

# **In Search of Lost Relations: Educational Approaches in the Light of Quantum Mechanical Equivalents**

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## ABSTRACT

This paper examines educational essays that advocate a transformative vision of education through the lens of quantum mechanical concepts. These essays argue that fundamental principles such as indeterminacy, uncertainty and non-locality need to be integrated into theories of education, as education has quantum properties. This perspective aims to challenge Newtonian, linear, and mechanistic educational models, calling for a paradigm shift in education. The essays adopt a comprehensive view of education, applying quantum concepts universally across disciplines from geography to philosophy, rather than compartmentalizing them into natural sciences or humanities. Using habitus analysis as a hermeneutic tool, this article analyzes the problems and solutions formulated by the authors. By reflecting these arguments through the ontological framework of Ernst Cassirer and Matthias Jung, this article identifies what is referred to in the essays analyzed as a lack of quantum and/or holistic perspective: a lack of in-depth and non-linear relationality. Cassirer's focus on the relational essence of all symbolic forms and his emphasis on accommodating multiple perspectives, along with Jung's ontology of ordinary experience integrating diverse knowledge domains, enable connections between educational theory and quantum mechanics. Moreover, these ontologies provide a theoretical and empirical basis for potential convergences among different knowledge systems, as proposed by the analyzed essays. Following, the relevance of the results for education policy and for the convergence of complex systems is discussed.

## **En busca de relaciones perdidas: Enfoques educativos a la luz de los equivalentes mecánico-cuánticos**

### RESUMEN

Este artículo examina ensayos educativos que abogan por una visión transformadora de la educación a través de la lente de los conceptos mecánicos cuánticos. Estos ensayos sostienen que los prin-

principios fundamentales como la indeterminación, la incertidumbre y la no localidad deben integrarse en las teorías de la educación, ya que la educación tiene propiedades cuánticas. Esta perspectiva tiene como objetivo desafiar los modelos educativos newtonianos, lineales y mecanicistas, y reclama un cambio de paradigma en la educación. Los ensayos adoptan una visión integral de la educación, aplicando conceptos cuánticos de manera universal en todas las disciplinas, desde la geografía hasta la filosofía, en lugar de compartimentarlos en ciencias naturales o humanidades. Utilizando el análisis del habitus como herramienta hermenéutica, este artículo analiza los problemas y las soluciones formuladas por los autores. Al reflejar estos argumentos a través del marco ontológico de Ernst Cassirer y Matthias Jung, este artículo identifica lo que se menciona en los ensayos analizados como una falta de perspectiva cuántica y/o holística: una falta de relacionalidad profunda y no lineal. El enfoque de Cassirer en la esencia relacional de todas las formas simbólicas y su énfasis en la adaptación de perspectivas múltiples, junto con la ontología de Jung de la experiencia ordinaria que integra diversos dominios de conocimiento, permiten conexiones entre la teoría educativa y la mecánica cuántica. Además, estas ontologías proporcionan una base teórica y empírica para las convergencias potenciales entre diferentes sistemas de conocimiento, como se propone en los ensayos analizados. A continuación, se discute la relevancia de los resultados para la política educativa y para la convergencia de sistemas complejos.

## 寻找丢失的关系。 根据量子力学等效原理的教育方法。

### 摘要

本文通过量子力学概念的视角，研究了那些倡导变革性教育愿景的教育类文章。这些文章认为，由于教育具有量子特性，因此需要将不明确性、不确定性和非定域性等基本原则融入教育理论中。这种观点旨在挑战牛顿、线性和机械教育模式，呼吁教育的范式转变。这些文章采用了全面的教育观，将量子概念普遍应用于从地理到哲学的各个学科，而不是将它们划分为自然科学或人文科学。本文使用惯习分析(habitus analysis)作为解释学工具，分析了作者提出的问题 and 解决方案。通过恩斯特·卡西尔和马蒂亚斯·荣格的本体论框架来反思这些论点，本文确定了所分析文章中提到的量子 and /或整体视角的缺乏，即缺乏深度且非线性的关

系。卡西尔聚焦于所有符号形式的关系本质，强调包容多种观点，加上荣格对日常经历的本体论观点（整合不同知识领域），使得教育理论与量子力学之间建立了联系。此外，这些本体论为不同知识系统之间的潜在相交提供了理论和实证基础，正如所分析的文章所提出的那样。本文随后探讨了这些结果对教育政策的相关性和对复杂系统相交的相关性。

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## 1. Introduction

The development of quantum technology as a disruptive key technology of the future (Christensen 1997) is accompanied by changes that affect all areas of society. This development of quantum technology is not an effort by the physics alone but is embedded in a process of scientific convergence. The first big convergence took part between physics and engineering, the second between biology and engineering, and the current one is to be expected between science and technology (technoscience) (Jandrić and Knox 2021: 6). These convergences imply collaboration between traditional scientific disciplines and require “a reconfiguration of the connection between analog and digital” (ibid, 10f).

In the educational framework, these developments have started to be reflected in STEM subjects. This reflection results in both didactic approaches on quantum technology in the classroom (cf. Müller et al. 2021), and new curricula that are embedding quantum mechanics in schools and in teacher training (cf. Stifterverband 2023; cf. <https://qusteam.org/about>). Empirical analyses of the practical and ideological

consequences of the teaching of quantum mechanics are emerging as significant areas of study (Stadermann and Goedhart 2020, Bouchée et al. 2021).”

However, the quantum technologies and their societal consequences are not only relevant for STEM subjects, but also for all school subjects. This is clearly shown both by the educational analyses critiquing the ontology and epistemology of education based in classical Newtonian physics (Turner 2020) as well as those that take digitalization as their starting point and criticize technological determinism and instrumentalism as well as reductions of education through neoliberal framing (Jandrić and Knox 2021: 11). Consequently, future education policy must be responsive and innovative if it is to not only meet the challenges of the future, but also to embrace change and open up new horizons. In this respect, the “quantum” approaches discussed in this paper could be a stimulus.

