

Yuliia Aleksandrova¹

Department of Social Philosophy, Philosophy of Education and Education Policy,
National Pedagogical Dragomanov University

The Paradigm of Science Education: an Attempt of Philosophical and Conceptual Foundations Explication

[Paradygmat naukowej edukacji: próba eksplikacji filozoficznych i pojęciowych założeń]

Streszczenie: W artykule przedstawiono problematykę dotyczącą paradygmatu nauczania przedmiotów ścisłych, który rozszerza tradycyjne rozumienie celu edukacji jako doświadczenia ludzkości zdobytego w drodze niekończącego się postępu i rozwoju. Wskazano, że pragmatyczna filozofia J. Deweya, podobnie jak cała współczesna epistemologia, przyjmuje, że celem poznawczym procesów ustalania i utwierdzenia znaczenia jest wartościowo-pragmatyczne skonfrontowanie zdobytej wiedzy. Z tego wynika, że w procesie badawczym mają miejsce określone stanowiska filozoficzne: subiektywizm jako indywidualne poszukiwanie nowatorskiego sposobu rozwiązania problemu oraz obiektywizm, odzwierciedlający depersonifikację procedur i metod eksperymentalnych, zaś konsensus w tym kontekście oznacza używanie sformalizowanego języka do publikowania wyników. Zgodnie z zasadami konstruktywizmu, sam proces edukacji należy traktować jako konstrukcję pewnego typu światopoglądu, oceny i zachowania. Uczenie się, zgodnie z paradygmatem nauczania przedmiotów ścisłych, jest konkretyzacją i interpretacją trwałych praktyk dyskursywnych społeczeństwa, a proces edukacyjny – interakcją w procesie wyznaczania zbiorowego sposobu definiowania i rozumienia zjawisk i procesów. W nauczaniu przedmiotów ścisłych postuluje się odrzucenie tradycyjnie utrwalonych praktyk akademickiego teoretyzowania oraz bezkrytycznego przyjęcia stanowiska autorytetu, gdyż zamiast tego następuje problematyzacja zasadniczego dyskursu.

Summary: The article presents the issues related to the science teaching paradigm, which extends the traditional understanding of the goal of education as an experience of humanity acquired through continuous progress and development. It has been proven that J. Dewey's pragmatic philosophy, like all contemporary epistemology, assumes that the cognitive goal of the processes of establishing and confirming meaning is

¹ Yuliia Aleksandrova, Department of Social Philosophy, Philosophy of Education and Education Policy, National Pedagogical Dragomanov University, 9 Pyrohova str., 010601 Kyiv, Ukraine, julia_aleksandr@ukr.net, <https://orcid.org/0000-0002-8135-3259>.

a valuable and pragmatic confrontation of the acquired knowledge. It follows that there are specific philosophical positions in the research process: subjectivism as an individual search for an innovative way to solve a problem, and objectivity, reflecting the de-personification of experimental procedures and methods, and consensus in this context means using a formalized language to publish the results. According to the principles of constructivism, the process of education itself should be treated as a construction of a certain type of worldview, evaluation, and behavior. Learning, in line with the science teaching paradigm, is the concretization and interpretation of society's enduring discursive practices. The educational process is an interaction in determining a collective way of defining and understanding phenomena and processes. In science education, it is postulated to reject the traditionally established practices of academic theorizing and adopt the position of authority uncritically. Instead, there is a problematization of the fundamental discourse.

Słowa kluczowe: nauka; naukowa edukacja; pragmatyzm; konstruktywizm; postmodernizm; badania; doświadczenie; eksperyment; komunikatywne społeczeństwo; dyskursywność.

Keywords: science; science education; pragmatism; constructivism; postmodernism; research; experience; experiment; communicative society; discursiveness.

Introduction

Thinkers from Antiquity to the contemporary have argued about the necessary connection between science and learning, about the relevance of scientific research in the educational process. As we know, Aristotle divided philosophy as a specific kind of knowledge into three parts, and the purpose of one of them is called knowledge for the sake of creativity. The author of "New Organon" F. Bacon, argued that students need to be taught scientific research methods so that knowledge is true, sound, and understandable. J.-J. Rousseau and J. A. Condorcet argued that education aims to master the experience of humankind on the path of endless progress and development. However, to what extent is it possible to transfer centuries of consolidated scientific experience in education simply? A large amount of information necessitates education reform, as the study of specific disciplines is difficult to call an effective education strategy (Czyż A., Svyrydenko D., 2019; Svyrydenko D., Yatsenko O., 2019). More pragmatic in today's world of intense change is the study and solution of specific problems, usually the subject of various sciences. Therefore, it allows us to understand and implement complex solutions. In this regard, it is fair to say that education is not about learning what happened but about preparing the younger generation for potential future threats.

