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D. B. Svyrydenko,
F. H. Revin

PROJECT 2061 AND OTHER SCIENTIFIC LITERACY INITIATIVES: OVERSEAS LESSONS FOR UKRAINIAN SCIENCE EDUCATORS

Abstract. *A rapidly growing number of nations presently strive for the active development of competitive knowledge-based economy, making the issue of achieving science literacy one of the crucial global priorities. Acknowledgment of the role of scientific enterprise in the ideological, political, economic, social, and educational context has led to a rapid increase of attention this problem receives from specialists in various disciplines. Drawing on foreign experience, the authors of this article put before them the task of reviewing Project 2061 initiated by the American Association for the Advancement of Science (AAAS) viewed as a promising approach to tackling the diminishing levels of science education both in our country and abroad. At the same time, we are interested in analyzing the underlying reasons that dictate the need to increase the scientific literacy of students representing various programs as they experience the effects of global technological advancement. The polydisciplinary nature of the natural sciences is yet another cardinal point of our current research since (when fully utilized) it allows one to approach study phenomena from all sides, thereby, forming a holistic picture of the world. As an international program aimed at assessing the academic achievements of schoolchildren PISA (Program for International Student Assessment) is based on precisely this kind of fruitful interdisciplinary method, whereby researchers gauge the level of the reading, mathematical, and natural scientific literacy of children. Serving as an effective evaluation tool, the PISA initiative not only helps estimate the volume of readily accessible knowledge but also measures the ability of learners to process information by utilizing scientific and critical thinking methods, dissect it and draw conclusions. Accordingly, it is our conviction that these academic benchmarking tools are invaluable for the modern generation of students worldwide as simple memorization and reproduction of information are on the cusp of being outperformed by the growing artificial intelligence industry which is able to provide more efficient alternatives for these simple mechanical knowledge acquisition skills. Consequently, if human intellectual development is swiftly reaching its bifurcation point we need to rely on ways of generating novel modes of thinking and problem-solving by taking into account consummate teaching methodologies that have the potential to serve as sure guidlines to increased global and national scientific progress and social wellbeing.*

Keywords: *academic standards, benchmarking, curriculum development, interactive learning, multidimetional approach, science education, scientific literacy.*

Clarifying the issue. In its 2016 edition, the famous Oxford Dictionary chose the term "post-truth" as the word of the year. Simply put, this entails living in a society for which objective facts are less important than personal emotional attachments and biases. This creates fertile soil for the spread of misinformation and the emergence of pseudoscientific accounts and theories. Viewed as an effective countermeasure, widespread propagation of science literacy helps combat such persistent superstitions as the flat earth theory, racial superiority, alternative history, medical speculation (COVID-19 antivaccination movement as the most recent example), etc. To a large degree, all of the aforementioned distorted (and often harmful) ways of perceiving reality are a direct result of the methods that are employed when imparting scientific knowledge as isolated, fragmentary facts bearing little to nothing on how things function in the real world. The cardinal prerequisites for the present surge of interest that the issue of developing a scientifically literate society receives are manifold. For one, social strategists engaged in ideological maneuvering view scientific literacy as an important tool for the formation of a person's worldview, shaping the system of their ideas about the environment, which in turn results in cultivating favorable conditions for the stimulation of rational perception and understanding of innovations echoing our modern agenda-driven, technocratic Zeitgeist [1].

Scientific literacy, likewise, creates the basis for the development of an inclusive political discourse able to (re)orient the existing power structures towards adopting effective, scientifically, and socially informed courses of action that reflect global challenges. This ensures the growth of economic development indicators, which, in turn, serve as precursors of the possibility of (inter)national sustainable growth in the global system of the worldwide trade and labor market. In other words, an educated approach to political and economic matters promotes favorable human socialization, brings about social synergy, and fosters successful behavioral strategies, thereby reinforcing the spread and strength of social ties and capital [2, p. 1350].

The goal of this article is in providing a theoretical substantiation of the notion of scientific literacy primarily exemplified by the aims of Project 2061 which focuses on providing long-term educational guidelines and mechanisms for achieving a significant paradigmatic shift in acquiring scientific competencies and learning skills among U. S. students. At the same time, the authors view the **task of the present research** in familiarizing Ukrainian policymakers and educators with specific tools such as Benchmarks for Science Literacy that have emerged both within and alternatively (the PISA initiative) outside the purview of Project 2061 as an effective means to supplement and enhance the efforts of these ambitious endeavors in the field of science education.