While the most recent educational developments are strongly influenced by technological advancements, the older approaches – discussed in this article – draw their inspiration not from specific technological achievements but from the broader individual and soci-

etal transformation of perception and action through education. This perspective is thoroughly inspired by the paradigm shift in quantum mechanics.

Starting from this, this article asks as to what problems are discussed and solved in education when quantum mechanical principles are used as a source of inspiration and/or as an equivalent in educational theory discussions. What is missing in education that the quantum mechanical perspective and not another, e.g. pedagogical or systemic perspective, is applied?

To answer these questions, we will reflect upon meta-analyses and case studies published between 1980 and 2007. The meta-analyses presented here provide the typologies of quantum-theoretical approaches relevant to pedagogical approaches, and address the methodological problem of analogical and metaphorical use of scientific terms in educational science. Among the case studies, those were selected and analyzed that explicitly discuss or develop an educational theory and/or a didactic approach starting from the premise, that educational practice operates in its dynamics much like quantum mechanics.

The methodological starting point of the study is relational habitus analysis, which we apply here as a hermeneutic tool. Habitus analysis, developed by Heinrich W. Schäfer in the context of empirical social research and religious research, is based on the analysis of relations between concepts and propositional logics (Schäfer 2015). In addition to this analysis, the method enables a connection between the actor

(individual and/or collective) and the field. While the field of events (e.g. religious field in a state etc.) acts with its “logic of practice” - in the sense of “this is how it works” (Bourdieu 1993: 107), the individuals or collective actors position themselves in relation to it with their own “practical logic”. With the practical logic or a “the way I do it/the way we do it”, the actors have an identity-forming effect and act in the field/society (Schäfer 2020). These two perspectives are sociologically intertwined by means of habitus. This methodology, with the corresponding theoretical foundation, is particularly suitable for reconstructing and analyzing the intended individual and societal transformations (cf. Seibert 2016, Höhne 2023). In education, it can be said that they are additionally linked by means of a habitus that is intended in the curricula and textbooks and is only to be developed in the future (Štimac 2017).

The educational arguments will be further reflected through the ontological frameworks of Ernst Cassirer and Matthias Jung, in order to reconstruct what is referred to as a lack of quantum and/or holistic perspective.

The analyzed papers (cf. Pike and Selby) have remained relevant, continuing to inspire UNESCO’s work. Today the Global Education is one of the most relevant UNESCO programs linked with new developments. Some developments prepare young people for a future that will be affected by the social and individual consequences of AI and quantum technology (UNESCO 2021: 182). Consequently, to empower the

youth, the new education should enable reflective, experiential, transformative, dialogic and ethical learning (UNESCO 2021: 145) by strengthening creativity, empathy, and critical thinking (UNESCO 2021: 137). Other developments foster the convergence of knowledge between the universalist or science-based school knowledge system and the holistic knowledge system of indigenous peoples (UNESCO 2018). This allows more space for the holistic knowledge of indigenous peoples in public schools, complements the universalist education system in a meaningful way and a synergy of both should help to better overcome current social challenges such as climate change (cf. Stimac 2022). On this basis, the question arises as to which of the past perspectives UNESCO has already taken into account in its education programs and which unapplied but further-reaching perspectives could possibly be incorporated into future education policy.

The reconstruction of given analogies and equivalents provides significant insights into complex systems by observing potential bifurcations when these systems encounter major challenges. Furthermore, it facilitates the examination of possible convergences between different complex systems. Additionally, analyzing these historical educational approaches offers valuable insights for comparing past and present dynamics using quantum mechanical arguments. This is particularly relevant because modern educational approach-

es, such as constructivist, experiential learning, and holistic learning, have been partly inspired by these older theories. Consequently, this reconstruction is highly relevant to ongoing normative discussions in education policy.

## **2. Meta-analyses: methodological approaches and taxonomies**

Two exemplary meta-analyses that work out the implications of quantum theories for educational theories come from educational researchers James F. Andris (2001) and James Gray-Donald (2007).<sup>1</sup> The authors reveal and discuss the methodological problems of the essays examined, and note that an analogy between education and quantum mechanics can be found in all of them. However, they evaluate this methodological approach in completely different ways. Furthermore, both Andris and later Gray-Davis work out a taxonomy of quantum theoretical principles that serve as inspiration and metaphor for new educational theories in educational research. Regardless of this, they themselves - independently of the essays they examine - address the quantum-physical phenomena and describe their relevance. Both authors are united by the conclusion that although the essays examined work conceptually with quantum theoretical implications, a “quantum worldview pedagogy” – as Gray-David put it – has yet to be written (Gray-Donald 2007, p. 328).

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<sup>1</sup> These meta-analyses differ in the number of articles examined in each case. While Andris analyzes five sources, Gray-Donald assumes around one hundred sources.

In his taxonomy, Andris reconstructs the following principles in various theories of formation: coherence: particles share properties with whole (laser, superconductivity), complementarity: matter has aspects of both waves and particles, nonlocality: distant particles connected in space/time at superluminal speeds, superposition (object occupies two states at the same time), quantum leap (particle transmutes instantaneously from one state to another and particles go into hyperspace between states), unmeasurability (cannot measure a particle without altering its properties) (Andris 2001: 6). Gray-Donald's taxonomy is rather a reconstruction of the main topics of educational approaches in which quantum mechanical principles become relevant (2007): an either/or dualism, the question of scientific paradigms, problems of methodology, chaos and uncertainty, nonlocality and spirituality. Both taxonomies are revealing because, on the one hand, they point to the perceived complexity of the educational process and, on the other, to the need to take this complexity into account both conceptually and terminologically in educational theories. The complexity can be deduced from the wealth of relations and dimensions that implicitly and explicitly emerge in education.