The basis of science education is traditionally considered to be the correlation of the historical and cultural context of scientific theory and the

experimental nature of the acquired knowledge. Science education is the subject of enormous attention of researchers worldwide and the practical experience of this project (Dovgyi S., Nebrat V., Svyrydenko D., Babiichuk S., 2020). This situation is explained by the existing competition between different scientific theories in modern science and, accordingly, different ideologies and methodologies for implementing scientific research. The absence of a dominant theory or paradigm of scientific knowledge leads to significant support for science education within the popular currents of feminism, poststructuralism, and postcolonialism. Therefore, governments in liberal economies value science education as a valuable pedagogical innovation, especially in a total decline in interest in exact and technical sciences among potential applicants.

John Dewey's pragmatism as a source of science education

John Dewey's pragmatic research is traditionally considered to be the origins of the paradigm of science education. Understanding science as a complex system and education requires novelty and creativity – the author's pedagogical theory (Semetsky I., 2013). The pragmatism of educational techniques means that it is pointless to consider known and well-known scientific theories as artifacts in a museum. On the contrary, understanding the scientific approach as a dynamic system, the potential of which helps solve problems in a new context, in the face of unknown challenges, in unforeseen circumstances, is an argument for the truth of the theory and the effectiveness of educational practices. The creativity of science education is aimed at destroying habits, persistent stereotypes of thoughts and behavior. Accordingly, it is unreasonable to limit research interest to particular sciences: "Educational problems, like life problems, cannot be confined to the boundaries of single academic disciplines, not to mention the situation in which each academic discipline is plagued by conflicting schools of thought or even warring sects, whether within economics or psychology, sociology or political science, philosophy or history." (Tanner D., 2018, p. 86)

An essential mission of a teacher in science education is to maintain a balance between innovation and experimental confirmation of the result. J. Dewey considered science as a universal tool for ensuring a better future for humankind. His "organismic ontology" (Tomlinson S., 1997), based on the principle of adaptation.

Therefore, the specificity of the scientific method depends on the structure of a democratic society, which solves current problems. His theory of

human nature and the public good is far from a schematic and unambiguous technological approach but offers complex and fruitful arguments for the development of pedagogical practice.

Experience is one of the basic terms of J. Dewey's philosophy. It is difficult to deny that experience, both, personal and cultural, is a prerequisite for forming personal identity, evaluation algorithms, the content of daily practices, and ways of communication in society. Therefore, the author's conceptualization of experience and habit is helpful for modern theories of humanities knowledge. An epistemological understanding of the nature of experience underlies pedagogical theories about the benefits of intensifying bodily experiences (Thorburn M., 2020) and its effectiveness in achieving various educational goals, such as the dynamism and plasticity of conventional research algorithms. Accordingly, the high theoretical abstractions of J. Dewey's philosophy are confirmed and implemented in modern classrooms (Fackler A. K., 2020). Thus, the belief that society is righteous and stable in its development only if the unity of collective moral goals and individual freedoms leads to an understanding of the need to foster activity and independence of students, the need for joint discussion of problems, and ways to solve them. Therefore, it is reasonable to believe that increasing interest through active participation in learning is a direct attribution to civil society and developed democracy (Thorburn M., 2019). And let's take into account the dominance of the experimental method of teaching. Such pedagogical technology teaches responsibility for their actions, develops the desire to design and predict the results of activities, and in a broad context – forms moral principles to combat the shortcomings of unlimited capitalism. The last thesis in the context of science education means pragmatism in achieving success not only by those who already own capital but by all people without exception. J. Dewey sees a close connection between education and democracy: "Dewey recognized these as problems, and Democracy and Education makes it clear that democracy is the key to progress; it is impossible to create a science of education – or grow as people and as a society – without democracy. Just as Dewey warns that the "exceptional teacher" paradigm stands in the way of progress, so too does top-down, non-collaborative approaches to improving teaching. Teaching will not improve without the presence of a strong democracy." (Frank J., 2017, p. 5)

