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Article

Quantum Insights as a Pedagogical Framework for Sustainability in Management Education

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Abstract

In Central and Eastern European countries in particular, we face the challenge of teaching sustainability management and business ethics. We are guided by accreditation committees and social demand. But how can we think and teach without having to follow what is mostly just formal pressure regarding the expected content of education? Political developments in Central and Eastern European (CEE) countries also point to the need for deeper and more serious argumentation. This conceptual study introduces a novel perspective on sustainability management by integrating foundational principles of quantum insight, such as uncertainty, probability, and interconnectedness, into both the theory and pedagogy of management education. Challenging the prevailing dominance of classical, deterministic approaches in business schools, the study argues for a quantum-inspired framework that emphasizes complexity, holistic context, interdisciplinarity, and universal responsibility. The discussion traces the philosophical origins of quantum thought and links its concepts to evolving global initiatives in responsible management education, such as the United Nations (UN) Principles for responsible management education (PRME) and the Sustainable Development Goals (SDGs). The paper addresses two key research questions: how principles of quantum insight can inform and transform traditional approaches to sustainability management, and what pedagogical implications emerge when incorporating quantum concepts into curricula focused on sustainability and ethics. It highlights the limited current engagement with quantum ideas in the sustainability management debate and calls for broader adoption of transdisciplinary, ethically infused teaching methods. The study concludes that embracing quantum perspectives offers management educators and practitioners a powerful lens for nurturing responsible leaders equipped to address the complexity and plurality of modern organizational and societal challenges.

Keywords: sustainability; consequences of quantum insights/theory; management education; responsibility
JEL: D81, M14, Q56

1. Introduction

For the educated reader, it is clear that the current emphasis on sustainability management is no longer just a fad in professional journals and business school curricula. The 21st century confronts us with an urgent need to address a fractured global landscape, a labile societal situation, cautionary environmental developments, and the natural implications for business and management. Discussing sustainability with an awareness of a complex dynamic world (Zettinig et al., 2021) and nonlinear dynamics has become a conscious existential need for surviving the modern crises of contemporary and future society (Mainzer, 2009).

The paper details how quantum physics principles can reshape traditional sustainability management strategies. It discusses the pedagogical implications of integrating quantum concepts into sustainability curricula, serving as a pedagogical grounding rather than a foundational theory. To remind ourselves of developments to date and the current expert debate, let us revisit the basic approach, which ultimately supports quantum physics and its managerial implications.

The first essential and well-known concept of management, which went beyond purely economic factors in business evaluation and opened up the contextual prospect of responsibility for business sustainability and its future development, was the concept of corporate social responsibility (CSR). The connection between social interests and business has been transformed over the last ten years into a United Nations Global Compact, Principles for Responsible Management Education (UN GC PRME) initiative. This organization revealed a much higher ambition and a broader dimension than just the balance between business and society (PRME, 2023). The PRME does not formally stem from quantum plurality and other quantum discoveries; it is a United Nations-supported initiative that aims to raise awareness of the complex profile of sustainability through quantum physics. Both principles are implemented here in business and management education through principles focused on serving society and safeguarding our planet.

The new emphasis of management in recent years has therefore begun to link business, social, and environmental sustainability (Kučera, 2020). The phenomenon of sustainability is logically related to time, to responsibility for the future in the broadest possible context of management strategies and activities. Literally, we read about PRME that "engages business and management schools to ensure

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they provide future leaders with the skills needed to balance economic, environmental, and social goals, while drawing attention to the Sustainable Development Goals (SDGs) and aligning academic institutions with the work of the UN Global Compact. Driven by its mission to transform management education, PRME equips today's business students with the understanding and ability to deliver change tomorrow" (PRME, 2023). The final emphasis on the future is the Sustainable Development Goals (SDGs) program (United Nations, 2015). The current form of a comprehensive approach to managerial responsibility is the Environmental, Social, and Governance (ESG) project. In official documents (European Commission, 2023), it represents a key European concept for sustainable investment and corporate responsibility. It combines an emphasis on management quality and comprehensive risk analysis with the financial impact of business on the environment and society (Hill, 2020).

All these steps over the last decades have provided an entirely new perspective on the classical concept of management, which business schools are learning to cope with and to integrate strategy adequately into their curricula and academic work. However, even within the European Union (EU) context, some schools and countries have not yet fully grasped or addressed the challenges. Especially the post-communist Central and Eastern European (CEE) countries even like to relativize them (Kučera, 2022). This is due to an overly entrenched emphasis on capitalism's utilitarian approach, profit, and market economy, which sees consideration of the human and natural context more as a brake on the private interests of investors, and owners of companies or shareholders (Kučera, 2020). The described separation of the economy from societal goals and the fragmentation of economic society into individual business models are unsustainable and directly contradict the idea of comprehensive responsibility for sustainable management.

Alongside the responses to the many megatrends of contemporary economics and management, the final argument presented in the study is quantum physics, which we start to discuss according to the following two essential research questions:

RQ1. How can principles of quantum insights inform and transform traditional approaches to sustainability management?

RQ2. What are the pedagogical implications of incorporating quantum insights into management education on sustainability and ethical responsibility?

The article opens with an analytical literature review of our topic, formulates the methodology of the study, and then describes the key pillars of the research: the conceptual background of quantum insights within quantum theory for management. The individual chapters provide the framework for formulating basic quantum theory and open up specific results as possibilities for its implications for sustainability management and education.

