning.

Key Words: The space-time concept, paradigm shifts of space-time, multi-dimensionality of space, multi-dimensionality of time, inter-dimensionality of space-time

1. INTRODUCTION

Teaching and learning in schools are determined by the space and time in which they take place. Allenhas argued that successful educational communications depend basically on when and where they happen rather than on any other kinds of conditions [1]. As a result, understanding and applyingthe concept of time-space is an essential aspect of teaching and learning and most ~~important~~importantly"independent of the subject or content being taught"(Rapp, 2021). Moreover, it is well known thatthe use of the concept of space-time in teaching varies between contexts, (i.e., cultures, regions,resources etc.). Finally, the spatial domain is**NOT** defined by the classroom, while the temporal domain is NOTdefined by the timing in any lessons. Spatial and temporal aspects of ~~students~~student'steaching and learning as well as their activities should beconsidered integrated principles in any modern school or classroom.

This suggestionis based on the following: firstthe disciplinary order proposedbyFoucault [3] who having this order as histheoretical starting point,accepted that spatial and temporal aspectsshould be considered as tightly related between themselves or **interrelated**; and second,Ecclesand~~&~~ Popper[4] consideration of our world into three parts: the physical world, our inner worlds and the cultural heritage, which has been established in our minds, and where the emphasis is on**integration**. Space-time, as a foundation for an integrated geographical/temporal consideration, tries to bring all these worlds together into a common framework.

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The concept of space-time until the last few decades of the 20th century, was based on the assumption that the three-dimensional representation of our world (its description in terms of locations, spatial patterns, and processes) was distinctly different from time (the measurement of when events occur,their duration and perspective). The concept of space-time took on a new meaning: first from the work of Einstein on thespecial theory of relativity[5]. Actually, the term **space-time** was coined by Einstein himself as he discovered the General Theory of Relativity; and second with theLorentz transformation, when Hermann Minkowski createda geometric interpretation of special relativity that combinedthe three dimensions of space and time and into a single four-dimensional expression, known as the Minkowski space [6]. This interpretation proved fundamental in the developmentof the general theory of relativitybyEinstein.

2. TEACHING AND LEARNING

In terms of teaching and learning, as we are into the first quarter of the 21st century, important changes in both technological innovations and educational reformshave occurred leading into a new way the concept of space-time is viewed in education. But understanding such an issue is possible only through understanding the role of technology in education as well as examining the evolution of these two educational dimensions, which in turn determine the way we perceive and practice the space-timeconcept.

On the first concern it has been proven that the implementation and use of new technology tools forces new approaches in the didactic processes [7], including viewing important educational concepts such as space-time. Specifically, such tools promote the education stakeholders to directly question the meaning of these concepts and their need to actively engage in applying them. But mainly that the pedagogic value of such technological changes is rooted in the existing social conditions that determine the viewing and implementation of such concepts in the classroom.

In understanding the second concern there are three issues that need to be clarified: first, the utility and comparison of chronotope with the concept of space-time; second, the role of society in considering the space-time concept in education; and third the influence of educational paradigm shifts.

2.1 Chronotope

The term chronotope, is formed from the ancient Greek words chronos (time) and topos (place),and was proposed byMikhail Bakhtin [8]. Bakhtin's idea has been erroneously considered it to be identicalwith the concept of space-time as it is considered in this paper and supported by the literature and common sense. The most avid proponent of chronotope in education [9] has stated that "the implementation of pedagogical approaches such as the flipped classroom [10], connected learning [11] and place-based learning [12] entail the transformation of the spatial and temporal organization of learning". In other words, chronotope is just a tool utilizing the pedagogical applications of technology for the organization of space and time in teaching and learning, such as the use of flipped learning to share lessons at home through the internet to study these lessons (teaching in different spaces and times as opposed to the same place and time at the classroom).

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2.2 Changes in the space-time concept

The second issue is related to the factors, which bring changes of howthe concept of space-timeis considered thatare the result of the shifts in the perceptions and beliefs of society. These in turn changed the teaching and learning approaches by the education stakeholders. It is well documented that societal values and goals are changing through time, resulting in important changes in all aspects of teaching and learning [13].Indeed, societal values and goals are changing through time, resulting in influential changes in all aspects of our lives, including the way the concept of space-time is regarded and applied in education.

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2.3 Paradigm shifts

The third issue is related to the influence of educational paradigm shifts. In epistemology, in the last few years, important changes havetaken place related to the way we view educational issues as well as their basic principles. The most important of these differentiations are the changes in the way we perceive the following:

- **Geographic space**: “from the assumption that the phenomena exist in order to be discovered to the perception that they constitute social constructs, our own creations” [13].
- **Time:**from the acceptance of the uniqueness of time to the perception that time is an abstract entity created inour mind on the basis of our experience of change.
- **Space-time:** from the belief that space and time are independent ofgiven realities to the perception that they are interdependent social constructs.