Democracy in this sense means freedom of thought, pluralism, and competition. Because science education reflects in the structure of their practices the specifics of scientific research, the effectiveness of which is impossible only within established theories and views. The teacher's special mission is to ensure that democracy is combined with scientific knowledge

(Martin M., 1974, p. 298). Therefore, it is fair to say that J. Dewey's philosophy is a dialogue between modernism and postmodernism (Gordon M., 2016), because his pedagogical theory combines modern optimism and postmodern freedom, belief in the existence of truth, and many possible ways to achieve it.

J. Dewey's pragmatism speaks to the need to build integrity. It is known that science education is a technique of teaching the disciplines of the natural cycle: physics, chemistry, biology. However, the idea of such a limited science education would be unfounded. The search for truth or a way to solve a problem is not purely rational. A practical solution is often based on arguments of expediency, harmony, sustainability, and beauty (Svirydenko D., Yatsenko O., Prudnikova O., 2019). Therefore, the pedagogical model focused on the education of transformative aesthetic experience (Pugh K. J., Girod M., 2007) combines rational-logical techniques of producing ideas from known concepts and theories with methods of aesthetic expression and emotional impact. In other words, science education presupposes its beauty, perfection, and emotional tension.

Like all modern epistemology, J. Dewey's pragmatic philosophy argues that the purpose of cognitive processes is not a classical understanding of truth as absolute and universal. Cognitive processes aim to establish and affirm the meaning or value-pragmatic focus of the acquired knowledge. Even more, the notion of indifferent truth, which is self-sufficient outside the axiological coordinates of definition, modern theories of cognition call a myth. Indeed, values as a concentration of meaning (causality and expediency) significantly influence decision-making not only in the field of public relations and personal life. In scientific practice, value-motivational attitudes also play a crucial role. On the one hand, this thesis is confirmed by precise regulation of science education practices: "Inquiry is central to science learning and a prominent feature of science education standards including National Science Education Standards (NRC, 1996), Inquiry and the National Science Education Standards (NRC, 2000), and Benchmarks for Science Literacy (AAAS, 1993) focus on scientific inquiry. A Framework for K-12 Science Education: Practices, Crosscutting Concepts and Core Ideas (NRC, 2012), and the Next Generation Science Standards (NGSS Lead States, 2013) also emphasize inquiry through "science and engineering practices" dimension. Meanwhile, decision-making is another important feature that has been emphasized in science education standards. 3". (Lee, E. A., Brown, M. J., 2016)

On the other hand, science education is a field of constant verification of known values, their assertion, and refutation, i.e., the key to social progress: "For Dewey, the primary goal of science education is to develop stu-

dents' ability to inquire as a habit of mind. Dewey's emphasis on scientific inquiry is similar to the emphasis made in Benchmarks for Science Literacy (AAAS, 1993), National Science Education Standards (NRC, 1996), and A Framework for K-12 Science Education: Practices, Crosscutting Concepts and Core Ideas (NRC, 2012). 4". (Lee, E. A., Brown, M. J., 2016)

Given the problem of values, the purpose of science education is the formation of scientific literacy, i.e., openness of research interest and the ability to make effective decisions based on ethical and axiological principles. This is the interpretation of J. Dewey's assertion that science should focus on what we should do, not just how we will do it (Dewey, 1910/1995). Reflections on the direction of scientific research indicate the value motivation of the research, and accordingly, science is a practice due to established values in society. The most objective or "pure" scientific research is valuable in terms of value, as it aims to form correct evaluative judgments. And it's not even a matter of a particular ideology, religion, or worldview. The powerful influence of science explains this fact on society and nature in a broad sense.

The public demand for the development of science can no longer be carried out chaotically and unpredictably. On the contrary, the specifics of their interaction are subject to strategic planning and education: "A science education program is incomplete if it neglects any of the following: a concern for scientific knowledge (certain facts, principles and theories are worth knowing), a concern for the processes and methods of science (reasoning and investigating), direct experience of scientific activity, appreciation of the complex relationships between science and society and the fostering of positive attitudes towards science." (Hodson D., 1985: 26)

We consider the latter to be the most convincing and realistic. Even more, in a way, all these individual philosophical positions take place in the research process. The subjectivism of scientific research consists of the individual search for an innovative way to solve a problem. Objectivism is embodied in the de-personified procedures of the experimental method, and the consensus stage means the use of the formalized language of science to publish the results. In other words, science education is an organic combination of irreconcilable philosophical oppositions.

