TED 5319 (CRN 35078)

Graduate Workshop in Education–Nature of Science in K-12 Classrooms

Course Syllabus

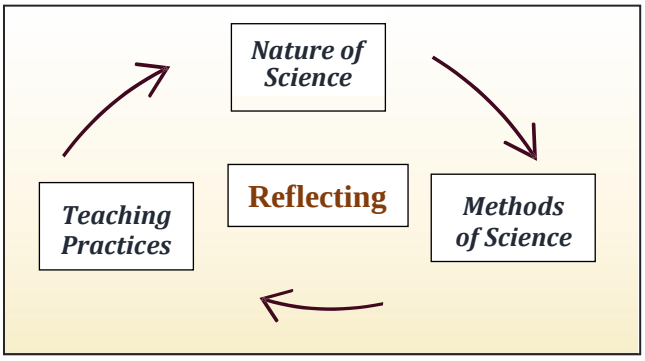
Instructor

William Medina-Jerez, PhD
Office: Education Building Room 604
Phone: 915-747-8608
E-mail: wjmedinajerez@utep.edu
Office Hours: Wednesday 1:00 – 3:30 pm.
(*Please email me to set up an appointment or to arrange a phone conversation*).

Course Overview

Last year, the *Pew Research Center* released the results of a survey entitled: 'What Americans Know about Science.' The goal of this survey was to assess the public views and level of understanding of science facts and processes. Findings indicate that most people can answer some questions about science; it also revealed that approximately one-third (32% of respondents) were classified as having medium science knowledge, and about three-in-ten (29%) are in the low science knowledge group. *Science for All Americans*, a document produced by the American Association for the Advancement of Science (AAAS) in 1989, targets scientific literacy and defines it as a concept that includes understanding some of the key concepts and principles of science, having a capacity for scientific ways of thinking, and being familiar with the nature of science.
The National Science Education Standards (NSES, 1996) reinforced this view of scientific literacy by defining what teachers of science should know.

> *Teachers of science must have a strong, broad base of scientific knowledge extensive enough for them to understand the nature of scientific inquiry, its central role in science, and how to use the skills and the processes of scientific inquiry (p. 59).*



This course is designed to help you think about the Nature of Science (NOS) and its implications for science teaching and learning in K-12 classrooms. A teaching and learning cycle framework with components of *Understanding the NOS, Understanding the Methods of Science, and Teaching Practices* is used to facilitate an understanding of the connectedness of this important concept across grade levels and science disciplines. All three components are linked to the most important feature of thinking like

a teacher, *reflecting*. Effective teachers are committed to professional growth through continuous reflection in and on their practice.

This course includes three major goals. ***The first goal deals with the understanding of the nature of science*** or nature of scientific knowledge, usually abbreviated NOS. This concept encompasses the history, philosophy, sociology, and psychology of science; it is about what science is and how it works. The nature of scientific knowledge is simple, on the surface. We accept a handful of principles as underpinning the way science works. Scientific knowledge relies on creativity and empirical evidence, it is subjective and culturally embedded, different classes of knowledge exist and each has its own methods. However, having a comprehensive understanding of these ideas proves elusive. For example, scientific knowledge is tentative; it is always subject to change. But it is also durable, long lasting, not likely to change. It is empirical, based on observations and experimental data. Science is always done by people; sometimes they act the way scientists are expected to, other times they do not. Some say scientific knowledge is invented or created, others say it is discovered. We will address these assumptions in this course.

The [new] Next Generation Science Standards (NGSS), which Texas and other states have not adopted, devote more attention to the nature of scientific knowledge. The new standards include eight understandings related to the nature of science which should be a part of all science classes:

1. Scientific investigations use a variety of methods
2. Scientific knowledge is based on empirical evidence
3. Scientific knowledge is open to revision in light of new evidence
4. Scientific models, laws, mechanisms, and theories explain natural phenomena
5. Science is a way of knowing
6. Scientific knowledge assumes an order and consistency in natural systems
7. Science is a human endeavor
8. Science addresses questions about the natural and material world

The second goal is to give you opportunities to understand the methods of science by looking into reports about scientific investigations. The K-12 science teacher needs to be able to help her or his students evaluate scientific reports presented in the media. Being able to do this requires an understanding of scientific methods and attitudes.

The NGSS use the term 'practices' instead of 'methods' or 'processes.' In relation to this goal, the new standards identify eight scientific and engineering practices which should be a part of all science classes (K-12).