James F. Andris answers the question of whether it is permissible to form a model of education on the basis of an analogy to another scientific approach in the affirmative. Based

on Charles Pierce, Andris embeds this question in the methodological question of retroduction (or abduction).<sup>2</sup> "Through retroduction, one devises characterizations-statements or theory about objects. Through deduction one clarifies and completes such characterizations. Finally, through induction, one determines the objects falling within the range of the characterization. Retroduction devises, deduction explicates, and induction evaluates." (Andris 2001, p. 5). This is a method of developing pedagogical theory in which better developed scientific models are used to develop models for less well understood pedagogical phenomena (Andris 2001, p. 13). Andris also sees this approach as justified because both education and quantum mechanics deal with complex systems (Andris 2001, p. 16).

James Gray-Donald tackles the methodological question differently and works out various problems of the metaphorical approach (2007, p. 316). He sees the problems, among other things, in the hasty conclusions based on quantum implications. Firstly, an error of reasoning, "There is nothing really new about the educational implications of quantum theory" (2007, p. 326), which arises from the fact that scientific analyses of education may see a proximity to quantum theory in holistic learning, hermeneutics, narration and spirituality (2007, p. 327). Secondly, he warns against the naturalistic fallacy in which something should be just because something else is (2007, p. 327).

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2 Darwin's theory of evolution is cited as the most striking example of retroduction. [https://www.ramesesproject.org/media/RAMESSES\\_II\\_Retroduction.pdf](https://www.ramesesproject.org/media/RAMESSES_II_Retroduction.pdf) (2017)

One example to illustrate this is the necessity of the paradigm shift in education simply because it has taken place in physics (2007, p. 316). What is particularly interesting for this essay is that he criticizes the “quantum argument” in the most important educational theories of the UNESCO education program, e.g. Global Education, without, however, addressing the corresponding approach by Pike and Selby (see below) in his meta-analysis (2007, p. 316).

### **3. Case studies: Systemic – holistic – quantum**

In order to answer the questions posed at the beginning about the causes of the problems in education and the solutions to these problems, several case studies are selected. The main focus in the selected essays is that the theoretical drafts enable and/or confirm a concrete operationalization of the quantum argument in educational practice. Another focus lies on the applicability of the pedagogical approaches in all areas of education.

In the analyzed essays, interdependence, uncertainty and indeterminacy, *in addition* to other relations (determinacy, binarity etc.), are seen as decisive for education. Didactically, these approaches emphasize the need for inner and outer transformation, the result of which is a new worldview. However, the most important model for education is not systems theory, but quantum mechanics with the completed paradigm shift from the deterministic or classical to the indeterministic or quantum paradigm.

In connection with the paradigm shift, some analyzed papers explicitly refers to Thomas S. Kuhn and his “Structure of Scientific Revolutions” (1962). However, Kuhn’s perspective is not sufficiently reflected in the analyzed essays. Presumably, it was applied because it emphasizes the historical embedding of changes within the scientific disciplines and thus the alteration in the standards of scientific research, which entails a transformation of the world (Kuhn 1976, p. 21). The essays illustrate this through the need to a) overcome various social and ecological crises as results of the old Newtonian paradigm and b) broaden the range of perceptions and realities of teachers and students.

Karl Popper’s approach could have been fruitful for educational theories, as he understands the scientific revolution as constant “rational progress” and not as a reaction to a crisis in the sense of Thomas Kuhn (cf. Lakatos & Musgrave, 1989, p. 93). This would raise the question of whether the change proposed by the educational approaches is merely a new perspective. If so, the idea of a paradigm shift would be counter-argued.

The most relevant terms in analyzed essays are used to represent systemic, holistic and quantum perspective. These terms have not been systematically differentiated from one another and the terms “holistic” and “quantum” are used synonymously when applied to the quantum mechanics and to the knowledge systems of indigenous peoples. In all analyzed examples, however, the logic prevails that

different levels of teaching and learning are ultimately interconnected, nested, and that they open up to each other in order to encompass different and new areas of reality.

### ***3.1 Global education: interconnectedness and social justice***

The first educational approach that sees itself as quantum mechanics-informed, and which is still used today in the UN-ESCO educational framework, is global education theory by Graham Pike and David Selby. They develop a model of transformative education based on four interrelated dimensions of globality, which was meant to be applied to different topics at schools. These address teachers, learners, classroom and curriculum and are explained using practical school examples. It defines: "Global education is a holistic paradigm that encompasses the interconnectedness of communities, lands and peoples and interconnectedness of all social, cultural and natural phenomena" (Pike & Selby, 1988, p. 1).

The first or spatial dimension illustrates how young people live in an interconnected world thanks to global markets, global information, global culture and global ecosystems (1988, p. 1-5). The temporal dimension addresses, first, economic development and its acceleration over time. Second, it addresses the fact that in most cases people shape the future on the basis of past and present perceptions (1988, p. 12). This opens up the perspective for questions of alternative futures and proba-

bilities: "we thereby choose a certain kind of future - a future dominated by the experts" in which "images of the future guide actions in the present" (1988, p. 14). At that time already, major social crises were discussed (overpopulation, poverty, ecological problems), and the question was raised as to how to deal with them - also in schools - in order to achieve the best results for the future (1988, p. 16).

The third or issues dimension, which has both macro and micro implications, is "contemporary phenomena affecting the lives of people and/or the health of the planet in a [potentially] harmful way, such as environmental pollution, racism and the threat of nuclear war" (1988 p. 22). It is assumed that "Collectively the whole multitude of crises appear to constitute a single global crisis-syndrome of world development" (ibid.). This dimension explicitly addresses the crisis of perception that goes hand in hand with the mechanistic paradigm or Newtonian paradigm, which the authors claim to have caused the problems in all the dimensions mentioned. This will be discussed in more detail as it applies to all the essays mentioned in this paper.