2. Materials and Methods

We are searching in professional literature sources of development classical managerial philosophy oriented on profit via authors analyzing topics that gradually moved towards the framework of CSR, SDGs, ESG, and the framework of PRME = universality, complexity, interdisciplinarity, or interconnectivity between business, society, and nature as described in the framework of quantum insights. Here presented reflects the growing crisis in society and the natural environment, of which business is a part (Zettinig et al., 2021). The new contextual complex analysis led researchers to finally establish business with social and environmental responsibility management (Bergquist, 2017; Fülöp et al., 2025; Hill, 2020). The difference lies in the fact that much of 20th-century management literature, rooted in scientific management and classical theories, prioritized efficiency and economic output over the holistic integration of business with society and nature (Harrison et al., 2023).

The research shows that the second level of publications broadens the concept of entrepreneurship, with the context including management's responsibility for the future. The impetus for this was the 1987 Brundtland Report, which brought environmental issues into the concept of sustainable development, paraphrased as: "meeting the needs of the present generation without compromising the ability of future generations to meet their own needs" (WCED, 1987). A completely new element of time has emerged, one that transcends the empirical perspective of the past and present. After quantum physicists pointed out that the world forms an indivisible whole, in management, physicists and managers began discussing responsibility for the future in a holistic perspective (Schüz, 1986, 2019). The reason for this is also the many crisis phenomena to which management must respond (Kliestik et al., 2026; Mainzer, 2009).

The last analytical steps discover the context directly in quantum physics. For nearly a century, we could follow the published discussion about the challenges of quantum discoveries. The following study describes its basic features (Trachanas, 2017; von Weizsäcker, 1985; Wenzl, 1960), and summarizes the quantum philosophy (Omnès, 1999). Management researchers found a link between the described philosophy and the internal logic of sustainability management (Schüz, 2019; Zohar, 2016). The reasons for opening the new perspectives brought by quantum physics and philosophy are within the limits of traditional performance management (Song, 2024; Yin, 2019).

After linking quantum insights with sustainability management, we are looking in the literature for practical applications of discoveries for management pedagogy and education (Kearins and Springett, 2003) to enable responsible decision-making across different management fields (Heim et al., 2026). And there are precisely the key pillars of quantum thinking that help us build a bridge between management, quantum insights, and learning out-

comes (Urdan and Luoma, 2020) as part of the scientific thinking of management (Laszlo, 2020).

The latest challenges of quantum insights for sustainable management education concern researchers, among others, the field of digital mindset (Allen, 2020), the role of big data in business and industry (Botoc et al., 2023), and artificial intelligence (Siminica et al., 2025). Similarly, other professionals include our focus on the constantly changing, intense, and competitive global pressure as one of the "hot topics" for management education and future needs (Ratten et al., 2025). A connection between quantum insight and sustainability management can be developed in various ways (Hummel, 2017): quantum organization (Kilmann, 2011), needs of quantum leaders (European Commission, 2025), or quantum strategy in a political context (ibidem, 2025).

The methodological approach outlined for integrating the concept of quantum insights into sustainability management and management education is primarily contextual and conceptual (refined by Nguyen and Tull, 2022). Conceptual mapping searches for and analyzes comparative points that enable the derivation of implications of quantum insights for sustainability management with an interdisciplinary approach. The correct description of the elements of quantum physics was discussed with some quantum physicists (personally with Mathias Schüz and some colleagues from the Institute of Physics in the Czech Academy of Sciences). Standard university database access methods were used to search for literary sources. The core methodological characteristics are as follows.

2.1 Contextual and Conceptual Foundation

The methodological inquiry began by examining the fundamental professional gradual development of managerial thinking, which moved away from the traditional focus on profit and incorporated business responsibility towards society, nature, and the future. This was followed by the identification of key elements of quantum insights that are relevant to sustainability management according to current understanding in professional literature. It revisits both the philosophical origins and the empirical implications of summarized quantum philosophy (such as uncertainty, complexity, and interconnectedness) as they relate to organizational realities.

2.2 Literature-Informed Synthesis

After the basic research and analyses of quantum insights, the process involves a review of literature that discusses the impact of quantum theory on management thinking. Key texts and studies are selected to draw parallels between developments in quantum mechanics (like the shift from classical determinism to quantum probabilities and non-locality). The literature review formed a concept of synthesis between key factors of quantum theory and the key principles of managerial responsibility and sustainability management. The results are described in the chapter "Conceptual background of quantum insights for management".

2.3 Universal Responsibility Framing and Business Ethics

The methodology of literature synthesis incorporates ethical elements for management. Awareness of quantum principles (e.g., universal interconnectedness, principle of uncertainty, etc.) implicitly leads to a new philosophy of managerial responsibility and ethics affecting managerial strategy and decision-making process. It emphasizes that actions taken within organizations have ripple effects over time, affecting not only immediate stakeholders but also broader social and environmental systems and future generations. This stems directly from quantum concepts such as non-locality and entanglement, advocating for universal responsibility in practice.

2.4 Identification of Differences and Changes in Management Thinking

Identification of key elements of sustainability management influenced by quantum theory emphasizes revealed characteristics of management that resist traditional disciplinary fragmentation, and draws new connections between management, physics, philosophy, and ethics. It advocates for holistic management orientation and comprehensive solutions that account for economic, environmental, and social dimensions today and in the future (Pietschmann, 1997).

2.5 Application Through Teaching and Reflection

The identification of key factors of quantum insights with sustainability management calls for a new description, interpretation, and valuation of management philosophy for management education. The methodology supports experiential learning, critical reflection, and curriculum development that foreground quantum principles according to the reality. This includes encouraging teachers and students to grapple with accepted quantum principles. It means that, e.g., the universality, uncertainty, complexity, and the implications of quantum principles for human actions have to be explained. It also means that the teaching has to bring arguments for a quantum understanding of sustainability management, rather than seeking solely deterministic or reductionist solutions.