These perceptions are very important, because they outline the need for an epistemological treatment of the space-time concept in education. Indeed, theconcept of space-timehas recently been involved in changes confirming what epistemologist Thomas Kuhn (1962) referred to as paradigm shifts and which are not unusual events in education [14]. As a result, it is necessary, in addition to defining the space-time concept, to examine the evolution of the consideration of them in accomplishing pedagogical goals.

For many years and reaching the end of the 20th century (1980’s), the space-time educational process usually explored on one hand where, and mainly why, events and phenomena take place in space. On the other hand, seldom do the educational stakeholders (students, teachers, curriculum designers etc.)explore the notion of time, or at best they are concerned only when and for how long these events and phenomena occur. That is, time functions considered mainlywithing a framework of a snapshot model “where several static snapshots of the subjects orphenomena of interest are captured so as to study the temporal trends and/or mechanisms behind such trends”[15]. As a result, the traditional idea of space-time is a conceptual model combining the three dimensions of space (longitude, latitude and elevation) with the fourth separate dimension of time and educational approaches are following that model[16, 17].This view dominated most scientific and philosophical approaches and in general the literature up to the end of the 20th century. For example, an excellent review of this traditional concept of space-time on database models is provided by Pelekis et. al. [18].

However,nowadays this approach cannot be accepted, because of the educational paradigm shiftsthat have occurred.Considering that the space-time concept has evolved considerably, itinevitably leads to the basic principle that the present approach to space-time in education, which can be termed as the **traditional four-dimension approach**, is now absolute and we are in the period of the **inter-dimensional**space-time teaching and learning. In other words, we consider the space-time concept that combines the three dimensions of space with the fourth separate dimension of time as an absolute approach. Education, with a century delay, started following the physical sciences in discarding the traditional four-dimension approach. In physical sciencesspace and time are interdependent when used in examining actions and phenomena, making it necessary and in education to examine space and time in anintegrated and coordinated way.

To understand this form of integrated/coordinate approach, it is necessary accept the principles supporting the changes in the consideration of the space-time concept, which certainly are **not** related to the organization of space and time in teaching and learning. These are:

- The existence of societal changes that have occurred, who are the determining factor in considering and applying this concept in education;
- The changes in concept considerations, such as space-time, are based on paradigm shifts, which produce non-linear differentiations; and
- The applicability the new space-time concept is based upon the technological literacy of the educational stakeholders.

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It is suggested that four educational paradigm shifts, following societal changes due to technological innovations, have been differentiating education approaches world-wide, namely: Personal Computers, Internet/Multimedia, Mobile Devises and Artificial Intelligence.Thissuggestion is in accordance with the Actor Network Theory [19], claiming that "societal and technological factors hold equal weight" at least in education.In very general terms the following space-time approach changes have been observed (Table 1).

Table 1: Space-Time paradigm shifts

PARADIGM SHIFT	USERS	SPACE-TIME
PERSONAL COMPUTER	few	4-DIMENSIONS
↓		
INTERNET-MULTIMEDIA	several	TRANSITIONAL
↓		
MOBILE DEVICES	many	MULTI-DIMENSIONAL
↓		
ARTIFICIAL INTELLIGENCE	nearly all	INTER-DIMENSIONAL

2.3.1 The Personal Computers Paradigm

There are many ways in which personal computers can be used to enhance the teaching and learning experience. For example, they can be used to access, examine and evaluate educationalmaterial and to interact with other students and teachers. As a report by the OECD [20] has pointed out, computer use in schools and in classrooms enhances students' performances.

The use of personal computers (PC) by students started from the '80s, leading education systems and schools to enhance learning experiences. However, results from severalinitiatives and reports (i.e.,OECD[20]) made clear, that all education stakeholders first need to be equipped with digital competences, such as knowledge, skills and values [21], so that they can participate fully in developing a digitized society and digitized schools. In other words, in this paradigm, at least in the beginning the use and value of PCs by all stakeholders was limited due to the fast development of these technological tools and their consequent technological illiteracy of the educational stakeholders. Therefore, for all practical purposes space-time was treated in the traditional four-dimension approach (Table 1, first row).

2.3.2 The Internet/Multimedia Paradigm

In the middle of the 90s, schools started usingtools of Information and Communications Technology (ICT)to a series of educational processes, such as:communicate, create, disseminate, store, and manage information, based on the capabilities the **internet**could provide**.** In a few contexts and few schools ICT became part of the teaching and learning process. At the beginning replacing standalone machines without graphical interfaces and internet connectivity with connections to the internet and progressively computers with numerous local and online applications, as well as changing chalkboards with interactive digital whiteboards and shifting towards new learning experiences through digital environments.

The Multimedia educational messages refer to lessons containing both words and pictures, which can be in a static or a dynamic form. As a result, **multimedia instructions** can improve education,because meaningful learning can be achieved when studentscan select words and images to help organize their words into compact and the images into a coherent structure, integrating them into a comprehensible whole. It should be noted that in multimedia learning, pictures do not replace words, but rather work

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together with words to form an instructional message that results in better teaching and learning.In short, people learn better from integrating words and pictures than from words alone.