This mechanistic paradigm is understood as the mechanistic world view of Descartes, the reduction of phenomena to their individual parts, as well as the Cartesian separation of mind and matter, subject and object, value and fact, mind and body, intuition and reason, spirit and matter, feelings and thoughts (1988: 25). The social consequences of this perception



of the world are obvious and lead to the strengthening of patriarchal structures with numerous contradictions (p. 25). A particular variant of this critique is the critique of the liberal-technocratic economic argument as an example of “the traditional mechanistic paradigm” (Selby 1999). According to this, education and culture have been completely appropriated by the relevant forces for the economic purposes of the elite and their markets, and “global competitiveness” and “global interdependencies” are postulated as the state of the art. What is urgently needed in education is therefore “a paradigm shift, a transformational process from one framework of thought and perception to another. The systemic or holistic paradigm has been influenced by the findings of modern atomic physics” (1988: 31). Here, reference is made to the physicist David Bohm and “the notion of unbroken wholeness” (p. 26) and the conclusion is drawn: “[...] the systemic paradigm views phenomena and events as dynamically interconnected; true understanding lies in accepting that, however much we may have to compartmentalize for practical purposes, everything in the final analysis, is woven into a multi-layered, multi-dimensional web of interactions” (1988, p. 27).

The fourth or human potential dimension asks about the possibilities of a systemic education (1988, p. 30). This is realized in a reconfiguration of monocultural education into multicultural education, as well as in the interweaving of inner worlds and outer realities, which are understood as com-

plementary and mutually illuminated. This in turn enables an exploration and discovery of the globality of human potential (1988, p. 31). The starting point for human potential is the idea that curiosity and enthusiasm as the most important capacities of human beings remain neglected in school (1988, p. 39). Thus, consciousness remains limited and leads to a separation of mind from the body. The individual and the social are interdependent: “the character and well-being of the individual and the character and well-being of global society are interdependent” (1988, p. 31).

The understanding of these interrelations and the possibility of the inner transformation within this model is deeply rooted in transformative education. The educational goals are multi-layered: systemic awareness (systemic nature of the world, holistic conception of our potential), perspective awareness (receptivity, not universally shared worldviews), health of planet awareness (e.g. global justice, future orientation in relation to the health of the planet), involvement consciousness (e.g. how individual decisions have an impact on the global) and process mindedness (learning as a continuous journey without a final destination) (1988, p. 37).<sup>3</sup> Based upon these prerequisites the authors see the “global learning” as person-centered and planet-conscious (1988, p. 43), participatory and co-operative (1988, p. 44) and experiential through personal feelings, attitudes, values which involves all senses (1988, p. 45)

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3 For the later interceptions and modifications of this theory of education, see McGregor 2023.

### ***3.2 Certainty and uncertainty in education***

In 1991, the authors Robert Schuck and Nelson Haggerson argued that educational science, as part of social science, should adopt the principles of quantum theory as it inspires and emphasizes the perception of what is inherent in education. This seems to be necessary because educational research shows a large number of conferring results with regard to certainty and uncertainty (1991, p. 58). The metaphorical application of quantum mechanical principles would make it possible to assume probabilities in both education and educational research (1991, p. 59) and to come to terms with uncertainty (1991, p. 60).<sup>4</sup> Up to now, educational theory has primarily been based on the separation of object and subject and has mainly followed empirical research such as experimental psychology, which seems to go hand in hand with an absolute knowledge of certain facts: “No one longs for certainty more than we do [...]. We sense, however, that such is a fallacy beyond our reach. We must live with our personal and professional quantum mechanics that tell us much about our world, with the caveat that we should not be too sure. (1991, p. 60).

In order to enable the “multiple manifestations of knowledge both in educational situations and activities and through ourselves” and the capability “to experience new visions, new vis-

tas of reality” (1991, p. 60), the authors argue for asking both substantive (e.g. about the main constructs and concepts of education) and syntactic questions (modes of questioning). Consequently, they provide a new perspective on existing curriculum theories by paradigmatically repositioning and reinterpreting existing components. “Inquiry is characterized by the relationship of the source of the problem, the role of the researcher, the method of inquiry, the subject under consideration, and the desired outcome.” (1991, p. 61). They compare the modes of questioning with the river that the observer can observe, on which he can sail in a boat and in which he can swim but also identify with (1991, p. 61).

The authors’ approach is operationalized using the rational, mythological and evolutionary modes of questioning. The rational mode or theoretical verification involves, for example, the statistical data of curriculum researchers who, as observers of an object, verify and validate the data in the research project. It involves traditional, logical, and empirical approaches to research and inquiry as in scientific research by observing the object separated from us. In education, the mythological mode (similar to practical discovery) would correspond most closely to an ethnological and phenomenological method, e.g. to observe specific cases, situations and relationships. It is about “finding out what the classroom encounter is ac-

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4 “If the discipline of education is to progress, we must intellectually absorb the difficult and bewildering principles that quantum theory has shown us reside in the heart of nature. We must learn to understand that flux and uncertainty are neither good nor bad, but inevitable. (1991, p. 60)

tually about, and formulating working theories from the data gathered in the classroom” (p. 61). The results of these are used to expand curriculum theory and for policy development. The evolutionary mode is transforming and self-organizing in that it is based on introspection and self-analysis, as well as a visionary understanding of the world - here explicitly based on Buddhism and psychology. This is made possible by diary writing, meditation and metaphors (1991, p. 61). This mode focuses on the interconnectedness (“person as space, knowledge and knowingness, self in relationship with others and the universe”, *ibid.*) and dynamic nature of educational phenomena. Against the background of Thomas S. Kuhn’s work, the different modes are linked to different paradigms. While the rational and mythological modes have been seen as belonging to the classical paradigm, the evolutionary mode belongs to the new quantum paradigm.

The desired goal in this last mode of inquiry is the transformation of the personality, which is understood as “our personal and professional quantum mechanics” (1991, p. 61). This is embedded in a holistic understanding of education and knowledge, which is called “our quantum theory of education”: “As we recognize the all-pervading, ever-illuminating nature of knowing, we are better able both to convey the nuts and bolts of the material we are teaching and to see every situation - including not knowing, difficulties, problems, constraints, ignorance- as inimi-

table teachers. Truly, there are no limits to learning, and education takes on its proper role - the fulfilling and liberating experience of value. (1991, p. 62).

