Increasing students' cognitive interest through the integration of disciplines

Elmira Kozhabekova[1], *Zhadyra* Yermekova[2], and *Sara* Ramazanova[3]

[1]South-Kazakhstan State Pedagogical University, Shymkent, the Republic of Kazakhstan
[2]L.N. Gumilyov Eurasian National University, Nur-Sultan, the Republic of Kazakhstan
[3]South-Kazakhstan State Pedagogical University, Shymkent, the Republic of Kazakhstan

Abstract. One of the main features of the updated educational content introduced into the general education system of the Republic of Kazakhstan is the improvement of pedagogical skills of teachers in the use of "interdisciplinary topics" in the classroom. The organization of interdisciplinary communication, in turn, increases the interest in the subject and activates the student's critical thinking. With the skillful use of interdisciplinary connections, it contributes to the formation of all the functions of teaching: the system of scientific knowledge, generalized cognitive skills, broad cognitive interests, students' worldviews. Implementation of interdisciplinary connections allows students to see the integrity of the image of the world, a clear understanding of the objectives of education. Therefore, in the article we have considered ways to use interdisciplinary connections in order to increase the cognitive interest of students in Physics lessons, in particular, the use of historical data in Physics lessons. Ways to solve the problem of increasing interest in physics through interdisciplinary communication, taking into account international and domestic experience. According to our research topic, we have analyzed the possibilities of developing students' cognitive interest in the process of teaching the subject "Methods of teaching Physics" in the educational program 6B01502 – "Physics Teacher Training". A plan of seminar topics on "Discovery of interdisciplinary links between Physics and History" was prepared, an experimental examination was conducted, quantitative and qualitative differences between control and experimental classes were identified. According to the results of experimental work, an increase in the level of students' knowledge through the use of interdisciplinary connections in Physics and History was identified during the lesson.

1 Introduction

The most important and interesting discoveries in modern science are revealed at the intersection of sciences, so it is especially important to organize interdisciplinary activities of future teachers. In turn, the interdisciplinary nature of preparing future teachers for the development of students' cognitive interest in teaching Physics contributes to the penetration of scientific ideas, concepts, values, as well as the formation of a holistic view of the environment. Through interdisciplinary connections arouse interest in cognition and

increase students' thinking activity. It promotes learning success, increases interest in knowledge in various disciplines, significantly expands the student's worldview.

In this regard, Zankova said that a peagogue is a teacher with a whole arsenal of tools for teaching and educating students, able to develop students' learning motivation and cognitive interests in the whole pedagogical process, striving to improve their professional knowledge and skills. In this regard, we have set the goal of our research, that is, we will offer several methods to increase cognitive interest based on the integration of physics and history.

But, unfortunately, today's graduates do not see their careers as a complex process, that is, it is not always easy to adapt to the constantly evolving and changing pedagogical system, technical and technological environment. Today, science and technology are developing so rapidly that after graduation there is no time to retrain and reach a modern level of high-tech production, so the university needs to focus on future professional work and intensive research [18].

The ongoing educational and methodological activities to prepare future teachers to ensure the continuity of disciplines can be seen in the curriculum of physics, developed in accordance with the State Educational Standards of the Republic of Kazakhstan and the requirements of the results of basic general secondary education.

Physics is the basis of modern natural science, which determines its organic connection with Chemistry, Astronomy, Biology, Geology and other natural sciences. In addition, it is associated with other forms of social consciousness - philosophy, history, morality, art, aesthetics; therefore, the objective possibility of developing basic knowledge in the course of physics can be realized in this relationship.

The importance of the implementation of IC (interdisciplinary connection) in the process of teaching Physics and other disciplines can be seen in the works of a number of scientists. For example, Mathematics and Physics are interrelated disciplines [2] and other researchers [11] have shown in their work that researchers find it difficult to succeed in Physics without knowing basic mathematical operations. Thus, at first glance, mathematics can be considered as a necessary condition for the study of physics. In his conceptual explanation, identified the importance of mathematical knowledge for the study of physics, agrees with him [9, 6].

In the course of Physics, Geography (reserves and location of mineral fuels and water resources), Chemistry (air composition, etc.), Botany (photosynthesis), Physiology and Hygiene (harmful effects of CO and other gases on humans and animals), as well as synchronous connections with Chemistry (combustion), Biology (the role of photosynthesis in animals and human life) and perspective connections with Biology (humans and the biosphere), anthropogenic factors of the environment, considering the rational use of natural resources in the study of electricity generation.