2.6 Conceptual Background of Quantum Insights for Management

Quantum insights that provide us with fundamental knowledge for our conceptual analysis and literature synthesis were made available to the world by well-known figures such as Max Planck, Niels Bohr, Erwin Schrödinger, Max Born, Louis de Broglie, Wolfgang Pauli, Werner Heisenberg, and others. Quantum theory represents a departure from classical physics, whose representatives were,

for example, Isaac Newton and Blaise Pascal. The summarizing concepts are well described by von Weizsäcker (1985). Of course, work on quantum insights was not immediately accepted without reservation. Among the first opponents was already Albert Einstein. Indeed, the representatives of quantum theory presented a departure from the classical conception of physics, whose representatives were, for example, Isaac Newton and Blaise Pascal, among others. Our interest focuses on the subsequent scientific discussion of physical discoveries, which deals with the philosophical treatment of quantum discoveries (Omnès, 1999; Wenzl, 1960). Contextual analysis and comparison with elements discovered the links that can be used for management (Schüz, 1986). Mathias Schüz expanded the philosophy of quantum theory logically to sustainability and ethics.

● *Quantum waves instead of particles*

The term quantum refers to the smallest possible value of any physical quantity. Max Planck opened the discoveries of quantum insights by showing that instead of individual parts, quanta play a role in reality. In the literature (von Weizsäcker, 1985) we find descriptions that say: In the microworld, the physicist observes the so-called corpuscular-wave dualism, according to which particles in the microworld have both particle and wave properties. According to quantum theory, for example, light or an electron can behave both as a particle and as a wave. This means that light is not just a uniform stream that we perceive with the naked eye. Quantum phenomena such as interference describe a situation where two quantum particles with wave properties collide. And when two wave maxima of similar frequency collide, the waves multiply. When the maxima of a wave and a minimum of a wave collide, the wave is cancelled out.

The basic concept of quantum theory poses completely new challenges and possibilities for the sustainability management we describe in next chapters as a new perception of complex and dynamic reality we cannot see with the "naked eye".

● *Principle of uncertainty and probability*

The described quantum theory (Trachanas, 2017; von Weizsäcker, 1985; Wenzl, 1960) mentions the fact that the microworld exhibits an uncertainty relation, sometimes referred to as the Heisenberg uncertainty principle (Heisenberg, 1979). Its essence is that we cannot simultaneously measure the complementary properties of particles. The best-known relation is the momentum-position relation. If we make the measurement of position more precise, we make the measurement of momentum less precise (de facto impossible), and vice versa.

The contextual analysis of published introductions to quantum theory contributes to our research question: What does it mean for management? Generally, the classical management theory and economics strive for maximum accuracy and certainty, the limitation of uncertainty or risk. Today, we are aware of the dynamic economic and financial environment, which must take into account many variables: time, energy changes, external and internal conditions, attitudes, etc. (Alvarez et al., 2018). In light of the quantum principle of uncertainty, classical management expectations are relativized (Ratten et al., 2025). A wide range of authors represent a whole host of new areas of sustainability management that call for a "paradigm shift in management philosophy".

Other relations of uncertainty include the time-energy relation, according to which we can never know both because both are always changing. We cannot know at the same time the exact time at which a particle was measured and its energy at that moment. The problem of relational uncertainty is related to the problem of measurement, which is often interpreted to mean that we change reality by measuring it. This is inconceivable, complex, and ungraspable for the classical economist and manager. And if a manager cannot measure something, he cannot manage it in the frame of classical management practice. Researchers started to use various methodologies, probabilistic methods, possibilistic methods, stochastic optimization, information gap decision theory, and hybrid approaches. Their comprehensive and comparative assessment approached researchers in selecting the most "appropriate uncertainty modeling technique". Managerial planning was developed in accordance with the characteristics of "uncertain variables" (Varathan and Belwin, 2024).

The consequences of our synthetic analysis invite management theory to take account that classical physics is deterministic, quantum physics is probabilistic, and therefore dynamic and open-ended. We know from quantum insights (above described) that each object in the universe can be assigned its wave function. Using the square of the wave function, we can calculate the probability that a particle is in a particular state. The nature of microcosm reality in quantum physics is thus highly contingent, and probabilistic. Probability and the non-locality of quantum theory play a role for our measurements in management. A direct consequence of Heisenberg's uncertainty principle is the questioning of classical deterministic views. These ideas influence management measurement by promoting models that embrace ambiguity, interference in decisions, and observer effects for more adaptive strategies (Louisot, 2024). In the chapter: "Risk management and Uncertainty" the author directly refers to quantum physicist Niels Bohr.

● *A new dimension of reality*

Quantum theory has confirmed the ancient philosophy that everything is connected to everything. Max Planck showed that instead of individual parts, quanta play a role in reality. We have only one world, we live on one planet, and it has the same physical laws. For our conception of the world and life, it has enormous consequences and necessary implications for everything. For management, the entitlement "universal responsibility" (Schüz, 1986) was formulated.