Research Presentation. The first post-war attempts at reforming scientific education in the United States were primarily guided by a number of outside influences such as the initial Soviet dominance in space (the launch of the Sputnik satellite in 1957), the beginning of the swift Asian economic and technological rise in the 1970s as well a host of internal factors prompting a complete overhauling of the American education system. All of this led to a shift in the teaching mentality (reflecting the idea that a high percentage of the scientifically literate, educated general public leads to tangible increases in economic and social development) regarding how educators should present scientific disciplines taking place in the late 1980s. These accumulated developments finally culminated in 1989 resulting in the publication by the American Association for the Advancement of Science (AAAS) of "Project 2061: Science for All Americans" followed by "Benchmarks for Science Literacy" (1993) both of which provided a way to further expand and measure previously elaborated ideas and guidelines in regards to the teaching of scientific disciplines [3].

Conceived as early as 1985 (right at the time when Halley's Comet was passing through our solar system) Project 2061 prompted the American academic community to try and envisage the kind of teaching methodology that would be prevalent at the time of its next cyclic return in 2061. In the words of F. James Rutherford, the goal of Project 2061 was to bring about major changes in pre-college science, mathematics, and technology education in the United States: highlighting what needs to be learned, how this can best be achieved, and, most importantly, how to convert these recommendations into practical programs that would benefit U. S. students. This suggested a growing need for working out a new school curriculum design that would allow students to get an understanding and systematically investigate a consolidated body of knowledge as opposed to looking at the world through the narrow lens of separate subject-oriented disciplines [4, p. 28]. While not denying the role of learning through the accumulation of factual information, Project 2061, nonetheless, suggests that a truly progressive emphasis of science education should be towards devising and implementing interactive modes of knowledge formation. The paramount thrust of the initiative is, therefore, in underscoring the advantages of facilitating a learning environment that helps crystalize critical thinking skills in contrast to regurgitating textbook

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contents and bits of scientific trivia as a reflection of the evolving paradigm of the more interactive doing and learning of science.

Among many similar prescriptions, our research into the documents comprising Project 2061 revealed numerous mentioning of the fact that the crux of its effectiveness hinges on the need to reorient and retrain teachers by updating their methodology in accordance with the latest social requirements and the growing demands of the labor market. The fundamental premise of these initiatives is that the focus of science education should be placed on quality rather than quantity, whereby instead of overloading students with fact-based science curriculum, instructors ought to be able to impart essential features of acquiring a scientifically-minded outlook while equipping them with a socially-relevant, flexible problem-solving toolset [3; 4]. In this regard, specific suggestions were made concerning the elimination of an overly abundant amount of material covered which was identified as a principal downside to improving the learning process. Another principal recommendation had to do with narrowing the subject matter boundaries resulting in tighter links between science, mathematics, and technology approached as a single interconnected enterprise of getting a balanced theoretical and practical grip on the world around us.

Having been crystallized as a result of several years of discussion and study by various advisory boards and scientific panels, the primary concern of the project was to provide an alternative critical perspective in regards to the nature of science education that should be taught. The initiative principally centered around six major guidelines. Apart from the already mentioned tenets like a core emphasis on the quality (over quantity) of the material covered in class, Project 2061 is geared towards providing the highest possible level of inclusivity engaging all manner of students regardless of their age, grade and/or study subject (area of future specialization). A related crucial point addressed by the 2061 vision presupposes a successful inculcation of a life-long learning attitude that has more to do with the ability to form and refine general academic habits than knowing the ins-and-outs of a particular discipline [5, p. 513]. Educational egalitarianism is yet another principal precept promoted by Project 2061 which, we believe, has significance not just for the American learning institutions, but bears important implications for global and Ukrainian education systems. Hence, through fostering equality in science education, the goals proclaimed in the document prescribe that all students should be given access to knowledge on a fair basis, irrespective of their race, ethnicity, gender, cultural associations, physical limitations, and economic circumstances.