Over the past 30 years, the literature from educational and cognitive psychology have presented evidence that human understanding can be improved substantially when appropriate graphics are added to the text. That is,teaching and learning is enhanced when learners can select needed information from a multimedia message.But ~~the~~ multimedia instruction, at least in the last century was not fully appreciated, even by some of the digital literate education stakeholders and thus it was utilized by a small number of teachers andschools, which, however, were constantly increasing. The value of multimedia instruction for improving how people think, process,and understand the concept of space-time, is measured by their ability to take available resources (texts and images) and apply them to such an integrated concept. As a result, the internet/multimedia paradigm was approaching the space-time concept in a transitional way: asmall part as a multi-dimensional, but mainly as the four-dimension traditional approach (Table 1, second row).

2.3.3 The Mobile Devices Paradigm

Mobile devices have become an integral part of teaching and learning very recently (the beginning of the 21st century or around 2005). Indeed, mobile devices such as laptops, personal computers and mobile phones have become successful learning and teaching toolsin and out of the classrooms. Although the literature on the use of mobile devices in education is very small, the few systematic analyses of the effects of mobile devises in education show that they are important. For example, a study by Sung et al. [22], has shown that integrating mobile devices with teaching and learning can have a positive impact on students' learning performance.In addition, the eNetLearning course on "Mobile Devices for Teaching and Learning" highlights meaningful ways that mobile devices can successfully support teaching and learning in and outside of the classroom. But most important it clearly shows the challenges faced by educators when trying to incorporatemobile devices into the teaching and learning process.

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Most educational stakeholders and especially teachers have come to realizethat the use as learning tools using mobile devises could effectively (and easily) be integrated into the classroom and enhance students' learning experience, without the need of labs or other educational approaches. They present excellent opportunities for students to work communicatively, creatively, collaboratively, and being 'mobile', as well as continue learning outside the classroom. As a result, the Mobile Devise paradigm, became usefulby helping bring the real world into the classroom. Moreover,as the number of stakeholders and their digital competences increased, they resulted in a truly multi-dimensional approach (combining or involving more than one dimension of any subject, discipline or field of study), which was utilized by many more schools and education stakeholders (Table1, third row).

2.3.4 The Artificial Intelligence Paradigm

Artificial Intelligence(**AI**) is a rapidly accepted tool providing knowledge, which is transforming the way we live, work, and from the perspective of this paper, learn .That is, **AI**is an emerging technology that started modifying teaching and learning tools and approaches as well as educational institutions. The existence of **Artificial Intelligence** basically changes the teacher's job, without, forcing them to lose their importance, becauseeven withing the **AI** framework teachers arethe principal force in any educational practice.

According to a report by the U.S. Department of Education, Artificial Intelligence is a tool to improve teaching and learning and support innovation in the educational system. In addition, Gocen & Aydemir [23] havemove a step further stating that Artificial Intelligence not only can be used, but is already used in education in an ever-increasing pace, despite the fact that now relative feweducation stakeholders have the knowledge to take pedagogical advantage of **AI**on a broader scale, and mainly how **AI** can impact teaching and learning.However, these conditions change rapidly[24].

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Basically, **AI** uses machine learning towards monitoring the speed of learning of any individual.From an educational point of viewA**I** systems offer to students effective support for individual and communal learning and to teacherssupport in their routine tasks, and mainly providing them adaptive assessments tools. As a result, all

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educational stakeholders through this paradigm have the means to consider the space-time concept in its real meaning (not simply as an organizational tool), which coupled with the rapid increase in users'numbers and digital competences [21] lead towards an inter-dimensional manner (combiningthe dimensions of educational systems, schools, and subjects)(Table 1, fourth row).

It shroud be evident that thespace-time concept in education is an evolving perspective of a combined spatial and temporal processes and events. Moreover, it has applicationsin curriculum, teaching tools, stakeholders' interrelationships etc. But space-time is not simply a subject, but rather an ontological framework in which space and time are the integrated dimensions of an educational processes. The space-time concept as an academic concern was originally developed by human geographers, but today it is utilized in most scientific areas.According to Swedish geographer Lenntorp[25],"**Al** is a basic approach, and every researcher can connect it to theoretical considerations in her or his own way".

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In sum, space and time are interrelated in any education process, forcing teaching and learning to examine space and time in an integrated and inter-dimensionalway. The necessity for such anapproach in considering the space-time concept can be adequately substantiated by the multi-dimensional nature not only of its basic dimensions (space and time), but of all their characteristics. And it is this reason that a detail examination follows.

3. THE MULTI-DIMENSIONALCONCEPT OF SPACE

The basic principle of space, within an academic context, is to link the basic dimensions of space with teaching and learning, and these are: the dimensions of **location**, **spatial patterns** and **spatial processes** as shown on Figure 1.

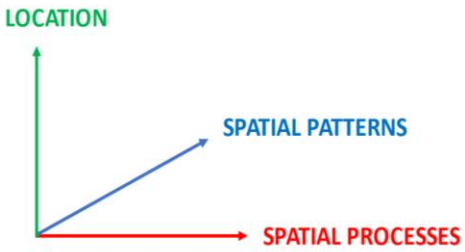

Figure 1: Dimensions of Space

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In modern mathematics spaces are defined as sets with some added structure. They are usually definedas different types of frameworks, which can easily be adopted to the graphic presentation of the Euclidean space[1]. Their properties are defined largely on the relationships of the dimensions of the framework. Among them the most important space is the Geographic space.