In the set of tasks solved using science education, the following should be considered especially indicative: mastering of factual knowledge and its critical analysis; use of theoretical knowledge to explain phenomena and processes, predict further development; generation and verification of hypotheses; planning and conducting experiments; an integrated approach to solving scientific problems.

A science education teacher needs to be part of the “research community” and be competent in solving non-standard problems and situations (Burgh G., Nichols K., 2012). Therefore, it is appropriate to say that science education involves using an arsenal of philosophical research methods. In the context of the affirmation and dissemination of European values, science education is supported at the highest level of the EU institution. Thus, the philosophical intentions of J. Dewey’s pragmatism have gained recognition not only among the scientists but also among the bureaucracy at the highest world level.

Constructivism: from radicalism to social conditioning

The philosophical current of constructivism is traditionally considered the dominant paradigm or research program of science education. This opinion is quite justified because constructivism means the fundamental complexity of the phenomenon, process, problem, theory, man, society, and world. Constructivism emphasizes the fundamental possibility of both knowledge of the world and its transformation. This philosophy is also characterized by the rejection of the universality of truth in favor of a pragmatic measure of its effectiveness. Constructivism means emphasizing causation in a multicomponent world. On the one hand, such a strategy of “knowledge in parts” embodies the Cartesian principles of cognition and provides the necessary space for free and independent research. Constructivism as a worldview basis of science education gives the required legitimacy to alternative ways of thinking of students. The classical ideal of education, in the course of which ignorance is replaced by abstract and universal knowledge, in modern philosophy of science and pedagogy is replaced by the priority of the expediency of knowledge, its understanding, and application (Terepyshchy S., Khomenko H., 2019).

Thus, science education means studying natural sciences by non-scientists: schoolchildren, students, various people. Science education mainly focuses on biology, physics, and chemistry, and the primary method is experimental proof. However, science education is not limited to natural sciences. It includes the methodology of cognitive and social sciences, pedagogical technologies, competencies of logical thinking, and argumentation theory. Under the influence of the philosophy of constructivism, the idea of the teacher’s mission in science education changes: to promote the formation of students’ fundamental principles of scientific thinking, to develop activity and independence of thought and behavior, the importance of the initiative, and responsibility for performance.

Consider in more detail the philosophical explications of constructivism in the paradigm of science education. Peter Slezak defines the range of basic ideas and key principles as follows: “However, the range of philosophical issues raised in the constructivist literature includes abstruse questions whose relevance to practical or theoretical problem in education has been questioned. Thus, among the topics discussed include Berkeleyan idealism, Cartesian dualism, Kantian constructivism, Popperian falsification ability, Kuhnian incommensurability, Quinean underdetermination, truth, relativism, instrumentalism, rationalism, and empiricism, *inter alia*.” (Slezak P., 2014: 1024)

In other words, science education is interested in the truth in its various interpretations and the methodology of its achievement and justification.

The consequences of Berkeley’s subjectivist views are the belief in the special status of knowledge, their unique nature, and mode of functioning. The idea of an objective and independent world of human consciousness is a trap from which world philosophy has sought to find a way out for centuries. Constructivism positions the world as a certain speculative construction formed by the activity of human cognition in the course of the combinatorics of a set of phenomenological experiences. Therefore, skepticism about the existence of the world around us, the adequacy of cognitive procedures, the value of the socio-cultural background is the baggage that can not be translated into pedagogical practice. But there are positive points in the skeptical attitude to knowledge. As we remember, D. Hume’s absolute skepticism woke Kant from a dogmatic dream. And in didactic instructions, skepticism is needed because of doubts and questions that it is possible not just to master information but also to understand and know.