The latter becomes an especially poignant subject matter if one considers a widespread negative global trend whereby elite educational establishments (private schools, Ivy League colleges, prestigious universities) enjoy the benefits of being able to draw the best students due to a disproportionate allocation of reputational, promotional and financial resources. All these aspects must be taken into account when designing and implementing an effective study program. At the same time, a common set of learning goals need not necessarily dictate uniform curricula, teaching methods, or materials, since multi-directional variety is, likewise, proclaimed as one of the chief guiding principles of Project 2061 [6, p. 242]. Accordingly, the particular benchmarks that each educational establishment puts forth do not in any way limit how curriculums should be formulated and instruction imparted, but rather simply outline the full scope of knowledge and skills that science-literate individuals should have at their disposal by the time they finish school.

Serving as a complementary assessment tool within the Project 2061 framework Benchmarks for Science Literacy outline what all students should know to be able to engage in successful science-based inquiry coupled with possessing mathematical and technical competencies by the end of grades 2, 5, 8, and 12. The recommendations provided at each grade level tie directly into the suggested levels of academic progress students are required to demonstrate on the way to attaining their science literacy goals. As a productive result of many years of collaborative exchange between Project 2061 staff and teachers at six School-District Centers, Benchmarks for Science Literacy provided educators with a number of sequentially divided specific learning objectives that helped better define and flesh out the design of a core curriculum [3, p. 44].

Thoroughly put together with regard to the needs and demands of a concrete learning environment Benchmarks aid students in achieving the basic science literacy goals previously outlined in Science for All Americans. As such it does not call for the implementation of a particular teaching methodology or require adopting a specific curriculum design. Even less attention is given to specifying performance targets, instead, drawing a line at outlining the knowledge and skills that students are expected to acquire on the way to becoming productive, critical thinking members of society. In particular, the Benchmarks initiative concentrates on a common learning program that contributes to the gaining of science literacy by all students acknowledging that many of them possess academic abilities and preferences outside the purview of the common curriculum core, while an even more significant number experience learning difficulties that must be considered, mitigated and ultimately overcome [7, p. 29].

Again, seeing how the two programs are mutually supplementary the Benchmarks initiative encourages teachers to incorporate the links between various scientific and science-related disciplines into their potential curricula framing its recommendations in plain, generally accessible terms so that a student's ability to utilize scientific vocabulary is not mistaken for the acquisition of profound conceptual understanding. Finally, as part of an ongoing Project 61 reform Benchmarks for Scientific Literacy (as just one in a family of other variegated tools) should not be regarded as the final say on all matters pertaining to science literacy assessment, but should instead be perceived as a basic outline that permits (in fact, welcomes) revision in light of the constantly evolving field of science education.

1997 saw the establishment of the PISA (Programme for International Student Assessment) initiative. The goal of this broad undertaking initiated by OSCD (Organisation for Economic Co-operation and Development) reflected the desire of the founding member countries to be able to better evaluate the effectiveness of national education systems by measuring the results of 15-year-old students in three categories (reading and interpretation, mathematics, and the natural sciences) viewed as crucial for the formation of educated adult citizens. Taking place every three years since 2000, the 2006 PISA evaluation round is of particular interest in relation to the goals of our research as it primarily focused on providing an adequate account of the level of scientific literacy among pre-university teens [8, p. 877].

Having said that, our investigation leads us to believe that in 2006 PISA approached measuring scientific literacy rather tangentially by primarily assessing the student's capacity to identify scientific issues, whereas the 2015 evaluation, added a layer of scrutiny supplanting the previous mostly descriptive requirements with the need to develop and evaluate scientific inquiry models. In particular, by effectively mixing epistemic and procedural knowledge acquisition techniques the PISA initiative managed to arrive at a more in-depth understanding of the student performance related to each of the three major competencies: providing a scientific explanation for everyday phenomena, critical interpretation, and scientific scrutiny of received information, designing models of scientific inquiry and data analysis.

The format of the 2015 PISA also changed from a previously paper-based assessment reflecting the rapid development of a wide range of ICT instruments and infrastructures whereby computerized modes of evaluation afforded the possibility to closely follow student progress, employ digital scientific inquiry approaches, interact with simulations and/or conduct all manner of technology-based studies and experiments [9, p. 84]. Accordingly, presently PISA can boast of being at the forefront of the international academic assessment community, to a large degree, due to the test's ability to take advantage of the latest technological tools for the evaluation of the level of science education.