Our question is what consequences does the new dimension of reality based on the knowledge of "waves" have for management? Generally, management is based on "particles" such as companies, departments, cost centers, financial entries in spreadsheets, local conditions, fenced areas, or employees. But the dimension of reality increases and opens up different interactions that never end. The contextual analysis led us to talk about quantum interconnections. It means that reality contains an infinite number of choices and combinations. For sustainability management philosophy, this means a new level of thinking about responsibilities in all its places of action over time and in different transformations. Exactly: the wave nature of reality, as revealed by wave-particle duality, reveals a probabilistic, multifaceted dimension beyond classical determinism. According to professional interpretations, for management, this shifts measurement and strategy toward embracing fluidity, context-dependence, and multiple potentials simultaneously (Siegel, 2020).

● *Change in the understanding of time*

The starting point of our contextual analysis in management today was ESG and the SDGs, with the vision of sustainable economic development (United Nations, 2015). It means we think about the future financial order with a positive expectation. But let us recall that physics points also to the negative role of time. Newly emerging orders cancel out past ones. To illustrate, the so-called law of entropy is offered.

According to the first theorem of thermodynamics, the energy content of the universe is constant. Energy can neither be destroyed nor produced. We only change its form.

According to the second law of thermodynamics, we know that some processes in nature are irreversible. It is impossible to recover heat from a cold reservoir without leaving noticeable changes in the surrounding environment. Entropy, therefore, changes with time.

In the context of the aforementioned physical laws, we discuss resource limits in management and economics. So, due to the law of entropy, we are losing the quality of our resources and their usefulness to the whole with each passing day. And let us remember again: entropy is universal. We cannot turn time back.

For sustainability management, this means an unimaginable increase in the awareness of responsibility. First implication for educational perspective, it means a new level of philosophical relevance of quantum theory (Anselmi, 2003; Schüz, 1986, 2019). The second implication relates to the education of business ethics because ethics is concerned with the human responsibility in sustainability management, not only for the present but concerning the changes in time and concerning the future challenges of our world (Baggott, 2004; Muller, 2023).

● *Reflections of physical laws and the experience of the world*

In the frame of our contextual synthesis, we can recall from the field of physics for sustainability management also three classic physical laws of Newton that support our analysis.

● *The law of inertia.*

The physical phenomenon is related to change management and must be seen as a challenge. Nothing changes immediately and all at once. Our world, nature, and processes will always be marked by natural, physical, social, financial, and corporate inertia. This puts an emphasis on our patience with honest, systematic, and long-term work full of difficulties. In management literature analysis, we find a synthesis with our research in studies about "strategic inertia". For managerial education, it offers seminars (e.g., agility training) about activating proactive forces in the situation of stagnation and resisting motion. The short-term management orientation is changed the long-term orientation (Perini et al., 2024).

● *The law of force.*

This physical law of force has become an inherent challenge for management. Unfortunately, physical force has often become the impetus for the violent managerial enforcement of certain concepts. The theme of the authors is the influence of the use of "mechanism" in authoritative corporate management (Kučera, 2020) that overlooks the implications of quantum.

● *The law of action and reaction.*

Newton's third law of action and reaction poses a particular challenge for sustainability management in our analysis. A manager is constantly under competitive pressure and often tempted to make quick changes, believing that the change they advocate will be valid for a long time and all. However, the physical law also requires us to reckon with the overall reaction to our decisions and actions, as manifested across all contexts and dimensions of the current conception of managerial responsibility. Group or authors (Ratten et al., 2025) describe new areas of sustainability management (geopolitical development, migration, cultural diversity, changed organizational forms, digital transformation, Artificial Intelligence, transcending the COVID-19 crisis, supply chain sustainability, etc.) that call for a new perspective of innovation.

Especially in CEE development and discussion, we must, however, not forget that in the context of physics, the world and society do not have unlimited resources, space, or possibilities. That is why it is very dangerous to keep talking only about the "free market" as a solution for contemporary society (Klaus, 2008). The law of action and reaction is valid in all areas of culture, business, and natural environment. The current discussion concerns the region of the author–CEE (Kliestik et al., 2026).

3. Results

Via conceptual analysis and contextual literature synthesis, we can summarize the results of the study as follows:

According to RQ1, we asked how principles of quantum insights can inform and transform traditional approaches to sustainability management. The results are formulated and explained.

According to RQ2, we asked what the pedagogical implications of incorporating quantum insights into management education on sustainability and ethical responsibility are? The results are formulated in 3.3–3.4.

3.1 Development of Managerial Thinking to Universal Context of Responsibility and Sustainability

The first result of the initial literature analysis summarizes the gradual shift in the concept of managerial responsibility from the classic managerial theory approach focused on profit to a comprehensive, universal responsibility. The path from classical management theory led to a new focus on sustainability. Individual steps were guided by an emphasis on CSR, SDGs, ESG, PRME, and culminated in responsibility for future generations.

3.2 Analysis of the Basic Elements of Quantum Theory Suitable for Sustainability Management

This analysis is described in paragraph 2.6: "Conceptual background of quantum insights for management". Sub-paragraphs discussed the pillars of quantum theory that resonate with the importance of sustainability management and fundamentally enrich it.

Sustainability management can learn from quantum theory that nothing in nature happens in isolation. Management has the task of explaining and managing reality. We live and work on one planet, governed by universal natural laws older than humans and any management theories. The main contribution of quantum insights is therefore the emphasis on the universal context, the interconnectedness, and the complexity of processes. The discovery of wave reality leads to a new concept of reality that is pluralistic and dynamic, thereby also preparing management for a certain degree of uncertainty. Instead of the traditional idea of determinism, it is necessary to allow for increased probability.

The demand for dynamic sustainability management is dictated by the laws of time and entropy. In this light, sustainability management means taking on complex responsibility for the present and for future generations. A reasoned perspective overcomes the emphasis on empirical approaches to management, which naturally do not have a conclusive view of the future.