### ***3.3 Role play in education: Transforming consciousness?***

Drama and role-playing have long been regarded in didactics as an important approach to making decisions, to having an action-oriented effect and to finding solutions to problems and conflicts.<sup>5</sup> They require role distance, empathy and tolerance of ambiguity. Alistair Martin-Smith opens up a new dimension in his essay when he speaks of early childhood perception and awareness being completely transformed by school drama and role play (1995). According to Martin-Smith, the processes that take place there are similar to quantum mechanical quantum leaps and non-locality. However, the author does not wish his approach to be understood as an inappropriate application of quantum theory to pedagogical practice; rather, this parallel is intended to suggest a metaphorical correspondence (1995, p. 34).

He starts with the observation that the problem of education is its apparent “invisibility”, which is intrinsic to all learning phenomena: “It is a paradox that teachers, who want to encourage learning, cannot see the child’s most profound learning moments [...]” (1995, p. 35) Also invisible is the phenomenon of non-locality, which takes place precisely in school theater: “[as] a collective shift from one set of space-

5 See cf. <https://ablconnect.harvard.edu/role-play-research>

time coordinates in the classroom to those of the fictional world of the story” (1995, p. 37). The principle of non-locality “may explain why the drama strategy of time-traveling is [...] so authentic” (p. 36). With regard to the development of consciousness through theater, Martin-Smith relies on other experts. “I am guided by Adam Blatner, who defined spontaneous action as “the product of a conscious rational mind receptive to the flow of images and impulses from the unconscious”” (1995, p. 38). According to Dewey, “every case of consciousness is dramatic; drama is an enhancement of the conditions of consciousness” (1995, p. 38). Consciousness is dynamic, as the system of meaning is subject to redirection and transformation (1995, p. 38). “Understanding how we project our consciousness implies that there is no distinction between inner and outer, or between subjective and objective” (1995, p. 38).

Martin-Smith carries on to discuss the quantum leap through theater and role play. These include the leap from the self-image to a role, from the fictional to the virtual world and from one self-created reality to another (1995, p. 34ff). Even though a transformation of the learner’s self-concept and consciousness takes place on all three levels, the third has a special place. According to Martin-Smith, it is relevant for learners to learn that they can not only create their own reality, but also transform it as required (1995, p. 36). This is said to have been proven with the experiments on perception at the time (Karl Pribram), and ties into the notion that there is “no distinction be-

tween inner and outer, or between subjective and objective” world (1995, p. 38). One consequence of this is the perception that “our personality as a limited notion of self may turn out to be only one choice from among the many which may be expressed on different occasions” (1995, p. 39). The perception that we participate in the creation of our reality “choosing and sharing our own way of being” (1995, p. 42) and that quantum physics enables a “reorganization of our imaginative lives” (1995, p. 42) is shared by the author with Bertrand Russel (1969, p. 9). Thus, for Martin-Smith, theater is full of quantum equivalents that enable a holistic worldview with transformation as the most important motor.

### **3.3.1 Science, Wisdom, Spirituality**

Education researcher Gerda Walz-Michaels offers a perspective based on an analysis of the publications of the younger generation of physicists such as David Bohm, Fritjof Capra, Danah Zohar and others. There she looks at the main concepts, such as time and space, wave and particle dualism, determinacy and indeterminacy, subject and object paradoxes, locality and non-locality, chaos and order (Walz-Michaels 1966, p. 1-7), and tries to link them to the education. On the other hand, she devotes herself to central educational concepts such as the relationship between knowledge and practice, self and others, methods of qualitative and quantitative educational research (1966, p. 8). She concludes that the publications by different physicists point to “expanding language” and “right vocabulary” in order to take up

the new dimensions and their entanglements (1966, p. 8): “To go beyond these boundaries [between the concepts above], by expanding language, helped me not only to understand scientific processes but also educational processes in a new light” (1966 p. 8). She concludes that the “middle way” seems to be the way between the extremes of thought and action (1966, p. 19).

Finding both the educational and the spiritual dimension in the mentioned sources, she asks conversely what implications the corresponding concepts have in relation to education (1966, p. 6). To tackle this, she chooses the example of indigenous peoples. The speeches of individual indigenous people, e.g. the Sioux Indians, are presented in textbooks as examples of special wisdom in both thought and action. Their “way of knowing” – or the combination of different ways of knowing that enable a unity of different knowledge dimensions – is understood as holistic. The author sees this as a path that is missing in the modern way of life. She concludes that also education requires a combination of wisdom, spirituality and science (1966, p. 9), as well as training “in switching consciousness thus incorporating both local and nonlocal” (1966, p.10). She links this to Albert Einstein’s request “to have a different mindset” as formulated in “A message to Intellectuals” in 1948 (1966, p. 10). With this approach, she encourages a new way of looking at concepts and reality. Even if the author makes no attempt to design a practical educational implementation of the above, her work points to the educationally relevant tools that become

accessible through an examination of quantum mechanics: new ways of speaking (vocabulary) and new ways of thinking. As previously mentioned, this is currently relevant to UNESCO, which has described indigenous peoples as holistic and has welcomed their ‘methods’ as part of universalist education.

## **4. Discussion**

### *4.1 Education as quantum phenomenon*

The analyzed essays address both the teaching and learning dimensions of education. They argue for a theory-based explication of the deeper dimension of education and emphasize the need to integrate this into everyday school practices.

The cause of the problem is sought in the Newtonian paradigm, which is described as deterministic, one-dimensional, mechanistic and dualistic. The solution to the problem, or the theoretical and practical extension of education, is seen in an educational paradigm shift similar to that in quantum mechanics.

This is made clear by Pike and Selby’s criticism of one-dimensionality and linearity. Pike and Selby are of the opinion that only multidimensional education makes social interconnectivity possible. Interdependence, as a consequence of the mechanistic perception, only leads to social injustice.