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Finally, you should be able to take what you learn about the NOS and apply it in your instruction. What can teachers do to encourage students to leave school with an accurate understanding of the NOS? ***The third goal is to apply knowledge about the nature of science to teaching science.***

By the end of this short course, it is my goal to help you understand this major idea (NOS) and therefore you will be able to respond to most of these questions:

- What is science?
- What characteristics distinguish science from other ways of knowing?
- What kinds of questions can science answer? What kinds of questions can science not answer?
- Is science an extension of common sense?
- How does history help us understand how science works?
- Is experimental science the only good science?
- What are inductive and deductive thinking? How are they important to science?
- What are the differences and relationships between observations, hypotheses, predictions, laws, and theories?
- Is observation objective?
- What is 'the scientific method'?
- Why can explanations (theories and models) never be completely proven or disproven?
- What does it mean to say a scientific idea is 'known' or 'true'?
- How is science distinguished from pseudo-science?
- How do we distinguish science and religion?
- What preconceived ideas do students have about the nature of science?
- What do the standards (TEKS) say about the nature of science?
- What can we do to help K-12 students learn about the nature of science?

Some of these questions are philosophical in nature, and do not have single correct answers. Some of the questions have responses generally accepted by most science educators or science philosophers, some don't. Be sure, this point is clear to you. I would look for your reasoning and how you support your thinking. Because of the philosophical underpinnings to this concept (the NOS), in this course we will deal with one branch of philosophy—epistemology. This area explores the nature of knowledge and the process of knowing. Philosophers or science ask how scientific knowledge is generated, presented, and validated.

Course Goals

By the end of the course, you will:

- Understand various philosophical positions on the nature of science.
- Have clarified and refined your own views of the nature of science.
- Have thought about the roles of the scientific society, culture, and gender in creating science knowledge.
- Have thought about the implications of perspectives on the nature of science for science instruction.

Course Format

The course is designed for an online format. It includes discussions postings and reflective writing. Thus the success of the course depends on the active participation of all members in helping to shape shared understandings. Our primary activity will be in-depth discussions of course ideas based on readings. To accomplish this, I will suggest the use of a generic reading guide.

Resources

You are not required to purchase a textbook for this course. All of the assignments for the course and most of the other necessary materials will be placed on the Blackboard course platform. There will also

be a **Question and Answer** (Q&A) Forum in which common questions can be addressed and viewed by all members of the class. I will post questions and answers only; your name will not appear in these postings.

Additional online resources that you will need include:

- National Science Teachers Association (NSTA) http://www.nsta.org/default.aspx
- Science Teachers Association of Texas (STAT) http://www.statweb.org/
- Texas Essential Knowledge and Skills (TEKS) http://www.tea.state.tx.us/index2.aspx?id=6148
- The New Generation Science Standards (NGSS) www.nextgenscience.org/next-generation-science-standards.

Technology Requirements

Each participant must be able to use their UTEP Blackboard account. You MUST have both a UTEP email address and password to take this course. Do not hesitate to contact me requesting assistance with the navigation of the course platform. I will happy to help!

Technical Assistance

The University of Texas at El Paso offers complete technical information and help desk support at: http://issweb.utep.edu/techsupport/.

> ***If I had to summarize this course in one sentence it would be****: Become an enthusiastic and curious science "teacher-learner," provoking and challenging your students to achieve an 'understanding of science' [what science is and how it works] that lead to appreciating and engaging in learning about the mysteries and wonders of science.*

Grades

Overall grading will be A-F, points weighted by percentages. All work is expected to be clearly written (and word-processed), reflect thoughtful response to the assignment guidelines, and be of high quality.

A = 90-100%; B = 80-89.9%; C = 70-79.9%; D=60-69.9%; E = BELOW 60%

Course Assignments

Assessment	Occurrence	Points
Nature of Science Survey	Twice	2x10
Group Discussions	Multiple, weeks 1, 2, and 3	3x5
Statements of Crucial Significance (SOCS)	Multiple, weekly	4x5
Lesson Modifications	Due in Week 4	20
Synthesis Paper	Due in Week 5	100
Total points		175

Description of Assignments *(See assignment rubrics in the Rubrics Folder in the Course Content area of Blackboard).*

Nature of Science Surveys

You will be asked to complete, at both the start and end of the course, a survey about the meaning of science and how it works. For this assignment, your grade will not be based upon any particular "correct" answers, but rather for thoughtful responses.

Group Discussions

There will be three Group Discussions prompts available (see course calendar), each posted on Monday morning by 7:00 AM and open until Sunday at 11:55 PM. Each contribution will be awarded 0, 2, 3, or 5 points based on the complexity and thoughtfulness of your comments. For example, 3 excellent participations at 5 points each can satisfy the entire 15 total points.