In addition, physics offers sustainability management a reflection of other natural laws, as described in the next sub-paragraphs (the laws of inertia, force, and action and reaction). Quantum insights thus provide the field of management with a completely new kind of argumentation that textbooks have not yet used.

3.3 Pedagogical Implications of Quantum Insights Into Management Education on Sustainability

The study has numerous pedagogical implications for education in sustainability management.

● *Connecting philosophy and quantum theory with science.*

The field of management has started to use the term "sustainability" since the 1992 UN Conference in Rio de Janeiro. The organizers responded to the situation of social and environmental crisis and formulated the term "sustainability", which is linked naturally to a sustainable economy and a natural environment, but also to a stable social environment (United Nations, 1992). The initial ideological impulses now find scientific support in quantum physics, as formulated by Friedrich von Weizsäcker (Schüz, 1986, 35–46):

It connects the world of ideas with reality, thereby overcoming the old dualism of spirit and matter.

It connects humans and their activities with the laws of nature in which they are rooted.

It justifies the unity of being in connection with universal laws.

It connects management responsibility with the whole world and the dynamics of time.

It deepens the theme of sustainability management beyond the world of matter and technology to the level of metaphysics (the meaning and purpose of life with a view to the future, which is under threat).

It brings a new order to managerial thinking, a solid foundation for respect for life, its quality, and sustainability. It relativizes the so-called neutrality of science.

Quantum insights therefore support sustainability management in the fields of anthropology (connecting thinking and being), sociology (business depends on the quality of society), natural processes, and positive developments for the future. The task of management education will therefore be to make aware of the human approach, the barriers, but also the potential. We can teach in the management context about "human sustainability", social sustainability and natural sustainability in time. This perspective of complexity over time leads us to a necessary rethinking of the long-standing narrow neoliberal focus on economic growth, which has overlooked the maintenance of life, and social stability concerning all related conditions and laws.

3.4 Overcoming Isolation and Fragmentation of Management Science

The quantum insights for sustainability management education disrupt the established modern view of management and business as fragmented fields with no direct connections or implications for human beings, society, and nature. As can be seen in Fig. 1 below, the current understanding of academic disciplines has led to economics being formally defined as a separate discipline that is not directly linked to either a social or environmental context. It

was also not very concerned with temporal implications for the universal future development. Hence, the fundamental implication of quantum physics for sustainability management is: to free modern science, and therefore economics and management, from the contemporary fragmentation of science, the reduction of social disciplines to isolated objects, and deterministic and strictly causal analysis using mainly mathematical formulas. Classical teaching, using economic models and experiments, has proved to be of little use in the face of the world's complexity and the lack of predictability.

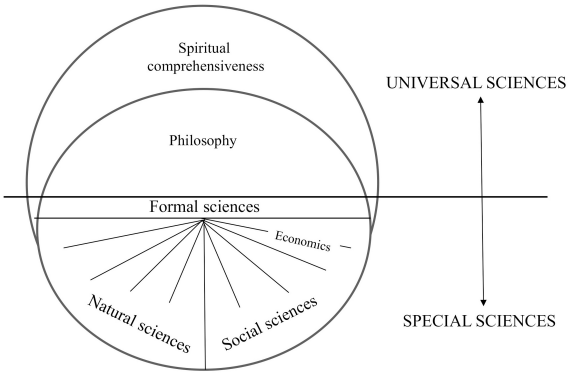


Fig. 1. The division of scientific disciplines. Source: Authors' adaptation from Anzenbacher (2002).

Philosophy and the natural sciences initially recognized universal values and contexts that also affected the life and business of society. We see above in the Fig. 1 the position of economics within the social, natural, and universal sciences. Finally, we have to teach about the need for multi-disciplinarity, inter-disciplinarity, and ultimately trans-disciplinarity in a globally interconnected world (Ming et al., 2023; Welsh and Dehler, 2012; Zettinig et al., 2021).

● *Transcending Rationalism and Empiricism*

For easy understanding in the classroom, we can present clear historical milestones from the 15th to 16th centuries, showing how the original universalism was replaced by fragmented sciences and rationalism. The astronomical discoveries of Nicolaus Copernicus and Giordano Bruno, developed by Galileo Galilei (1564–1642), gave an entirely new emphasis to mathematical models. But after the discovery that the Earth is just one rotating planet among others, the natural question arose as to what is now central to our status, life and work. What are the sustainable values?

The class should understand how René Descartes (1596–1650) opened the period of modern science to a reliance on human thought. He separated philosophy and the social sciences from the natural sciences (res cogitans vs. res extensa). We speak of the so-called "Cartesian dualism" by which he wanted to reveal a clear and distinct truth through human critical thinking (Descartes, 2013).

The emphasis on natural sciences continued in physics with Newton's laws of inertia and gravitation. Isaac Newton (1643–1728) began to speak of "exact science". And Francis Bacon (1561–1626) had already declared before him that knowledge based on mathematics represented a certain "power". And because he was following Machiavelli and Descartes, we also know of his admiration for the power use/abuse of "knowledge" for partial ends. The grand conception of the world, society, and man has been displaced by the exact sciences and precise expertise. Above all, let us recall the absolute claim of the paradigm of mathematics or mathematization as a scientific method. And here also begins the critique from the perspective of quantum physicists who summarized the scientific falsity of the approach (von Weizsäcker, 1985). Wenzl (1960) then pointed out the tension between mathematical fiction and physical reality, between subject and objectivity.