Further problems can be observed in the separation between object and subject. According to Schuck and Haggerson, this leads to one-di-

mensional learning that is superficially cognitive and leaves intuition, emotion, imagination and embodied learning neglected. According to Pike and Selby, it is only when the Cartesian pairs of opposites are brought together that an expanded perception and epistemology, including the diversity of non-linear relations, emerges. These, in turn, are necessary prerequisites for the most important goal of an education, i.e. the inner and outer transformation.

For all authors, the transformation represents the added value of the corresponding new didactics, which Schuck and Haggerson call “our quantum mechanics”. Martin-Smith and Walz-Michaels link the inner transformation with the expansion of consciousness. For Martin-Smith, inner transformation, or the ability to perceive and change different self-concepts, takes place through play and theater at school.<sup>6</sup> Walz-Michaels goes one step further and speaks of a different mindset and new worldviews (in the sense of a holistic worldview), which arise when the inner transformation takes place by linking different knowledge systems.

These essays have obviously inspired some current theories on transformative learning and holistic education. While today’s theories tend to address transformation through crisis, these earlier approaches address other domains. They imply an understanding of the world that has profound dimensions. In order to recognize these in education, they should be taught,

and young people need to engage with them comprehensively. Consequently, they imply a view of humanity that is only just beginning to discover its potential as interconnected and therefore multi-layered.

Obviously, these perspectives are linked to the new dimensions of reality, the perception of which should first be practiced and developed in education. Consequently, they implicitly or explicitly depict education as a “quantum phenomenon” that is only to be theoretically unfolded in its entirety. The authors speak of a “quantum theory of education” and postulate a comprehensive, holistic worldview or quantum worldview.<sup>7</sup> When it comes to worldviews that are influenced by advances in the natural sciences, this concept can be denominated as quantum humanism.

#### **4.1.1 Complex systems and knowledge convergencies?**

While the case studies analyzed in this paper do not explicitly aim to develop methods or approaches to knowledge convergence, their examples and the applied didactics suggest this. The authors highlight transdisciplinary integration of systemic approach, holistic systems such as the knowledge system of indigenous peoples, and quantum knowledge systems. This integration suggests, though, that convergence is a natural process at the intersection of complex systems not only in natural science but also in education science. In the realm of current research, this

<sup>6</sup> The echo of this approach can be found in Biersteker (2022).

<sup>7</sup> In particular in Selby (1999).

convergence approach aims to solve complex problems employing transdisciplinary (cf. Evans 2015). Key points where these convergences are observed in the analyzed essays include:

**Integration of Quantum Mechanical Equivalents in Education:** This represents an early attempt of convergence between educational science (as social science) and natural sciences. The application of quantum mechanical equivalents in education has obviously led to the development of new theories that not only expand the teaching and learning but also expand the worldview and the understanding of humanity. This is supposed to help the shift from deterministic to indeterministic paradigm through emphasis on probabilities, uncertainties, and dynamic interactions in education theory and practice.

**Systemic Awareness and Holistic Worldview:** The convergence between systemic awareness and a holistic worldview is facilitated by the interconnected and systemic nature of global learning, which recognizes the interdependence of various dimensions such as space, time, issues, and human potential. On the other hand, holistic integration combines multiple dimensions of human potential and global consciousness, reflecting a comprehensive understanding of interconnectedness. This integration is only possible if learning is accompanied by transformative processes involving both teachers and learners.

**Transformative Education** is inherently convergent in itself, and focuses on both internal and external transforma-

tive processes that lead to new worldviews consistent with the principles of quantum mechanics. Another aspect tackles learning processes, such as role-playing and experiential learning, that promote this transformation. It is supported by *metaphorical* application of quantum theory. The example of role play illustrated how quantum mechanical metaphors are used to describe internal processes, and emphasizing the transformation of consciousness.

**Integration of science, wisdom and spirituality** combines scientific concepts from quantum mechanics, pedagogical principles, and indigenous knowledge systems, promoting new ways of thinking and understanding. This approach creates a comprehensive and unified educational framework that merges seemingly disparate epistemologies and ontologies. These convergences claim to enable a transition from traditional mechanistic paradigms to more interconnected, holistic, and transformative educational approaches.

The question arises as to whether some of these examples can be fruitfully applied in current education policy. In the introduction to this paper first convergencies between disciplines in natural sciences, and second the example of the UNESCO have been mentioned. UNESCO's promotion of convergence was justified by the fact that environmental/climate issues cannot be effectively solved by using solely universalistic knowledge (UNESCO 2018). By arguing so UNESCO moves beyond dichotomies, such as universalist-particularist and secular-religious indicat-

ing that knowledge convergences add significant value to education and thus to the society. Although partly based on the educational theory of Pike and Selby, Global Education by UNESCO neglects an important part of their quantum approach. If UNESCO were able to open up education policy to convergences with other bodies of knowledge than those of indigenous peoples, it could benefit from the additional sources of innovative potential and inspiring new perspectives for education. However, this “quantum education” still requires in-depth adaptation to practice and the adjustment of education to the requirements of entirely new perspectives of thought and action.

#### ***4.2 Missing relationality as a problem, quantum equivalents as a solution?***

By discussing different areas of education, the authors explicitly make it clear that they neither lack specific educational content nor new school subjects. On the contrary, their approaches support the interpretation that the whole educational process is based on the same perceptual logic. If so, what problem in education do the analogies or equivalents with regard to quantum mechanics point to?

The analyzed educational theories utilize quantum properties implicitly and explicitly, and claim that underlying dynamics in education exhibit quantum-like characteristics (“education is quantum”). For example, a student’s multiple potential learning outcomes before an assessment paral-

lel the superposition concept, existing in a state of potentiality influenced by various educational interactions. Quantum phenomena like superposition and entanglement show particle properties defined through relations, not isolated attributes. Likewise, educational interactions among students, teachers, and knowledge systems create a relational network where teaching and learning emerges dynamically and non-linear at different levels. Although it is intuitively addressed in practice, it remains insufficiently reflected in theory.