Thus, we can see that in any field of science, using many examples, it can connect with some other branches of science. In our research work we will consider the main topical issue in connection with the History of Science Philosophy in the lessons of Physics.

2 Significance of the study

The use of interdisciplinary connections to develop students' cognitive interest in teaching Physics contributes to the formation of students' holistic view of nature, dialectical-materialist understanding, acquaintance with the history of science and the scientific basis of the interaction of nature and society, the organization of educational activities.

That is, the importance of teaching Physics in a complex and interdisciplinary way is determined. The philosophy of science in the fields of education, which has a significant impact on this activity, is closely connected with the disciplines of World History and

Pedagogy. The assessment of the nature of the contribution of each of these areas is constantly changing, reflecting the ever-evolving development of our understanding of the teaching Physics [5].

It is important to teach the Humanities in with the Natural Sciences. Educational standards in a number of countries offer a better learning strategy for a deeper understanding of History, Philosophy of Science and Mathematics, the development of high-level thinking skills, and an understanding of the nature of science. The view of the History and Philosophy of Science is confirmed by the increase in empirical data that reflect the positive effects of lessons enriched with historical information, past scientific experiences and ideas about the history of science [12].

One of the most important tools for understanding how students think is to get acquainted with the decision-making process in a complex thematic learning, such as a socio-scientific problem [7].

Students' thinking and behavior vary according to the conceptual framework and the impact on each direction [10]. For example, students' ideas - in particular their ideas about learning - play an important role in their desire to learn Mathematics [1], and the Natural Sciences [15] define concepts, rules, mental images and preferences, and learning concepts are defined as "general ways of understanding students' learning" [3].

The study considered ways and directions of work on the formation of students' cognitive interest in Physics. First of all, it is necessary to pay great attention to the choice of the content of educational material, which is the basis for the formation of the scientific horizons of students, necessary for the emergence and strengthening of cognitive interest. Practical experience shows that a Physics teacher should do the following:

- to acquaint students with new data that can reflect the current level of science and the prospects of its movement;
- to reveal the history of the problem (the emergence of ideas, scientific research, the results of innovations, difficulties);
- to show various contradictions through problem-based learning and to teach a dialectical approach to the understanding of scientific facts and ideas;
- to show the need for scientific conclusions obtained as a result of personal experience to explain the phenomena of life;
- to reveal to students the practical power of scientific knowledge, the ability to apply the knowledge acquired at school in industry, agriculture, everyday life in later work.

The search for important ways to motivate students to learn is a necessary condition for the development of cognitive interest.

The purpose of the experimental study of our research:

- to study the state of preparation for the development of cognitive interest;
- to provide guidelines on the topic of interdisciplinary connection in Physics and History in order to prepare for the development of cognitive interest;

During the search phase of the experiment, a study was conducted to determine the level of cognitive interest.

A survey of students was conducted on the following topics: "Are you interested in Physics?", "What is important to make teaching Physics interesting?", "Key factors in students' interest in Physics". Comparative analysis of students' responses showed that the main factors are interesting teaching of the subject and personal qualities of the teacher.

In this regard, the initial monitoring of the level of pedagogical knowledge, skills and abilities of future Physics teachers was carried out, which revealed insufficient work in higher education to prepare future Physics teachers to develop students' cognitive interests. The teacher's readiness to develop students' cognitive interests necessarily includes the development of motivational, content and operational components. We consider this

training as an important professional quality of a teacher to develop students' cognitive interests.

Table 1. Description of the level of readiness of students to develop in accordance with the components of cognitive interest

Student levels	Levels		
	low	medium	high
Motivational	The student does not understand the importance of the process of developing students' cognitive interests, does not show due interest in the research process	The need for knowledge about the organization of the process of developing students' cognitive interests is poor; The interest in the research process under study is episodic	The interest in the process of developing cognitive interests and the desire to implement this process in the practical context of secondary school is fully developed
Content	Poorly developed pedagogical knowledge, qualifications, skills in the organization of the process of development of cognitive interests, often act on the model	Partially acquires knowledge, skills and abilities to organize the process of developing students' cognitive interests	Students have full knowledge, skills and abilities in the organization of the process of development of their cognitive interests, have a conscious, solid knowledge and skills in the implementation of the research process
Operational	Students do not fully master the skills and abilities to organize the process of developing their cognitive interests; do not seek to implement it successfully	Students have knowledge of the organization of the process of developing their cognitive interests, but it is difficult to apply them in practice	Students have the skills and abilities to organize the process of developing their cognitive interests and uses them effectively in the educational process of the school

The analysis of the obtained data allowed to determine the level of readiness of future Pphysics teachers in the process of developing students' cognitive interests.