For management, this means a new space for thinking, analyzing, and strategic planning from an ideal through reality to a potential future. Such thinking, however, takes place at a higher level, which will not be bound by strictly isolated statistical data and hasty managerial applications.

● *Extended Dimension of Responsibility*

Management education needs pedagogical support for teaching fundamental physical laws and the development of science, which helps support new arguments for sustainability management. The classical fragmentation of the sciences at the beginning of the Renaissance and modernism was replaced in physics by the search for a "theory of everything" (Hawking, 2006). The classical theory was challenged by the theory of relativity and by reference to far more complex and intricate processes in the cosmos and on Earth. Complexity, intricacy, and the need to take into account various relationships, special conditions, limits of physical measurement, quantum phenomena, waves, unpredictable motions, etc.

Pedagogues are aware that managers still want a simple overview of everything, to understand everything, to measure and control everything, to know the causes, consequences, and influences, and to be able to predict, organize, manage, control, calculate, and change their image. And to do this, they use experience (empirics), statistics (data from the past and drawn boundaries), and their plans. But beware—the tools chosen and used are limited. Quantum physics recalls the limits of empiricism, causality, determinism, and short-term statistics. Quantum phenomena are non-deterministic, probabilistic, and non-local (Schüz, 1986). There are new pedagogical challenges. According to Georg Picht, we face new challenges: if we want to know everything, we must take responsibility for everything within our power (Picht, 1985).

Table 1. Differences between classical and quantum management.

Classic approach to management	Quantum approach to management
Fragmentation, specialization	Universality, Interdisciplinarity, Interconnectivity
Isolation, individualization	Complexity and context in society and nature
Particulate matter	Wave reality
Accuracy and security	Overcoming of probability
Causality and determinism	Overcoming of uncertainty
Measurement accuracy	Relation of momentum and location
Stability	Relation of time and energy, variability
Short-term orientation, past, presence	Long-term, time consequences, sustainability
Special responsibility	Responsibility for everything
Functionality	Accountability, responsibility, justice
Rationalization	Limits of pure ratio
Experience	Limits of pure experience and statistics
Paradigm of reduction	Plurality

Sources: Authors' own elaboration/adaptation.

4. Discussion, Limitation of the Study

The fundamental limitations of the study are evident primarily in the enormous philosophical scope provided by the concepts of quantum physics.

The second limitation stems from the unfinished discussion of the foundations of quantum physics' views on natural processes.

The third limitation stems from the broad scope of the fields of management, economics, and education that we have tried to address.

Next: Each section in this study represents a separate area that could be deepened and expanded; somebody could include more examples.

Discussion on linking quantum concepts to the theory of managed sustainability is minimal. Only a few scholars have compared quantum physics with sustainability management. For this reason, the present study remains unique and beneficial.

The paper will likely arouse new interest among scholars and subsequent enriching publications in this direction.

The challenge of the presented perspective is a pedagogical one that never ends. For teachers, the perspective outlined will pose a considerable challenge: to show the complexity of reality to management students, to teach in contexts, to take into account the possible impact on future generations, and yet not to lose their interest in the substance's complexity.

For example, to further demonstrate the possible linkage between sustainability management and the implications of quantum physics, we can cite the application formulations in the Sarbanes-Oxley Act of 2002 (https://sarbanes-oxley-act.com). The federal law of the United States governs the application of complex managerial responsibility in financial recordkeeping and reporting for corporations.

A final example is the link between management and psychological, neuroscientific, and sociological contexts, which are less mentioned than industrial environmental or medical, chemical, neurological, and biological impacts. The recent COVID-19 crisis, with its overall effects, will have consequences that will continue. Despite all the complexities, we cannot forget that our lives are finite and our planet provides a finite space; we have only one planet and only one life in which to fulfil our tasks. The application of our responsibility will depend on understanding the challenges to the human spirit in the physical world (Jantsch, 1992).

5. Conclusions

To summarize the results following our two essential research questions, we can conclude: According to RQ1, we have formulated how principles of quantum physics, such as uncertainty and interconnectedness, can inform and transform traditional approaches to sustainability management.

According to RQ2, we are formulating the pedagogical implications of incorporating quantum concepts into management education on sustainability and ethical responsibility in the following table.

In this way, we list in the following Table 1 the essential points with the help of other researchers who are leading the professional discussion on the topic (Sebhatu et al., 2021).

The research can and should continue. The basic findings of quantum physics and their implications for sustainability management education have appeared in professional literature in recent years. Studies are emerging that link management with quantum physics, e.g., in concrete fields like teamwork, leadership, organizational structure, and management or quality models. Of course, each new author should be aware of the new challenges, various barriers, and tensions associated with the topic and the growing systematic literature overview (Russo et al., 2023). Nonetheless, today, international companies have come up with even more recent ESG initiatives to encour-

age investors to use current methods (Silvola and Landau, 2021).

There are new examples of interest among neuroquantologists, also recognizing the connection to the topic of sustainability (Bante and Dange, 2022) and experts in quantum computing (Norton, 2023). The lack of connection between quantum insights and sustainability management can be a new potential for future research, teaching, and practice.

Abbreviations

CSR, Corporate social responsibility; SDGs, Sustainable development goals; UN GC PRME, United Nations Global Compact, Principles for Responsible Management Education.

Availability of Data and Materials

All data reported in this paper will be shared by the corresponding author upon reasonable request.

Author Contributions

DK designed the study, conducted the research, analysed the data, and wrote the manuscript. The author read and approved the final manuscript and is accountable for all aspects of the work.