Thus, we can clearly see that an interdisciplinary approach to the study of natural sciences becomes a dominant trend in the architecture of the education systems in a growing number of different countries. Such polydisciplination apparent in the way we survey the impact of natural sciences on the school curriculum, to our mind, is fully justified since it allows students to investigate the phenomenon from all sides and form a holistic picture of the world. PISA is based on precisely this kind of an interdisciplinary approach since the tasks for the assessment of the natural sciences section are divided into three blocks: live systems, physical systems, earth, and space systems. To successfully solve them, demonstration of scientific expertise is required on several levels at once, whereby knowledge of biology and ecology must be combined with an understanding of astronomy and a grounding in physics [10, p. 4].

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The PISA initiative, therefore, echoes many of the points previously stated as cementing the principal guidelines of Project 2061. In particular, what the OECD pursues with this kind of assessment is measuring not just the knowledge acquisition rates and capabilities, but also probing the ability of students to work with data through utilizing scientific (critical) thinking methods, analyze it and draw conclusions. Simple memorization and retransmission of information are quickly becoming meaningless representing an obsolete skill easily reproduced and outperformed by the growing artificial intelligence industry which is able to provide more efficient alternatives for these simple algorithmic knowledge accumulation operations [11].

In light of the different models of scientific literacy presented above, we would like to conclude our review by briefly scrutinizing one more approach. Based on the definition proposed by UNESCO in 1993, literacy is defined as the ability to identify, understand, interpret, create, communicate and measure using printed, written, and visual materials associated with different contexts [12]. As becomes evident from a rather extended list of competencies above, literacy (scientific one included) involves a considerable degree of training required to equip a person with a set of skills necessary to achieve goals and develop their intellectual potential by becoming an active participant in social activities and processes [10]. Of special interest is the acronym GSL (Global Scientific Literacy) found throughout similar UNESCO literature, which involves the reorientation of pedagogical activity in the direction of sustainable personal development. When approached from this angle, scientific literacy is understood as developing the ability to use knowledge attained by means of scientific analysis which creatively employs critical deliberation in everyday contexts to solve problems, make educated decisions and arrive at scientifically-informed choices often relating to various global issues [13].

Combined with "global education", UNESCO take on (science) literacy seeks to widen the intellectual horizons of young people by fostering a wider perspective among students, namely, promoting understanding of the way our planet functions and is influenced ecologically, facilitating intercultural awareness, cultivating knowledge of global social and economic processes and dynamics, as well as demonstrating how our personal choices are impacting all of the above as inseparate links in a chain of worldwide transformation [14]. With the international academic community rapidly acknowledging the role of knowledge attained through the means of natural science, civil scientific literacy is equally on the rise, helping a growing number of consumers to better understand mundane phenomena while competently utilizing everyday modern conveniences, whether it is a microwave or cloud storage service.

The value of the skills characteristic of the scientific process, namely, the ability to think critically, put forward hypotheses, analyze information, compare facts, arrive at logical conclusions, is increasingly gaining momentum as a competitive advantage in the life of ordinary laymen. As a result, scientific literacy has garnered significant support in the job market sphere where companies prefer to hire employees with a firmer grasp on the latest technological paradigm and competent manipulation of the cutting-edge technical know-how.

Conclusions. The notion of "scientific literacy" has long ceased to be characterized by the emphasis on the importance of acquiring the basic level of knowledge and skills in writing, reading, and performing mathematical operations. Literacy nowadays is defined as a fundamental basis for the possession of continuously evolving competencies, technical and technological savviness necessary to make informed, effective decisions in personal, professional, and social life. The development of literacy, in particular, the scientific kind, reflects the stated goals of the consolidated global community to safeguard and improve the conditions of societal and environmental coexistence, foster its preservation, promote the establishment of harmonious relations between cultures and countries. It is precisely these efforts and policies of the scientifically literate citizenry that are crucial in overcoming the pressing issues which regrettably continue to plague third (and some first) world countries like famine, military unrest, environmental pollution, and degradation, in their quest for raising the standards of living and providing for an adequate model of worldwide sustainable development.

The cornerstone block at the heart of effective scientific literacy curricula manifests itself through the development of proper, impartial, and coherent evaluation methodology. As a consummate result of many years of collaborative exchange between Project 2061 staff and the wider American academic community, Benchmarks for Science Literacy equipped educators with a number of sequentially divided specific learning guidelines that helped better define and flesh out the design of a core curriculum. A similar undertaking holds promise in the form of the PISA initiative launched by the OECD, many finer aspects of which, in our opinion, still require further detailed scrutiny and thorough analysis.