The results of the pedagogical research became the basis for the need to develop guidelines based on interdisciplinary cconnection in the preparation of Physics teachers for the development of students' cognitive interests.

In this regard, the educational program "6B01502-Physics Teacher Training" prepared and used in a formative experiment a seminar on "Discovering interdisciplinary connections between Physics and History" for use in teaching the subject "Methods of teaching Physics" to 3rd year students. We offer to get acquainted with a number of lessons designed for interdisciplinary connection in Physics. In connection with the integration of Physics with the History of Science, we present the plan of the seminar "Development of

science and its importance in human life", students prepare special reports and reports for the seminar.

The first student-speaker states that in the Middle Ages, political and spiritual power belonged to religion, and this left a certain mark on the development of science. Science was to serve primarily as an illustration and proof of theological truths. J. Bernal wrote in "The Role of Science in Society": "Until the eighteenth century, science was mainly interested in celestial bodies". Here is the paradox: at the beginning of the IV century BC. forced Socrates, who was sentenced to death, to drink a glass of poison, in the same century philosophy prevailed and the schools of Socrates' students and the Platonic Academy appeared. In 1600 J. When Bruno was set on fire, science overcame religion in that century. Then monarchs such as Louis XIV, Frederick II and Catherine the Great laid the foundations of the academies. Thus, science made Newton a great person.

The second student-speaker reports that science is developing exponentially: the volume of scientific creativity in the world in the twentieth century has doubled every 10-15 years. The number of scientists and scientific fields increased, and in 1900 there were about 100 thousand scientists in the world. Today, there are more than 5 million scientists, 90% of all scientists living on the planet are our contemporaries, and now there are more than 15 thousand disciplines.

The next student -speaker will make a report on the important achievements of physical science of the XX century and its discoveries.

Determining the importance of the successful development of Physics in the development of science and humanity increases the general cognitive interest of students, in this regard, we can highlight several important innovations.

1) Max Planck's quantum hypothesis (1900) supplemented the previous notion of light as electromagnetic waves, advancing the hypothesis of its quantum (corpuscular) nature: байланысты $\varepsilon = h\nu$ depending on the frequency of light emission, where h-Planck's constant 6.62 • 10-34 J/s;

2) Discovery of A. Einstein's special theory of relativity (STR) - 1905 and general theory of relativity (GTR) - 1916;

3) Э. Rutherford's discovery was the atomic nucleus in 1911;

4) Development of quantum theory of atomic structure (N. Bohr, 1913);

5) Model of the universe expansion (A. Friedman, 1922);

6) Louis de Broglie's (1924) hypothesis about the wave properties of microparticles: if the mass m moves at a particle speed υ, then the wavelength $\lambda = \frac{h}{m\upsilon}$, where h is Planck's constant.;

7) Formation of quantum mechanics (Heisenberg and E. Schrödinger, 1925-1926);

8) Antiparticle to the electron - the discovery of the positron (P. Dirac, 1928);

9) The discovery of quasars - quasi-star systems, ie the most mysterious objects in the world (M. Schmidt, T. Matthews, etc., 1963);

10) The discovery of pulsars - fast-rotating neutron stars (E. Hughes, 1967).

Further, in order to increase the students' cognitive interest and strengthen theoretical knowledge, reports on the interdisciplinary connection of Physics and History were developed for the seminar classes on "Methods of teaching Physics." Here are some examples of interdisciplinary problems.

Task 1. The famous ancient Greek scientist Aristotle, who lived in the 4th century BC, weighed the weight of an empty leather bag and then that air-filled bag to prove the weightlessness of air. Seeing that the weights are the same, Aristotle concluded that air has no weight. Why did Aristotle draw the wrong conclusion? What is Aristotle's mistake?