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The author declares no conflicts of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the author used Google for the formal control of topics and Grammarly to check spell and grammar. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

References

Allen SJ. On the Cutting Edge or the Chopping Block? Fostering a Digital Mindset and Tech Literacy in Business Management Education. Journal of Management Education. 2020; 44: 362–393. https://doi.org/10.1177/1052562920903077

Alvarez S, Afuah A, Gibson C. Editors' Comments: Should Management Theories Take Uncertainty Seriously? Academy of Management Review. 2018; 43: 169–172. https://doi.org/10.5465/amr.2018.0050

Anselmi D. A New Perspective on the Philosophical Implications of Quantum Field Theory. Synthese. 2003; 135: 299–328. https://doi.org/10.1023/a:1023578026046

Anzenbacher A. Einführung in die Philosophie. Herder: Freiburg im Breisgau, Germany. 2002. (In German)

Baggott JE. Beyond Measure. Modern Physics, Philosophy and the Meaning of Quantum Theory. University Press: Oxford. 2004.

Bante K, Dange B. A study on effects of innovation in education and its sustainability. NeuroQuantology. 2022; 20: 2474–2482.

Bergquist AK. Business and Sustainability: New Business History Perspectives, Harvard Business School General Management Unit Working Paper. 2017: 18-034. https://dx.doi.org/10.2139/ssrn.3055587

Botoc FC, Khaled MD, Milos LR, Bilti RS. The role of big data in the fintech industry: A bibliometric analysis. Transformations in Business and Economics. 2023; 22: 853–868.

Descartes R. Meditations on the first philosophy. HarperCollins Publishers: New York, USA. 2013.

European Commission. Commission launches strategy to make Europe a quantum leader by 2030. 2025. Available at: https://digital-strategy.ec.europa.eu/en/news/commission-launches-strategy-make-europe-quantum-leader-2030 (Accessed: 3 February 2026).

European Commission. Corporate sustainability and responsibility. 2023. Available at: https://single-market-economy.ec.europa.eu/industry/sustainability/corporate-sustainability-and-responsibility_en (Accessed: 3 February 2026).

Fülöp M, Cifuentes-Faura J. Do ESG Strategies Drive Green Innovation in Emerging Economies? Business Strategy and the Environment. 2025; 35: 2453–2468. https://doi.org/10.1002/bse.70296

Harrison D, Prenkert F, Hasche N, Carlborg P. Business networks and sustainability: Past, present and future. Industrial Marketing Management. 2023; 111: A10–A17. https://doi.org/10.1016/j.indmarman.2023.03.011

Hawking S. The theory of everything: The origin and fate of the universe. Phoenix Books: Beverly Hills, CA, USA. 2006.

Heim I, Laker B, Tabaeifard SJ. Responsible leadership: A systematic literature review, theoretical framework, and future research directions. Journal of Business Research. 2026; 203: 115801. https://doi.org/10.1016/j.jbusres.2025.115801

Heisenberg W. Das Naturbild der heutigen Physik. Rowohlt: Hamburg, Germany. 1979. (In German)

Hill J. Environmental, Social, and Governance (ESG) Investing: A Balanced Analysis of the Theory and Practice of a Sustainable Portfolio. Elsevier Science & Technology: San Diego. 2020.

Hummel D, Jahn T, Keil F, Liehr S, Stieß I. Social ecology as critical, transdisciplinary science—conceptualizing, analyzing and shaping societal relations to nature. Sustainability. 2017; 9: 1050. https://doi.org/10.3390/su9071050

Jantsch E. Die Selbstorganisation des Universums: Vom Urknall

zum menschlichen Geist. Carl Hanser: München, Germany. 1992. (In German)

Kearins K, Springett D. Educating For Sustainability: Developing Critical Skills. Journal of Management Education. 2003; 27: 188–204. https://doi.org/10.1177/1052562903251411

Kilmann R. Quantum organizations: A new paradigm for achieving organizational success and personal meaning. UNKNO: London, UK. 2011.

Klaus V. Blue planet in green shackles: What is endangered: Climate or freedom? Competitive Enterprise Institute: Washington, DC, USA. 2008.

Kliestik T, Dvorsky J, Chaudhuri S, Chatterjee S. The effect of crisis events on sustainability of SMEs in Visegrad region of Europe: perspectives from leadership and strategy. Strategy & Leadership. 2026; 54: 225–254. https://doi.org/10.1108/sl-05-2025-0104

Kučera D. A historical approach to understanding values and its importance for corporate responsibility. In Farache F, Grigore G, Stancu A, McQueen D (eds.) Values and Corporate Responsibility: CSR and Sustainable Development. Palgrave Macmillan: Cham. 2020. https://doi.org/10.1007/978-3-030-52466-1_4

Kučera D. Challenges of managerial responsibility and ethics for Central and East European countries based on the experience from the Czech Republic. The International Journal of Management Education. 2022; 20: 100583. https://doi.org/10.1016/j.ijme.2021.100583

Laszlo C. Quantum management: the practices and science of flourishing enterprise. Journal of Management, Spirituality & Religion. 2020; 17: 301–315. https://doi.org/10.1080/14766086.2020.1734063

Louisot JP. Risk Management and Uncertainty. Enterprise Risk Management in Today's World: Enterprise-Wide Risk Management and Strategy, Part a. 2024; 9–22. https://doi.org/10.1108/978-1-83797-406-120241002

Mainzer K. Challenges of complexity in the 21st century: An interdisciplinary introduction. Cambridge University Press: Cambridge, UK. 2009.