Suppose the world as a whole is a speculative construction or a system of orderly chaos of sensations. In that case, the process of education itself should be considered as the construction of a certain type of worldview, evaluation, and behavior. Such a line of philosophy of education is proposed by I. Kant, who considered education not a transfer of theoretical material, but a process of building (*Bildung*) a person, the development of inherent abilities and talents. In other words, design is the only universal way of human interaction with the world: both social and natural – the material for such combinatorics or design experiences, both personal and collective. The specificity of science education is that the coordinator of such combinatorics or design is a teacher. The teacher has the role of supporting, stimulating, and evaluating the research of students. Therefore, the subject of observation in this case is:

- 1) the behavior of students at the stage of acquaintance with the problem, when the algorithm for its solution is still unknown;

2) activity and degree of understanding of acceptable and effective ways to solve the problem, which becomes evident during the collective discussion;

3) awareness and persuasiveness of students at the stage of presentation of research results.

Empiricism as a critical principle of constructive philosophical research expands the concept of experience. For this epistemological setting, experience is a collectively acquired kind of knowledge, and learning is a process of understanding this experience in a particular situation. The uncertainty inherent in learning requires the creative application of collective experience or previously accumulated knowledge. Thus, theoretical abstractions acquire the necessary expressiveness, persuasiveness, and internalization into individual experience. In essence, learning is the concretization and interpretation of sustainable discursive practices of society, and the educational process is an interaction in the process of assigning such a collective way of defining and understanding phenomena and processes (Petrenko I., Filipchuk V., 2020).

According to the axioms of social constructivism, the discourse of scientific theory is built according to the mental construction of a particular community, i.e., implicitly contains stable principles and attitudes of perception and evaluation of reality. Rational-logical tools of knowledge substantiation play a purely auxiliary role, namely the function of establishing cause-and-effect relationships. And in this context, education in general and science education in particular, there is reason to consider the practice of the hermeneutic circle, ideological and manipulative in nature of its influence. In this context, any cognitive procedure is a desire to find a new algorithm for solving the problem, which corresponds to a lasting public consensus. Undoubtedly, such a logic of substantiation of scientific research contradicts the traditions of Western epistemology and threatens absolute relativism. Naturally, in this context, the problem of demarcation of knowledge, a clear distinction between the scientific and non-scientific way of knowing the world, is particularly acute. At the same time, the problem of knowledge assessment acquires special significance; the need for its verification and falsification in the methodological sense becomes obvious. It is appropriate to consider science education as a total struggle against relativism. The only effective tool for overcoming it is the localization of the problem field, critical analysis of possible solutions by the communicative community, and empirical verification, i.e., reproducibility of the problem result. In other words, the algorithm for overcoming relativism is the basis of the methodology of science education.

Note that relativism is inherent in certain stages of science education, namely at the stage of discussion and competition of various proposals to solve the problem. Relativism as the embodiment of philosophical doubt (in the traditions of J. Berkeley, D. Hume, R. Descartes) is a necessary component of the movement from chaos to order, from uncertainty to construction. Without the application of relativity, it is impossible to reveal the descriptive and interpretive potential of scientific theory. Moreover, an indication of the social nature of scientific theories does not imply their erroneous status. On the contrary, this way of substantiating the discursiveness of scientific practices testifies to their socio-historical approbation, to the effectiveness and demand of society. Based on completeness, consistency, and simplicity, the rationalism of scientific theories expresses the internal coherence of arguments and judgments. The noumenal reality, or reality “as such,” is not revealed by scientific theories. And such recognition is a just and conscious rejection of the utopian nature of absolute truth.

If absolute truth is unattainable, then what should be the strategy of operations with relative truth? After all, any scientific theory is an example of such a relative truth. Accordingly, we return to the problem of combinatorics of scientific research tools and the problem of choosing among equivalent and available alternatives to scientific knowledge. And the question also remains unresolved: does the scientific theory describe a phenomenon, or does it provide the necessary model for its interpretation?

Constructivism encourages the availability of alternative choices in attempts to solve problems scientifically. Positioning each fact of reality as constructed in a certain way (both in the sense of formation and in the sense of understanding), constructivism insists on the fundamental cognition of world phenomena, the possibility of their rethinking, and innovative use.

Thus, both radical and social constructivism provide a productive basis for science education. Applying these philosophical principles in pedagogical practice allows achieving a dual goal of learning: mastering socio-cultural experience in the form of ready scientific knowledge and developing critical, analytical, and independent thinking of students in connection with the inherent currents of relativism. There is a distinction between abstract and concrete, general and personal, rational-logical and experimental, meaningful and situational in science education. Learning in such a context is a procedure for establishing such a demarcation, distinguishing between truth and error, facts and illusions, beneficial and harmful.