The concept of "Geographic Space" is one of the most fundamental ones ineducation. There is not any activity in any subject that does not need to utilize it. Unfortunately, geography has yet to provide a succinct and explicit definition of geographic space. This fact has had negative consequences not only for geography in the development of its theory, methodology and application, but, in the interest of this work, its relationship with space-time, which should take into accountthe followingproperties of geographic space that influence the consideration of space-time:

[1]Given that the Euclidian postulates are naturally adapted and easily understood by all, in all the figures expressing the multi-dimensional nature of every space and time characteristic is presented as Cartesian coordinates to provide the reader a visual presentation that is easily understood.

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- **Relational:** It acquires meaning and value only when it is related to other concepts.
- **Supplementary:**Itshould be conceived as a supplement to entities, such as objects, phenomena and processes.
- **Individuality:**It should be conceived as a framework to individual spatial concepts.
- **Totality:**It should be conceived as related to the totality of human constructs. In other words, it is a systemthat is characterized as “synergic”, which includesits relationship to the space-time concept.

Based on the above, geographic space can be defined as the space determined and organized by society. It is a space within which human groups interact with human characteristics, social behavior as well as natural resources, emphasizing three different manifestations/dimensions, namely: location, spatial patterns and spatial processes (see Fig. 1).

3.1Location

Despite the many definitions, approaches and the various terms proposed by many Geographers, location can be described as a basic dimension of geographic spaceexpressed in a three-dimensionalsystem consisting of the **longitude** axis, the **latitude** axis and the **elevation**axis (Figure 2), whichrepresent the fundamental parts of location. In addition,however there is another dichotomy of geographic location,namely: absolute and relative location [26, 27, 28].In the former location (or the x, y and z coordinates) are determined by the known geographical coordinate system, while the latteris determined by an anchor/origin in the geographical space as a reference and all other locations are defined in relation to that origin. But most importantly making this dimension of space a **multi-dimensional** one.

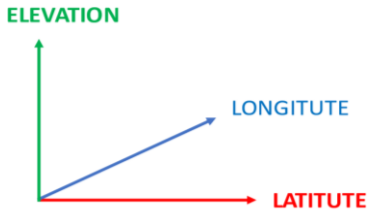

Figure 2: Location

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3.2 Spatial Patterns

A spatial pattern manifests the distribution of a set of objects, or phenomena that determines the way they are arranged in geographic space and mainly their geographical relationship. Basically, a spatial pattern reflectsan underlying spatial process within a specific time domain. As a result, the generalization and quantification and at the end the examination of spatial patterns leads into understanding the complexprocesses determining the distribution of spatial entities.

Spatial patterns can be observed everywhere. They include **natural**spatial patterns in the physical world, such as the arrangement of plants life in a region,as well as **man-made** patterns, such as patterns of human behavior in a specific area. A spatial pattern can be considered as an analytical tool to measure the **distance between locations** of two or more objects or phenomena. It can be used in a number of applications to explain human behavior or physical phenomenal, such as to analyze human behaviors or the interactions of various systems (i.e., ecosystems).

Spatial patterns are also a **multi-dimensional** component of space, providing three main types, namely: **uniform** patterns, which denote an even distribution of specific points or surfaces in the geographic space; **random** patterns indicating that no special correlation exists between these points or surfaces; and **clustering** patterns when most of the points or surfaces are congregated in a specific geographic area, although they may not be separated evenly.

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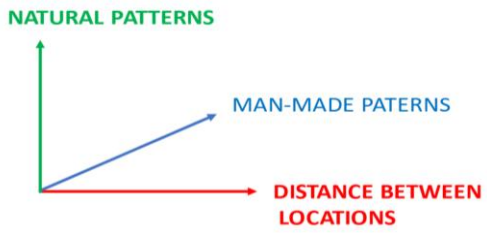

Figure 3:Spatial Patterns

3.3 Spatial Processes

A common acceptable definition of process is thatof a sequence of events leading to a particular outcome. Cheng& Adepeju [29] defined spatial distributions as these processes that are taking place in geographic space. That is, there is a need, in addition to describing **how** some subjects or phenomenaare distributed over geographic space,to provide an explanation of **why** these subjects or phenomenaaredistributed in a specific way over geographic space. This *why* question basically tries to explain the process or processes determining the observed distribution of data. As Harvey [30] noted: "different processes become significant to our understanding of spatial patterns at different scales",an observation expounded later by Cheng Adepeju [29]who considered that spatial distributions are based on processes taking place in geographical space. This interest onthe process rather than only on the form has led to the development of many differenttypes of spatial process modelssubstantiating that this dimension of space is also **multi-dimensional.**

4. THE MULTI-DIMENSIONAL CONCEPT OF TIME

Radovan [32] argued that "change is ontologically and epistemologically a more basic phenomenon than time. Time is an abstract entity created by the human mind on the basis of the experience of change". The proposition of this paper is opposite to this thesis. We believe that the correct perception of the flow of time is a fundamental element not only of how humans understand the world, but also the human existence. Therefore, time, although part of change,is an important aspect of human life through which the intensity and amount of physical reality is measured.