Ming X, MacLeod M, van der Veen J. Construction and enactment of interdisciplinarity: A grounded theory case study in Liberal Arts and Sciences education. Learning, Culture and Social Interaction. 2023; 40: 100716. https://doi.org/10.1016/j.lcsi.2023.100716

Muller FA. The influence of quantum physics on philosophy. Foundations of Science. 2023; 28: 477–488. https://doi.org/10.1007/s10699-020-09725-6

Nguyen DC, Tull J. Context and contextualization: The extended case method in qualitative international business research. Journal of World Business. 2022; 57: 101348. https://doi.org/10.1016/j.jwb.2022.101348

Norton MG. A modern history of materials from stability to sustainability. Springer International Publishing: Cham, Switzerland. 2023.

Omnès R. Understanding Quantum Philosophy. Princeton University Press. 1999.

Perini L, Carneiro J, Miller KD. Strategic inertia and renewal: Contrasting responses to market changes. Long Range Planning. 2024; 57: 102441. https://doi.org/10.1016/j.lrp.2024.102441

Picht G. Philosophie der Verantwortung. Klett-Cotta: Stuttgart, Germany. 1985. (In German)

Pietschmann H. Limits of Specialization and Integrated Approaches. In Mizrahi A, Fulder S, Sheinman N (eds.) Potentiating Health and the Crisis of the Immune System (pp. 39–45). Springer: Boston, MA. 1997. https://doi.org/10.1007/978-1-4899-0059-3_4

PRME. The Seven Principles. 2023. Available at: https://www.unprme.org/what-we-do (Accessed: 3 January 2026).

Ratten V, Nanere MG, Cunha MPE, Fujimoto Y, Intezari A, García-Fernández J, et al. Hot management trends. Journal of Management & Organization. 2025; 31: 420–442. https://doi.org/10.1017/jmo.2025.6

Russo F, Wheeldon AL, Shrestha A, Saratchandra M. Responsible Management Education in Business Schools – High on principles but low on action: A systematic literature review. The International Journal of Management Education. 2023; 21: 100843. https://doi.org/10.1016/j.ijme.2023.100843

Schüz M. Applied business ethics: Foundations for study and daily practice. World Scientific: Singapore. 2019.

Schüz M. Die Einheit des Wirklichen. Günter Neske: Pfullingen, Germany. 1986. (In German)

Sebhatu SP, Enquist B, Edvardsson B. Business transformation for a sustainable future. Routledge: London, UK. 2021. https://doi.org/10.4324/9781003188773.

Siegel E. In quantum physics, even humans act as waves. 2020. Available at: https://www.forbes.com/sites/startswithabang/2020/08/19/in-quantum-physics-even-humans-act-as-waves/ (Accessed: 6 February 2026).

Silvola H, Landau T. Sustainable Investing. Beating the Market with ESG. Palgrave Macmillan: Cham. 2021. https://doi.org/10.1007/978-3-030-71489-5

Siminică MI, Cîrciumaru D, Manta AG, Cârstina S, Badareu G, Gherțescu C. FinTech, artificial intelligence, and European Union banks: A double-edged sword for performance? Oeconomia Copernicana. 2025; 16: 1099–1176. https://doi.org/10.24136/oc.3798

Song H. Beyond tradition: The implications of quantum management theory for modern performance management. In: Proceedings of the 2024 4th International Conference on Enterprise Management and Economic Development (ICEMED 2024). Atlantis Press. 2024; 20–26. https://doi.org/10.2991/978-94-6463-506-5_3

Trachanas S. An introduction to quantum physics: A first course for physicists, chemists, materials scientists, and engineers. John Wiley & Sons: Hoboken, NJ, USA. 2017.

United Nations. Transforming our world: The 2030 Agenda for Sustainable Development. 2015. Available at: https://sdgs.un.org/ (Accessed: 20 December 2025).

United Nations. United Nations Conference on Environment and Development, Rio de Janeiro, Brazil, 3-14 June 1992. 1992. Available at: https://www.un.org/en/conferences/environment/rio1992 (Accessed: 3 February 2026).

Urdan MS, Luoma P. Designing Effective Sustainability Assignments: How and Why Definitions of Sustainability Impact Assignments and Learning Outcomes. Journal of Management Education. 2020; 44: 794–821. https://doi.org/10.1177/1052562920946798

Varathan G, Belwin EJ. A review of uncertainty management approaches for active distribution system planning. Renewable and Sustainable Energy Reviews. 2024; 205: 114808. https://doi.org/10.1016/j.rser.2024.114808

von Weizsäcker CF. Aufbau der Physik. Hanser: Berlin, Germany. 1985. (In German)

Welsh MA, Dehler GE. Combining Critical Reflection and Design Thinking to Develop Integrative Learners. Journal of Management Education. 2012; 37: 771–802. https://doi.org/10.1177/1052562912470107

Wenzl A. Die philosophischen Grenzfragen der modernen Naturwissenschaft. W. Kohlhammer: Stuttgart, Germany. 1960. (In German)

World Commission on Environment and Development (WCED). Our common future. Oxford University Press: Oxford, UK. 1987.

Yin X. Review and Prospect of Quantum Management. American Journal of Industrial and Business Management. 2019; 9: 2220–2230. https://doi.org/10.4236/ajibm.2019.912147

Zettinig P, Aleem M, Majdenic D, Berry M. Learning Laboratory: An Integrative Learning Design for International Business in a Complex Dynamic World. Journal of Management Education. 2021; 46: 531–557. https://doi.org/10.1177/10525629211029630

Zohar D. The quantum leader: A revolution in business thinking and practice. Prometheus Books: Amherst, NY, USA. 2016.