Postmodernism as a relativistic strategy of cognition

The assertion of relativism inherent in science education logically presupposes an analysis of postmodernist theses in substantiating the paradigm of such a didactic approach. Rhizomatic configurations of modern science (Gough N., 2006), inspired by the philosophy of J. Deleuze and F. Guattari, significantly destabilize the classical tree-like concepts of Western science, the idea of orderly, stable, hierarchical nature of knowledge of the world, a reliable and absolute foundation for the procedure. In science education, the rejection of traditional settled practices of academic theorizing, authority, and a priori domination is postulated. Instead, the problematization of the dominant discourse is carried out, such as the mechanics of I. Newton. And the world around us is understood not as a substantial but as a harmful variable complex of hybrid connections and relations. According to this orientation, some positivist arguments about the essence of science and educational practices are assessed as outdated and biased (Burbules N.C., Linn M.C., 1991). The traditional dualism of the classical theory of cognition is proclaimed by postmodernism as irrelevant and needs to be overcome intellectually (Zembylas M., 2006). Accordingly, science education goals and methods are often based on outdated notions of scientific knowledge, ways to prove and modify the theory. The revolutionary nature of science education in the practical dimension is often a sham, an imitation of free research. At least, each student must be evaluated by the teacher for the work in the lesson, its level, quality, and effectiveness.

This dimension of science education through the prism of ethics is not unique. A more critical perspective of science education is forming an ethical view of the world as Other, a subject and partner of communication. Extrapolation of the face of the Other to the non-human world (Blades D.W., 2006) envisages as the goal of the pedagogical process interaction with the world based on openness to its requirements and principles. Therefore, we consider it fair to say that science education is the implementation of the ethics of responsibility in forming the experience of such a model, the implementation of which will save the world for future generations.

Thus, investment in science education is justified not only in terms of the knowledge economy, modern medicine, and the agricultural sector. Without the professional training of technical specialists, it is impossible to protect humanity from disease, provide food and paid work (Mackenzie J., 2014). Adherents of postmodernism claim that the common opinion that rational science belongs to Western European culture is wrong. Every culture projects its samples of scientific, i.e., evidence-based and sound devel-

opment of the world. And even if the discursive practices of different cultures do not match in the context of their thesaurus or methodology, it is not a sufficient basis for determining the non-scientific status of knowledge.

The natural metaphors of postmodernism challenge a standard scientific view on the world. Unlike the Enlightenment, with its optimism, universalism, critical mind, and belief in progress, postmodernism is a philosophy of pessimism, and therefore of personal responsibility; local truths, i.e., personal beliefs and values, a cynical mind that understands the future as a project and the result of human activity.

For the project to be positive and viable, it is necessary to consolidate collective efforts through dialogue in a real communicative community, including the scientific one. Within the framework of science education, such communication can be presented as an integrative course of different disciplines, implementation of joint school projects, organization and implementation, which will provide acquaintance with worldview, values, motivations, and principles of behavior of different people, different social age, professional level. This discussion format of existing practices in science is significant for an adequate understanding of social, political, and ethical issues of current socio-culture.

Conclusions

The paradigm of science education is based on the principles of the philosophy of pragmatism, constructivism, and postmodernism. The evolution of scientific knowledge in the history of world culture is closely linked to educational practices. The modern knowledge society needs to intensify scientific research and increase mentioned practices' effectiveness. Technologies are evolving and being implemented in everyday life extremely fast. And the social demand in this regard seems to have no limits. The intensity of this demand is so impressive that the revolutionary concepts of the philosophy of science and knowledge in general even look like certain anachronisms compared to modern theories.

The general logic of the development of science and science education is direct proof of the crucial role of communication, coherence, and collective effort in the efficiency and effectiveness of scientific research. Of course, the resources involved in science education and actual scientific research differ significantly: institutional, instrumental, intellectual, professional, material, economic, and so on. However, it will be reasonable to state a specific genetic link in the nature and strategies of scientific re-

search between professional scientists and students who are learning and developing in the course of their approbation and implementation of the acquired experience. In other words, the set of cognitive and methodological resources involved in research processes increases significantly due to implementing science education principles. But the expected result of science education should be considered a new generation, which will no longer form a knowledge society, but a research society.

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