In terms of education,there is abundant literature suggesting that time can assist teaching and learning in three ways (dimensions) that should be taught. The first basic dimension of time is its**nature** (i.e., spot or interval) in the temporal domain. For example, the concernis "when things occur"? The second dimension is related to the time **duration**, in which the concernis "when and for how long things occur"? The third dimension is the time **density**, which in essence is a constraint that has a dominant effect on the occurrence of events. The concern for this dimension can be:given a certain amount of time, "what will happen"? "Where can someone go"? "What will someonedo"?In sum time is also **multi-dimensional**(Figure 4).

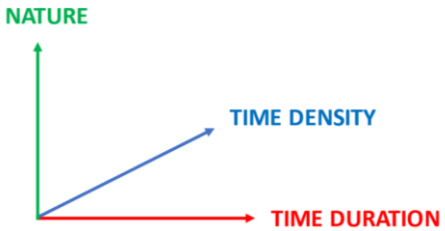

Figure 4:Dimensions of Time

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4.1 Nature of Time

In general, the literature in education has ignored timeuntil now, but mainly avoided defining it. Yet it rules our lives, and we all… wish we had more of it. But what, exactly is time and its nature?Smolin&Mangabeira [33]have written "it is central to the success of attempts to understand reality itself".Despite the many philosophical arguments, the concept of the nature of time can be described as a basic dimension of time depicted in a three-dimensional system consisting of:

- the dimension of **understanding**representing educational, scientific, philosophical etc. issues,
- the dimension of **position** in the temporal domain, and
- the dimension of **time perceptions** or temporal relationships(Figure 5),

These dimensions are integral parts of the nature of time. In addition, and similar to location dichotomy, time can also be differentiated in terms of absolute and relative time.The absolute time is expressed by the standard time units (i.e., reding the second, minute, and hour in a watch) indicating a specific point in the temporal domain.On the other hand,the relative time is defined in relation to a memorable event (death, marriage, birth, earthquake etc.), which indicate that and this dimension of time is **multi-dimensional**.

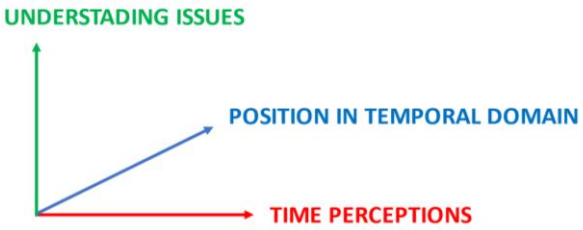

Figure 5:Nature of time

4.2Time Duration

In the literature and from our experience, it is clear that in a relationship the crux of the issue is not how close is this relationship, but **the time duration** during which such relationship exists. As a result, in the framework of determining the concept of time, duration is equivalent to the length of time, which however can be considered from different points of view, namely as the:

- **Amount of time** or a particular time interval within the framework of time, which leads into a progressiontowards the future with the passing of present events into the past.
- **Rate of time,** which is used to measure or record the time.
- **Length of time**, which is used to substitute an amount of time or a particular time interval (figure 6).

In addition, however there is a series of other dichotomies of time duration: first, duration of time can be short, long or have other characteristics; second it belongs tothe past, which has ceased to be and can be described; third it cannot be present for the present has no duration, because an event or a phenomenon that is still going on, its duration cannot be assessed [26, 27, 28], making this dimension of time also a **multi-dimensional** one(Figure 6).

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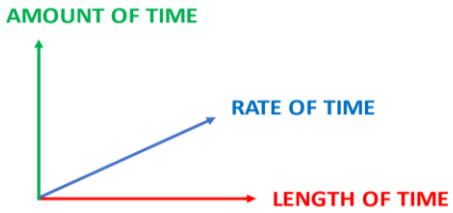

Figure 6:Duration of time

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4.3Time Density

Time density is associated with the changes in the **value of a time** characteristic, and which can be divided into discrete and continuing. A time entity exhibits a discrete value (i.e., seismograms that measures earthquakes at the time they occur), while a continuously changing type is an irregular one or at various differentiating time intervals (i.e., taxis moving in a city servicing different customers).Additionally,certain time entities never change or are stationary (i.e., historicdates), while other entities may be constantly changingor depend on the time itself (i.e., temperature) indicating different types of**time changes**[34].

Finally, an important time density characteristic is the **limit of time**.A formal definition of that limit is: a specific time by which someone has to do something or the time when something happens or is planned to happen. In other words, time may have a determining effect on the occurrence of events and therefore the third dimension of time can be considered as a constrain within the temporal domain. Traditionally, the following three different forms of time limits exist:

- **Official Time Limit**, which referrers to the notion that places constraints on when there is a need to set an artificial time limit.
- **Original Time Limit**, which concerns an agreed by all that an action should be completed at a specific time.
- **Statutory Time Limit,** which relates to submitting something that is impossible to do otherwise.