Solution: Because the weight of the air in the inflated bag is equal to the repulsive force exerted on it by the air. To prove the presence of air weight, it must be pumped into a container or inserted into a solid container.

Task 2. During the Great Patriotic War, sappers used minesweepers. Mine detector is a generator of electromagnetic oscillations that do not extinguish sound frequencies. The inductance of the circuit is made of wire in the form of a ring. As the ground ring approaches the mine, the high tone on the phone headset changes to a low tone. How to explain this phenomenon?

Solution: The body of the mine as an iron rod increases the inductance (L), where the frequency (tone) decreases according to Thomsy's formula $v = 1 / (2\pi LC)$.

These proposed works are elements of a system of lessons designed to focus on the interdisciplinary relationship of Physics, which is of general scientific-historical and practical importance.

3 Research methods

The following types of methods were used in the study: (1) theoretical (analysis, synthesis, classification, generalization, deduction, induction, similarity and modeling); (2) empirical (observation, survey, questionnaire and interview); (3) experimental (diagnostic, developmental and diagnostic experiment); (4) statistical (statistical analysis of data, qualitative and quantitative analysis of research results). It was important to aim to obtain statistics that were sufficiently representative and reliable, so we used a number of methods, such as questionnaires, expert assessments, interviews, surveys, interviews, testing, which included observation and open-ended questions.

Thus, the method of interviewing students of the educational program of the university 6B01502 – "Physics Teacher Training" is to know the basic concepts of the process of developing cognitive interest, the reasons for appropriate pedagogical activity, the degree of cognitive interest, various methods and forms of its implementation; The following blocks of questions determine the degree of effectiveness of various methods and forms of teacher training at the university.

The method of expert assessment included questions that reflect students 'understanding of the development of students' cognitive interests and their readiness for pedagogical action on self-assessment of this preparation; identifies effective ways to develop the pedagogical knowledge and skills of future physics teachers;

During the observation, we identified the effectiveness of various approaches to stimulate the interest of future physics teachers in the process of developing students' cognitive interests. In the pedagogical practice of students, the method of observation and the method of conversation helped to identify the different approaches that students use to develop students' cognitive interests in the classroom and in extracurricular activities.

To determine the degree of readiness of teachers to develop students' cognitive interests, it is necessary to have an understanding of the actual level of its development, so it was important to obtain accurate information about the level of readiness of future teachers to implement the research process. The characteristics of the level of readiness of future Physics teachers to develop students' cognitive interests in accordance with its components were studied.

4 Results

The pedagogical experiment was conducted on the basis of "South Kazakhstan State Pedagogical University" in Shymkent by students of the educational program 6B01502 –

"Physics Teacher Training". 43 students took part in our research. The results of the formative stage of the experiment were obtained by analyzing the performance of tasks for students on the integration of Physics and History. In the course of experimental work, the dynamics of the formation of the readiness of future Physics teachers to develop students' cognitive interest in the basic components of the experimental groups was observed. The "system of interdisciplinary educational lessons for the development of cognitive interest in physics" was introduced into the educational process of experimental groups. Upon completion of the formative experiment, students were given tasks, their implementation was monitored, the nature of the difficulties, the level of success of the tasks, the degree of satisfaction with the results of the work were determined.

In this context, we studied the dynamics of the level of interest of students in the study of the problem of teaching physics in connection with historical data.

Experimental work

The results are presented in Tables 1 and 2.

Table 2. Indicators of the level of interest in teaching in connection with historical data in the direction of integration of Physics in our research (data from the detection experiment).

Level of readiness	Experimental groups	Control groups
Low	51.5%	50.8%
Medium	32.1%	32.2%
High	16.4%	17.0%