From this, the observation can be drawn that all the mentioned analogies or equivalents with regard to quantum mechanics might point to the missing *in-depth* and *non-linear relationality*. If so, what theoretical frameworks from disciplines outside of quantum physics could provide insightful and expansive lenses through which to reimagine the scope and possibilities of education, as envisioned by the authors? Furthermore, how can we reflect the proposed intersection between educational theory and concepts drawn from quantum mechanics in a way that allows these two seemingly disparate domains to be productively connected and mutually inform each other?

##### **4.2.1 Ontological Foundations for Educational Theory and Quantum Mechanics**

The fundamental question of reality and relationality, described by Carlo Rovelli (2021: 89) as the “web of relations that weaves reality,” has been extensively explored across disciplines, ranging from neo-Kantian philosophy (Cassirer) and



phenomenology to feminist philosophy of science (Barad, Haraway) and quantum social science (Wendt and Der Derian). These perspectives offer fertile ground for further research into how a relational ontology can enrich and expand educational theory and practice.

Here, we propose a relational ontology according to Ernst Cassirer, and the holism of ordinary experience according to Matthias Jung, as theoretical frameworks. They enable the ontological and epistemological expansion of education through the application of relations as the common core of the whole educational process. This theoretical positioning is explored for the following reasons: a) It facilitates a linkage between educational science and quantum mechanics, bridging diverse areas of knowledge and ways of knowing; b) It allows for explicitly capturing and incorporating quantum-inspired pedagogical perspectives; and c) It provides a robust theoretical and empirical foundation for potential convergences across different knowledge systems.

#### **4.2.2 Ernst Cassirer's relational ontology**

Ernst Cassirer's relational ontology offers a profound philosophical foundation for expanding the ontological and epistemological scope of educational theory through a quantum-inspired lens. Cassirer identifies a common thread across diverse human endeavors, including science, art, and culture, in the primacy of relations over substances, forming the basis of his relational theory.

In his examination of modern physics, Cassirer proposes that wave-particle duality exemplifies the multiplicity of perspectives: "[...] the fact that the change of the standpoint [...] when we move from one dimension of meaning to another, whenever we change the world of science for that of ethics, art, etc., is not confined to this type of transition alone. The manifold of perspectives which open up before us has its counterpart within the scientific realm itself" (Cassirer 1956, 212f). He views the findings of quantum mechanics as relational and interdependent where the fundamental entities of the quantum world are not isolated particles but interdependent relations. As Jacobs (2021) concludes, "In a web of relations, causality and indeterminacy are complementary." This perspective challenges the juxtaposition of classical and quantum paradigms in analyzed educational approaches, suggesting instead their complementarity.

If relations are indeed fundamental across nature and culture, then educational theories lacking a "quantum" dimension may overlook new types of relations previously unconsidered. These relational dynamics, akin to the complex interdependencies revealed by quantum mechanics, are already present in educational settings, even if not formally recognized in theory. Just as quantum mechanics reveals complex interdependencies at the subatomic level, education involves intricate relational networks among students, teachers, and various forms of knowledge and ways of knowing.

Cassirer's emphasis on the "many variations of a common theme" and the "unity of creative process" in his *Philosophy of Symbolic Forms* underscores the multiplicity of perspectives and the continual redefinition of reality across symbolic domains such as myth, language, art, and science (Cassirer 1944, p. 96). This aligns with the authors' vision of integrating diverse knowledge systems and modes of understanding in education.

In Cassirer's perspective both perception and knowledge – as relevant for education – are relational. Thereby, knowledge is not a direct grasp of objects but a symbolic mediation through "signs" and their "reciprocal relations." This involves: a) Accessing objects through symbolic signs/representations and b) Relations among these signs shape our understanding of objects. Thus, knowledge is relational between the knower and the object, and among the symbolic mediators themselves, challenging the idea of unmediated access to objects (Katsur 2019).

Cassirer also views perception as inherently relational and interpretive, not just a collection of data. Perception involves recognizing structural patterns and configurations rather than receiving raw impressions (Cadayona 2021). Humans uniquely isolate and consider relations "in themselves" through symbolic systems like language. "No matter how complete our knowledge may be in itself, it never offers us the objects themselves, but only signs of them and their reciprocal relations" (Cassirer 1953, 303). Hence, both knowledge and

perception for Cassirer are inescapably relational, constituting objects through signs and symbols.

This leads to the concept of "double relationality" (cf. Schäfer 2015, 100) indicating that the relation between knower/perceiver and object is shaped by the internal network of symbolic relations, challenging any notion of unmediated access to reality. Here, the perception of relations is an active process, closely linked to judgment (Cassirer 1953, 341).

The notion of "double relationality," where perception is an active relational process, resonates with the transformative and participatory nature of learning envisioned by the authors. It challenges the subject-object divide prevalent in traditional or classical educational models. By emphasizing the primacy of relations, "double relationality," and the potential for convergence across symbolic forms, Cassirer's perspective provides a fertile theoretical lens for reimagining education through a relational and holistic ontology inspired by quantum mechanics.

#### **4.2.3 Matthias Jung's ordinary experience**

In his neo-pragmatist ontology, Matthias Jung takes ordinary experience as the starting point, broadening John Dewey's perspective. He frames ordinary experience as a holistic and embodied way of accessing the world, intertwined with our actions, where cognitive, emotional, and volitional dimensions are not yet clearly differentiated (Jung 2014: 172). This holistic view necessarily en-

compasses the totality of experience, including religious and ideological dimensions. Jung's approach is valuable for educational theories because it addresses the relationship between ordinary experience and domains like science, politics and religion, reconstructing them as species within the broader genus of "meaning/reference". Under this genus, different species have their respective realities and truths<sup>8</sup>.