In sum all these subcategories of time density indicate that this dimension of time is also **multi-dimensional** (Figure 7).

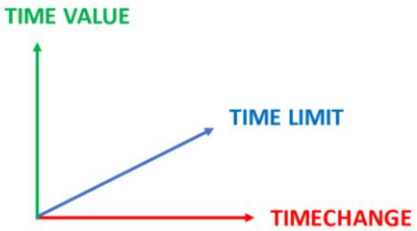

Figure 7:Time Density

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4.4Example of Time Multidimensionality

The three major dimensions of time can be illustrated as follows: Consider a student after finishing his classes. He leaves his school at 4:00 pm. and is determined to be home no later than 5:00 pm. At the same time, he should stop in a bookstore to buy some items he needs to complete hishomework. It takes him about 10 minutes to get to the bookstore, and about 40 minutes to do the shopping. Finally, it takes him 10 minutes to walk homeand be there on time. In this scenario, there are: first, the nature of the time,

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whichexplains events and phenomena; second, the time span or duration (from 4:00 pm to 5:00 pm); and third a time limit/deadline that controls or at least has an impact on his schedule (i.e., his classes end at 4:00 pm and he should be home at 5:00pm). In this scenario, time has a determining effect on objects, events and phenomena.

5. SPACE-TIME IN EDUCATION

Hägerstrand [31] the father of space-time Geography was intrigued by "the workings of large socio-environmental mechanisms" involving how events in geographic space occur in relation to time. Actually, he realized that understanding space is impossible without taking into account time. He described that relationship as " life paths (which) become captured within a net of constraints, some of which are imposed by physiological and physical necessities and some imposed by private and common decisions".Indicating that the relationship between space and time is a fundamentally important aspect of teaching and learning.

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Moreover, in education, most space–time teaching and learning involves integration, from space-time determination, to pattern and process revelation and prediction. Example questions can be: how will the objects, events or phenomena of interest can be located at certain times? or how will the extent of these entities change through time? which cannot be answered outside an integrated space-time framework.

5.1 Space without Time and Time without Space?

In examining the space-time concept in education, it should be noted that: first, the relationship between space-time and education is a complex one and has been studied from various perspectives. Actually, most studies are focused on space-time as a key aspect and determinant in educational processes; and second, the significance of considering the changes that are taking place in the policy, practice, and the empirical and theoretical study of education has been shown to be animportantand determining factor in considering space-time. That is, the relationship between space-time and education is a topic that has been explored in various research studies. Recent developments in educational research,easily available, have established the significance of considering the way people experience and understand space and time [35], denying the notion thatSpace without Time and Time without Space is a valid one.

5.2 A new approach to Space-Time

Thispaper, following the previous notion and opposingcurrent approaches, presents a new and different approach to space-timeconcept. More specifically, a two-prong position in considering space-time is presented here, which is simple in its presentation and explanation, but radical when considered with the traditional framework in teaching and learning. The first point of this position is that the concept of space-timeexpressed in such issues as: address emerging learning issues,shaping the application of education,raising questions regarding the relationship between context and teaching and learning processes,indirect over explicit knowledge, as well as the sharing learning resources cannot be addressed in the traditional way. That is, in considering space-time we can neither rely on what we are taught about it (changes in the contents of teaching and learning), nor on how we are taught (changes in teaching tools), both aspects (what and how we are taught) are important [15], but the approach to achieve them is the determining factor. This proposed approach is not new, the difference is that the focusproposed here is not only towards the learner, but towards all educational stakeholders, who all play an important, but differentiated role.

The second point in considering the space-time concept is the idea of thresholds at which a change in educational approaches triggers a non-linear transformation in the consideration of the space-time concept in education. It is suggested that the four paradigm shifts proposed earlier represent the tipping points in considering space-time in education. More specifically, it is suggested that recently a mechanism has been developed characterized: first, by multiple changes of space-time considerations

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due to the paradigm shifts in teaching and learning approaches, whichimply an evolution away from the initial four dimension space-time state and the creation of new states of space-time considerations that have been instituted from that evolution; second by a non-linearity or disproportionality between cause (paradigm shift) and effect (i.e., the impact of the new ICT teaching tools, which appear in shorter intervals than in earlier periods and with greater influence than previous tools); third, by fluctuations (FC), which express the competing effects of any triggerand expected resistance to that trigger (i.e., the resistance of stakeholders in accepting the paradigm shifts in teaching and learning); fourth, byfeedbacks (FB) as system-internal drivers of change in the space-time consideration as well as new state stabilizers (i.e., the increasing number of teachers' ICT literacy); and fifth the difficulty of the application of the new paradigms is getting easier and less time consuming and sometimes, especially at the later shifts, is related to the previous characteristic(Figure 8).

Therefore, the triggers or tipping points with regards to space-time considerations can be defined as a threshold at which teaching and learning changes trigger a non-linear educational process that initially resists any changes, but also is driven by system-internal feedback mechanisms that inevitably leads to a different state in considering space-time, which have different characteristics and are often irreversible.