Overall, the significance of the NOS component in the structure of science education will depend on the breadth of vision underlying a particular teaching agenda. Indeed, the principal governing considerations informing the way teacher educators are trained in colleges and universities (not just in the U. S.) will need to be revamped in order to adjust to the novel curricula modes and models of instruction, ultimately bringing about a wholesale restructuring of the school system. Lastly, reiterating what the outline of the 2061 initiative briefly sketched, the major groundbreaking educational novelty that it pursues lies in treating scientific literacy (mathematics, science, and technology) as a revolutionizing instrument called upon to form a unified learning core solidifying the ties between the natural and the social sciences.

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Д. Б. Свириденко,
Ф. Г. Ревін

ПРОЄКТ 2061 ТА ІНШІ ІНІЦІАТИВИ З НАУКОВОЇ ГРАМОТНОСТІ: ЗАРУБІЖНІ УРОКИ ДЛЯ УКРАЇНСЬКИХ ВИКЛАДАЧІВ ПРИРОДНИЧО-НАУКОВИХ ДИСЦИПЛІН

Анотація. *Стрімке зростання кількості країн, що прагнуть до активного розвитку конкурентоспроможної економіки, яка ґрунтується на інтелектуальному потенціалі, робить досягнення наукової грамотності одним із найважливіших глобальних пріоритетів. Визнання важливості ролі наукового підходу в ідеологічному, політичному, економічному, соціальному та освітньому контекстах зумовило посилену увагу фахівців з різних дисциплін до цього феномену. Звертаючись до закордонного досвіду, автори статті ставлять перед собою завдання ознайомчого огляду Проєкту 2061, ініційованого Американською асоціацією сприяння розвитку науки (AAAS), який розглядається як перспективний підхід до вирішення проблеми занепаду рівня наукової освіти як у нашій країні, так і за кордоном. Водночас ми зацікавлені в аналізі основних причин, що диктують необхідність підвищення рівня наукової грамотності учнів, які представляють різні академічні програми, у процесі впливу на них різних факторів глобального технологічного прогресу. Полідисциплінарний характер природничих наук — це ще один вкрай важливий аспект нашого поточного дослідження, оскільки (будучи повноцінно реалізованим) він надає можливість підходити до вивчення явищ з усіх боків, формуючи таким чином цілісну картину світу. Як міжнародна програма, спрямована на оцінку академічних досягнень учнів, PISA (Програма міжнародного оцінювання учнів) ґрунтується саме на такому плідному синтезі міждисциплінарного методу, за допомогою якого дослідники оцінюють рівень читання, математичної та природничо-наукової грамотності студентів. Слугуючи ефективним інструментом оцінювання, ініціатива PISA не тільки допомагає виміряти обсяг доступних знань, а й діагностує здатність учнів обробляти інформацію, використовуючи наукові та критичні методи мислення, аналізувати її і робити висновки. Відповідно, ми переконані, що такі наукові інструменти порівняльного аналізу незамінні для сучасного покоління учнів (студентів) у всьому світі, оскільки просте запам'ятовування і відтворення інформації перебуває на межі повного нівелювання, програючи індустрії штучного інтелекту, яка бурхливо розвивається і здатна запропонувати більш ефективні альтернативи примітивним механічним навичкам отримання знань. Отже, якщо людський інтелектуальний розвиток швидко досягає точки біфуркації, ми повинні покладатися на створення нових моделей мислення і розв'язання проблем, з урахуванням успішної методології навчання, що має потенціал бути орієнтиром щодо підвищення рівня глобального і національного наукового прогресу та соціального добробуту.*

Ключові слова: *академічні стандарти, бенчмаркінг, розвиток навчальних планів, інтерактивне навчання, багатопрофільний підхід, наукова освіта, наукова грамотність.*

Д. Б. Свириденко,
Ф. Г. Ревин

ПРОЕКТ 2061 И ДРУГИЕ ИНИЦИАТИВЫ ПО НАУЧНОЙ ГРАМОТНОСТИ: ЗАРУБЕЖНЫЕ УРОКИ ДЛЯ УКРАИНСКИХ ПРЕПОДАВАТЕЛЕЙ ЕСТЕСТВЕННОНАУЧНЫХ ДИСЦИПЛИН