While these species all emerge from contingent experiences, they extrapolate and interpret those experiences differently. Scientific disciplines methodologically extrapolate ordinary experience, while religion does so through practices like meditation and prayer. However, Jung cautions against a "horizontal misunderstanding" where a species exclusively understands itself as the sole realization of the genus, akin to "concluding from the properties of the island to the properties of the ocean" (Jung 2014: 104). Jung's idea of "horizontal misunderstandings" among different knowledge systems (and symbolic forms) resonates with the authors' critique of disciplinary silos and their call for transdisciplinary convergences. It provides a rationale for integrating diverse epistemologies and ways of knowing in education. A classic expression of this misunderstanding are dichotomies such as particularist-universalist and religious-secular.

Jung's framing suggests that educational science's use of analogies<sup>9</sup>, metaphors, and equivalents from quantum mechanics is not a naive imitation but a search for insights and inspiration from other "secondary species" that have already extrapolated ordinary experience in a novel and paradigmatic ways (cf. Wegerif 2016). This does not necessitate a simple dichotomy but rather a dynamic interplay and mutual enrichment between fields like education and quantum mechanics.

A perceived similarity between processes in education and quantum mechanics points to the same underlying ordinary experience, according to Jung. The difference lies in the degree of extrapolation. The authors are drawn to quantum mechanics, rather than systems theory, because the former has accomplished a paradigm shift by extrapolating holistic experience from a classical to a quantum level. This provides a vivid example of how new relations and states can be theoretically and methodologically integrated into a scientific field. Moreover, this paradigm shift in physics inspires and serves as a starting point for educational science to reopen ontological and epistemological questions. The authors of the analyzed essays quote figures like Einstein, Heisenberg, and Bohm, understanding physics as a discipline suitable for transdisciplinary discussions and scrutinizing different perspectives on reali-

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8 Beyond the linguistically formulated experience and interpretation of meaning (values give meaning, significance, orientation), rules of action (norms) and cognitive worldviews are articulated. These determine what can be considered reality ("truth") in each context (Jung 2014: 102f.).

9 For the later criticism see Karen Barad and the more complex metaphor of diffraction.

ty. Thus, the use of terms like superposition, entanglement, and non-locality across disciplines, including educational science, is a permissible approach that can enrich various fields.

From this we can conclude that Jung's holistic conception of ordinary experience can be perceived as the common ground from which diverse knowledge systems and symbolic forms emerge. Additionally, it legitimizes the use of analogies and metaphors from quantum physics as a means of extrapolating and enriching educational theory, rather than dismissing it as mere imitation.

## **5. Limitations of the “quantum approach”**

**T**he authors anticipate a future education, society and humanity by means of the paradigm shift and societal transformation far from the Newtonian determinism and dualism. The use of analogies and metaphors from quantum mechanics is insightful in this context. However, different limitations and challenges can be associated with this approach.

The emphasis on inner transformation, expanded consciousness, and new worldviews as important goals of education may be perceived as overly idealistic or unrealistic, particularly within the constraints of traditional educational settings or current school systems (which the authors intend to broaden). However, current educational approaches such as constructivism, experiential and holistic learning show

that traces of these earlier ideas have found their way into today's education.

The authors acknowledge the theoretical and conceptual nature of their discussion, but the lack of empirical data to support the proposed education approaches and their relevance to students is a notable gap. The survey on students' attitudes and interests in this regard would have strongly supported this approach.

An important consideration arises regarding whether quantum mechanics can draw substantive inspiration from these educational approaches, especially concerning knowledge convergence. Addressing this would require clear articulation of how such connections could shape future educational strategies. Some of the reconstructed principles – such as interconnectedness and paradoxes – might be incorporated in the future education in STEM subjects when dealing with quantum mechanics.

As the practical implications and actionable steps for educators and policymakers remain vague, the next steps would be to tailor them according to the needs of the education today, and to enable the mentioned nuances and complexities of educational processes.

## **6. Conclusion**

**T**he discussed papers highlight a transformative vision of education understood by the analyzed authors as a quantum phenomenon, integrating ideas from different scientific disciplines and bodies of knowledge.

Nevertheless, they show that educational theories suffer from an ontological and epistemological limitation, which the analyzed authors attempt to rectify by proposing didactics to transform education, students and teachers.

This vision challenges Newtonian, linear, and mechanistic models of education, advocating for a holistic understanding that recognizes entanglement, superposition, and non-locality as inherent components of teaching and learning processes. By integrating diverse knowledge systems they anticipate the transformation of humanity and rise of new worldviews that can be attributed as quantum humanities.

To ground this constellation beyond quantum mechanics this paper is offering philosophical foundations based on Ernst Cassirer's and Matthias Jung's ontology. Consequently, the paper identifies a critical issue in analyzed essays: the lack of non-linear *relationality*. Cassirer's in-depth perspective focused on the relational core of all symbolic forms and his emphasis on the accommodation of multiple perspectives supports the authors' vision of integrating diverse ontologies and epistemologies. Matthias Jung's neo-prag-

matist ontology of ordinary experience as a holistic one supports the integration of cognitive, emotional, and volitional dimensions in modern education. His perspective provides a basis for integrating different knowledge domains and overcoming dichotomies like religious-secular and universalistic-particularistic. Furthermore, following Cassirer, it can be argued that a paradigm shift is only necessary insofar as quantum principles such as indeterminacy and uncertainty (as relations) are nested in manifold symbolic forms and thus omnipresent.

Based in Cassirer and Jung, this paper goes beyond analogies between different scientific disciplines, and explores the possibility of convergences of complex systems. This approach have been partly exemplified by UNESCO's efforts to integrate universalistic and indigenous knowledge systems. Nevertheless, the analyzed approaches open up far more avenues for convergence in education and can possibly inspire UNESCO for future steps. Therefore, the paper concludes that both transdisciplinary research and education policy can benefit from engagement with quantum equivalents and metaphors in education theory.

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