Moreover, it is suggested that the proposed space-time consideration confirms the actor network theory, which consists of actors (triggers in this paper terminology) or assemblages (network fluctuations and feedbacks in this paper terminology) that have the dynamic power to induce the space-time concept evolution or change of their state, but most importantly its principles support this paper's argument that there is no complete distinction between the social, the natural, and the technological aspects in one's actions.

An example is considered necessary and as such the **paradigm shift from internet to mobile devices** is chosen, which has had the following characteristics and impacts on the consideration of the space-time educational approach. The trigger has been the appearance of a digital educational assistant in the form of mobile devices, while teaching and learning was impacted by the following. In that transition (paradigm shift) the fluctuations (resisting any changes) ranged from the denial of stakeholders in accepting differentiations brought by the new technology and consequently addressing the needed change in considering space-time to the difficulty in creating the necessary visual classes with the use of cloud-computing that have an enormous impact on space-time approaches, and which later on with the coming of COVID 19 was intensified. In terms of feedbacks (internal drivers of change), they ranged from the increasing number of teachers' ICT literacy to the availability of relative not expensive mobile devices (i.e., tablets), which have tremendously modified the approach to space-time concept. These resulted in the following:

- The *fluctuations* and *feedbacks* processes, due to the uneven impacts of all the previous factors created a non nonlinear educational change.
- The principle that cloud-computing' use can be applied from **anywhere** (space) at **any time** (time) by anyone [13] was firmly established, facilitating a new approach in considering the space-time concept as well as creating the framework for the next paradigm shift (i.e., AI).
- There has been a change in the educational process of paramount importance, namely: from the mobility of the available ICT tools to the mobility of educational stakeholders, given thatmost mobile devices are not mobile!It is the educational stakeholder that is mobile(i.e., a mobile student carrying a non-mobile device).

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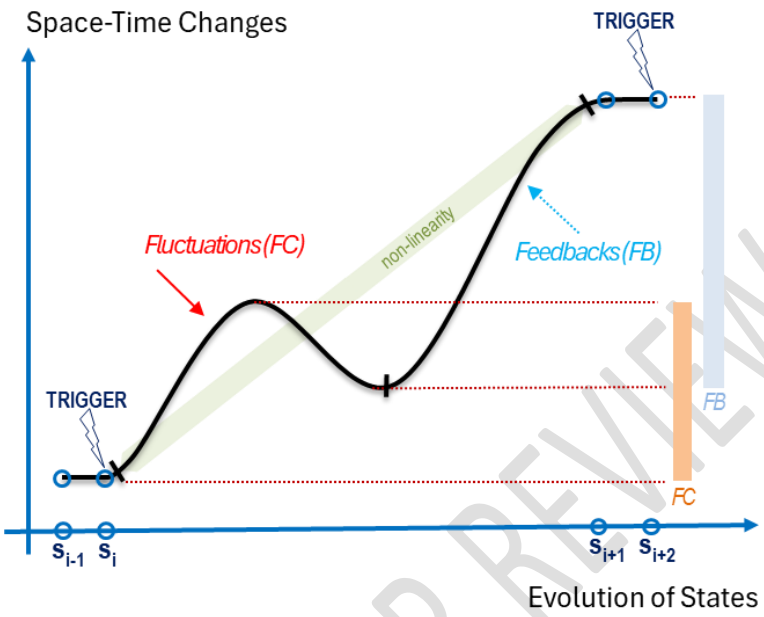

Figure 8: The Space-Time curve paradigm shift in Education

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5.3 Overview of the space-time consideration

Before addressing the specific aspects of space-time in education, there is first a need to provide a general theoretical overview of what space-time actually represents. It is argued that despite the sometimes differentiations in the presentation of space-time in many sciences (i.e., the physical and the social sciences), the most appropriate strategy for considering its use is to adopt a different from the traditional approach of consideringspace-time within the educational system.

From a philosophical point of view,the concept of space-time is regarded in terms of its ontology and epistemology.Actually,this focus has been central to philosophical concerns from its inception, resulting in a philosophy of space and time asbeen inspirational, but mainlyas a central component of analytic philosophy.Therefore, the subject of space-time focuses on a number of fundamental issues, the most important of which are: whether time and space exist independently of human minds;whether they exist independently of one another;and whether times other than the present moment exist; as well as questions about the nature of identity paradigm shifts, which are of paramount importance in this paper.

Philosophicallythere are two approaches towards space-time: the traditional **realist** position, which declares that time and space exist apart from the human mind; and the **Idealists**,which by contrast, deny or doubt the existence of objects independent of the mind. Immanuel Kant,the most influential philosopher on space-time, has resolved this dichotomy in his book the “Critique of Pure Reason” (1787). He proposed that**time** is a priori notion as is **space**, which together they allow us to sense experience. However, he insisted that neither of these notions are entities in themselves, or learned by experience. Actually, he proposed that spatial measurements are used to quantify how far apart objects are and temporal measurements are used to quantitatively compare the interval between (or duration of) events. According to Kant, space and time are held to be transcendentally ideal in this sense—that is, mind-dependent—and they are also empirically real, and thus their combined effect is a part and determinant of human actions, including paradigm shifts in education.