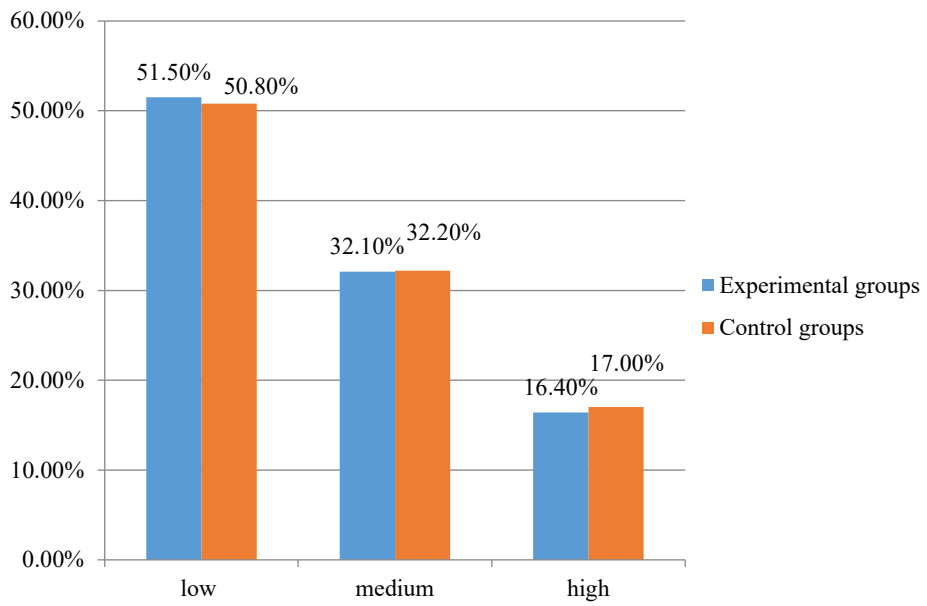

Fig. 1. Diagram of indicators of the level of cognitive interest of students using historical data in physics (experimental data).

Analysis of indicators of cognitive interest of students shows that the requirement of representation in the selection of experimental and control groups for the stage of formation of the experiment was observed during the experiment.

Indicators of the level of formative experiment on changes in the interest of students in the integration of history in the study of physics in our research and control groups are shown in Table 3 and Figure 2.

Table 3. The results of diagnosing the level of cognitive interest of students using historical data in the teaching of Physics (formative experimental data).

Level of readiness	Experimental groups	Control groups
Low	12.1%	51.3%
Medium	50.8%	34.5%
High	37.1%	14.2%

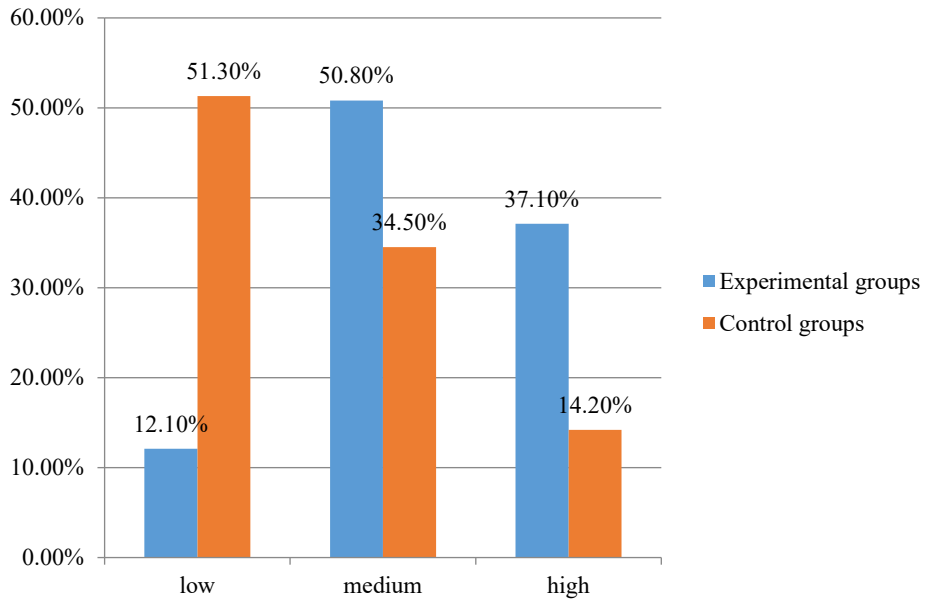

Fig. 2. Diagram of indicators of the level of cognitive interest of students by connecting with historical data using the technology of integration in the teaching of Physics (data of the formative experiment)

According to the data obtained, the use of historical data in the teaching of physics can be clearly seen in the high performance of students of experimental groups, which significantly increased the level of cognitive interest of students.

Thus, the analysis of experimental work with the introduction of historical data in the teaching process in the teaching of Physics has shown great effectiveness.