Аннотация. *Стремительно растущее число стран, активно развивающих конкурентоспособную экономику, основанную на интеллектуальном потенциале, делает достижение научной грамотности одним из важнейших глобальных приоритетов. Признание важности роли научного подхода в идеологическом, политическом, экономическом, социальном и образовательном контекстах привело к увеличению внимания специалистов в различных дисциплинах к этому феномену. Черпая из зарубежного опыта, авторы статьи поставили перед собой задачу ознакомительного обзора Проекта 2061, инициированного Американской ассоциацией содействия развитию науки (AAAS), который рассматривается как перспективный подход к решению проблемы упадка уровня научного образования как в нашей стране, так и за рубежом. Вместе с тем мы заинтересованы в анализе основных причин, диктующих необходимость повышения уровня научной грамотности учащихся, представляющих различные академические программы, в процессе воздействия на них различных факторов глобального технологического прогресса. Полидисциплинарный характер естественных наук — это еще один крайне важный аспект нашего текущего исследования, поскольку (будучи полноценно реализованным) он позволяет подходить к изучению явлений со всех сторон, формируя, тем самым, целостную картину мира. Как международная программа, направленная на оценку академических достижений учащихся, PISA (Программа международной студенческой оценки) базируется именно на таком плодотворном синтезе междисциплинарного метода, с помощью которого* *исследователи оценивают уровень чтения, математической и естественнонаучной грамотности студентов. Служа эффективным инструментом оценки, инициатива PISA не только помогает измерить объем доступных знаний, но и диагностирует способности учащихся обрабатывать информацию, используя научные и критические методы мышления, анализировать ее и делать выводы. Соответственно, мы убеждены, что подобные научные инструменты сравнительного анализа незаменимы для современного поколения учеников (студентов) во всем мире, поскольку простое запоминание и воспроизведение информации находятся на грани того, чтобы быть полностью нивелированными, проигрывая бурно развивающейся индустрии искусственного интеллекта, которая способна предложить более эффективные альтернативы простым механическим навыкам получения знаний. Следовательно, если человеческое интеллектуальное развитие быстро достигает точки бифуркации, мы должны полагаться на создание новых моделей мышления и решения проблем, с учетом успешной методологии обучения, у которой есть потенциал быть ориентиром по увеличению уровня глобального и национального научного прогресса и социального благосостояния.*

Ключевые слова: *академические стандарты, бенчмаркинг, развитие учебных планов, интерактивное обучение, многопрофильный подход, научное образование, научная грамотность.*

INFORMATION ABOUT THE AUTHORS

Svyrydenko D. B. — Doctor of Philosophical Sciences, Professor Chairman of the UNESCO Chair on Science Education, National Pedagogical Dragomanov University, Kyiv, Ukraine, denis_sviridenko@ukr.net; ORCID ID: https://orcid.org/0000-0001-6126-1747

Revin F. H. — PhD in Philosophy, Assistant to the Chairman of the UNESCO Chair on Science Education, National Pedagogical Dragomanov University, Kyiv, Ukraine, frollrevin@gmail.com; ORCID ID: https://orcid.org/0000-0002-7349-8079

ІНФОРМАЦІЯ ПРО АВТОРІВ

Свириденко Денис Борисович — д-р філос. наук, професор, завідувач кафедри ЮНЕСКО з наукової освіти, Національний педагогічний університет імені М. П. Драгоманова, м. Київ, Україна, denis_sviridenko@ukr.net; ORCID ID: https://orcid.org/0000-0001-6126-1747

Ревін Фрол Геннадійович — канд. філос. наук, асистент завідувача кафедри ЮНЕСКО з наукової освіти, Національний педагогічний університет імені М. П. Драгоманова, м. Київ, Україна, frollrevin@gmail.com; ORCID ID: https://orcid.org/0000-0002-7349-8079

ИНФОРМАЦИЯ ОБ АВТОРАХ

Свириденко Д. Б. — д-р филос. наук, профессор, заведующий кафедрой ЮНЕСКО по научному образованию, Национальный педагогический университет имени М. П. Драгоманова, г. Киев, Украина, denis_sviridenko@ukr.net; ORCID ID: https://orcid.org/0000-0001-6126-1747

Ревин Ф. Г. — канд. филос. наук, ассистент заведующего кафедрой ЮНЕСКО по научному образованию, Национальный педагогический университет имени М. П. Драгоманова, г. Киев, Украина, frollrevin@gmail.com; ORCID ID: https://orcid.org/0000-0002-7349-8079

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