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In terms of reality, however, it has been shown that the application of the concept of space-timecannot easily followsuch well-regarded philosophical principles. A characteristic example is the way that teachers arefacingteaching challenges such as:

- **Resistance to change**: Teachers may be resistant to change, especially if they are used to a specific way of teaching and doing things for a long time.
- **Lack of resources**: Schools may not have the necessary will or resources to make changes in order to implement new teaching strategies.
- **Lack of training**: Teachers may not have the necessary training or literacy to implement new teaching strategies or to use new technologies effectively.

In education and in practical terms, all stakeholders (experts, administrators, teachers, and students) agree that learning is more than just the simple input and output of information. In educational issues such as: value and forms of learning, freedom, exploration and discovery play an important role and thus they are vital elements to the teaching and learning process. For example, the literature and experience have shown that students who are given a combined time and spaceopportunity, can be happier, more productive, and enjoy learning far more than students for whom this combined space-time experience is absent. While teachers can enhance considerably all aspects of their work.In general, at every level of learning, from to kindergarten, through K-12 and at the college level, the concern ofintegrated space-time can have an extremely positive impact on education.

On the other hand, in aneducational environment of differentiated approach to spaceand time, the spatial dichotomy, for example between outdoor recess and class work(i.e.,students have hard time focusing during class, when they can have fun outdoors), has no relation or impact to studentsspending time at rigid, fixed educational subjects(i.e., students prefer educational tools that tend to inspire them), which means that if we resolve one of these issues, it will not necessary lead inresolving the other.The question is: can these notions be integrated? or learningboth inside and outside the classroom(space), can be influenced by temporalprocess (time)? Our answer is a definite YES.

We strongly believe that the approach differentiatingspace and time cannot be acceptable, at least in education, anymore. We suggest that an integrated teaching and learning approach is needed,in which space and time are interrelated, in dialectic harmony and respecting all multidimensional geographic space and time characteristics, an integral part of which in education isall its stakeholders. As Openshaw [36] havewritten “the holistic nature of the space-time data model is simply science” and we might add education. In other words, we are arguing that an integrated approach is necessary in order to express the multi-dimensionalnature of space and time and the interrelationships and interdependencies of all their factors that constitute the concept of space-time, which is the “whole”. As a result, an **inter-dimensional**approach is necessary, which can lead towards the integration of space and timeand thus overcome the fragmentation of the educational processes and subject knowledge.

6. CONCLUSIONS

In summarizing the previous presentation,it was suggested that there has been an evolution in the ways education has regarded the concept of space-time. It commenced with the traditional paradigm of the four dimensions. Then through a transitional period evolved into considering space-time as a multi-dimensional and later on as an inter-dimensional concept.This evolution has resulted in the present notion that space-time is a dialectic unit, a conceptual “whole”, leading to an “integrated” space-time approach to teaching and learning.

It is suggested that ultimately, prioritizing the integrated concept of space-time will help to redefine what is expected by educational stakeholders, but mainly of students, and more importantly, what they might hope to expect from themselves. By empowering for example, students to inhabit more authenticintegrated space-time environments can encourage them to be not only more productive, but

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also happier, and more conscious individuals. Positioning students at the center of the space-time educational process by acknowledging the incredible value of the concept (freedom, flexibility, innovation, discovery, and creativity in education), promises to overwhelmingly transform the contemporary learning experience for the better.The same holds true for teachersin utilizing opportunities of the concept in enhancing their work experience as well and for the rest of the education stakeholders. To put it in a different way, living in a world determined by space-time without understanding its true meaning and effect, is like been in a library and not using its books.

In conclusion,this paper suggests that this new time-space concept creates a foundation for a general educational perspective. It represents a new structure of thought that has been evolving in the last few years, which integratesboth the spatial and temporal perspectives of various aspects of education on a different basis than it has been considered thus far. Space-time is not ateaching subject area per se, or even lessa simple object, but rather an attempt to create a thought structure.We, therefore, propose to extend the concept of "**objects-to-think-with**" (as proposed by S. Papert in 1980 [37]) to the "**agents-to-think-with**" (as proposed by dos Santos et. al.in 2023 [38]), and can be seen as a form of hybridization between human (education) and non-human (technological) actors, as suggested in the **Actor-Network Theory** (as proposed by Latour in 2005 [19]).Because the theories of social and technological determinism, which assume that phenomena or concepts can be described or explained exclusively either in terms of social or of technological factors, are not accepted anymore andthe name of the game is anymore integration.

In addition, this proposal provides a new framework capable of enhancing two educational processes. The first is to provide the necessary knowledge to help everyday teaching and learning. The second is to reveal the inter-relationships of the space-time concept, exposing its nature, which have been ignored by the major educational stakeholders and unfortunately the researchers.

A final word to show our strong believes: the paper's position, might not not very easy to grasp or accept, but so was Torsten Hagerstrand time-geography concept many years ago.

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Comment [AD29]: Put DOI or URL links in all reference

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