5 Conclusion

In the literature review of the research, teachers of secondary schools showed that they are not yet ready to develop students' cognitive interest in the basic sciences, so special preparation for the development of students' cognitive interest, in particular, Physics requires special training to develop an interest in the fundamental sciences of nature. We offer a focus on the development of professional knowledge of History teachers and Science teachers based on their beliefs and creativity. Teaching natural sciences with the help of History and Philosophy, i.e. the method of integrating Physics, has a positive impact on the development of programs and teaching materials for future teachers and the introduction of History and Philosophy in the teaching of Natural Sciences.

The results of our research show that the importance of teaching through the integration of Physics is very high in order to increase the interest of students. This research can be considered as one of the possible solutions to the problem of increasing student activity.

References

1. P. Andrews, G. Hatch, Educational Studies in Mathematics, **43 (1)**, 31-64 (2000). DOI: 10.1023/A:1017575231667
2. I. Basson, International Journal of Mathematical Education in Science and Technology, **33 (5)**, 679-690 (2002) https://doi.org/10.1080/00207390210146023
3. J. Bowden, F. Marton, Instructional Science, **3 (1),** 87-108 (2003) https://doi.org/10.4324/9780203416457
4. Elder Sales Teixeira, Ileana Maria Greca and Olival Freire Jr, Science & Education, **21(6),** 1-26 (2012) http://dx.doi.org/10.1007/s11191-009-9217-3
5. I. Galili, & A. Hazan, Science and Education, **10 (1-2)**, 7-32 (2001). https://www.researchgate.net/publication/225897435_The_Effect_of_a_History-Based_Course_in_Optics_on_Students'_Views_about_Science
6. P.G. Hewitt, *Conceptual Physics* (10th ed.) (2006)
7. J.S.C. Leung, International Journal of Science and Mathematics Education (2021) https://doi.org/10.1007/s10763-021-10177-y
8. M.R. Matthews, *Science teaching: the role of history and philosophy of science* (New York: Routledge, 1994) https://philpapers.org/rec/MATSTT
9. L.C. McDermott, American Journal of Physics, **61 (4)**, 295-298 (1993) https://www.ijpce.org/index.php/IJPCE/article/view/79
10. J.P. Ponte, *Mathematics teachers' professional knowledge (plenary conference)*, In J. P. Ponte & J. F. Matos (Orgs.), Proceedings of the XVIII International Conference for the Psychology of Mathematics Education (PME), **I** (Portugal, Lisbon, 1994) 195-210. https://repositorio.ul.pt/handle/10451/4387
11. A. Quale, Science & Education, **20**, 609- 624 (2011) http://dx.doi.org/10.1007/s11191-010-9257-8
12. J. Solomon, J. Duveen, L. Scot, S. McCarthy, Journal of Research in Science Education, **29(4),** 409–421 (1992) https://onlinelibrary.wiley.com/doi/abs/10.1002/tea.3660290408
13. S. Suratno, B. Wahono, C.-Y. Chang, A. Retnowati, Yushardi, Journal of Turkish Science Education, **17(2),** 211 (2020). https://www.researchgate.net/publication/342465891_Exploring_a_Direct_Relationship_between_Students'_Problem_Solving_Abilities_and_Academic_Achievement_A_STEM_Education_at_a_Coffee_Plantation_Area/citation/download
14. L.V. Zankov, *Training and development. Experimental and pedagogical research,* (M., Pedagogy, 1980) 290.
15. C.C. Tsai, International Journal of Science Education, **26 (14),** 1733-1750 (2004). https://doi.org/10.1080/0950069042000230776
16. Zk.K. Yermekova, N.M. Stukalenko, E. Kozhabekova, A. Magauova, S. Pazylbek, Z. Sadvakassova, E3S Web Conf., **258**, 10002 (2021).
17. R.T. Abdraimov, T.A. Turmambekov, B.S. Ualikhanova, M.D. Berdaliyeva, Journal of Advanced Research in Dynamical and Control Systems, **11(11 Special Issue)**, 146-151 (2019) doi:10.5373/JARDCS/V11SP11/20192941

18. Zh.K. Yermekova, N.M. Stukalenko, *Preparing future teachers for the development of students' cognitive interest in teaching fundamental sciences using the example of Physics*, Monograph, (supplemented Astana: L.N. Gumilyov ENU, 2012) 225.