Do not post your responses to the discussion board as attachments! Please type directly or copy and paste the text into the discussion boards.

Statements of Crucial Significance (SOCS)

***SOCS A**. Statement Regarding the Nature of Science Based Upon the Relationship between Substantive Content of Different Readings*

The overarching goal of this course is for you to develop an understanding of the nature of science and apply it when teaching science. Towards the first end, you are required to make statements regarding the nature of science that coalesce in various readings. The relationships (comparison, contrast, similarities, etc.) between ideas, examples, and arguments presented in different readings should, therefore, be pursued to make statements regarding the nature of science.

***SOCS B**. Statement Representing Implications*

This type of statement represents action-level thinking on your part. A SOCS-C is a statement regarding what should be done. For example, think about implications of an understanding of the nature of science for science instruction in the classroom with examples of a learning scenario where the implication point may take place.

Rules and Helpful Hints for Writing SOCS

1. Write at least one SOCS per week.
2. Weekly SOCS should be based on a single reading schedule for the week.
3. Always indicate the type of SOCS you have written.
4. Each individual SOCS may contain no more than 55 words (listing the type of SOCS, reading title, and the author of a reading to which a SOCS refers does not count towards the 55 words. This is a succinct and precise writing exercise. Suggestion: this is not an essay writing exercise, therefore we do not have the space to discuss our opinions or on describing in detail previous science teaching and learning episodes.

5. SOCS statements should be submitted within the assigned week, no later than Sunday, and on the course platform. If you have problems submitting your SOCS, or other course assignments, (a) please contact me right away, and (b) email your assignment before the due date.
6. All SOCS must include one reference to another course reading that support or refute a position with which you would like to draw comparisons or conclusions. *Suggestion*: In order to keep the statement within the space limit, avoid inserting long quotations, instead paraphrase the author/s' ideas.
7. Each week you will have a chance to ***practice writing one SOCS*** statement before submitting ***a second one for a grade***. Although you are not required to participate in the SOCS writing practice each week, I highly encourage you to do so.
8. The ***SOCS weekly writing practice*** entails the following steps:

    A. Email your instructor one (and only one) SOCS statement to receive feedback
    B. Email your practice SOCS between Monday and Friday (by 5:00 pm) of each week
    C. Your instructor will email you back with feedback. You will not earn points on t
    D. Email your instructor back if you need further clarification on his comments
    E. If you participate in this optional task, your second submission [for a grade] should be based on a different reading

SOCS must be carefully written and reviewed for clarity and sense (a matter of whether the statement says what you want it to say and whether what you want to say makes sense).

Lesson Modifications

In this assignment you will tweak a pre-existing lesson to better exemplify aspect(s) of the nature of science, starting with lessons *not initially created with NOS as a primary student learning outcome*. You don't need to start from scratch; curriculum materials are available in NSTA journals, and other online or printed outlets. *The purpose of the assignment is to accent the importance of teaching students about the nature of science within the context of "regular" lessons.*

I will ask you to modify one inquiry-based laboratory activity.
Your assignment will include separate discussion about how your lesson modifications exemplify aspects of the nature of science and (1) what you changed, (2) your rationale for the change, the aspect(s) of the nature of science whose learning is facilitated by the change, (3) what you would do (or say) during the changed part of the lesson, and (4) what you would expect students to be doing (or saying) during the changed part of the lesson.

I can't say ahead of time what you will change, but common changes include adding questions, changing written or spoken wording to be a more accurate reflection of the nature of science, "lecturettes" at opportune points in a lesson about a relevant aspect of the NOS, and changing activities to become more open-ended (along with thoughts about aspects of the NOS students might likely demonstrate during the more open-ended activity).

Synthesis Paper

Besides readings and discussions aimed mainly at understanding and analysis, you will benefit most from the course if you also engage in application and synthesis level thinking This can be accomplished by writing a manuscript. Below are some paper ideas to consider:

- Pick a particular philosophical issue (e.g., the nature of objectivity in science; the influence of culture on science) and delve into it in greater depth. Sort out the various positions, then develop your own argument, including implications for teaching and learning.

- Critically analyze, from a standpoint not currently addressed in the literature, a current science education policy document (e.g., *National Science Education Standards*) to determine what it has to say about the nature of science.

- Ask a question about science teaching and learning from the perspective of the nature of science and then see what the research says about this question. For example: Does teaching the history of science help students understand the nature of science? Does a teacher's nature of science beliefs affect how she/he teaches science? What are commonly-held teacher (or student) beliefs about the nature of science? Write a review of the literature and derive your own set of recommendations grounded in the literature.
- Pick a particular scientific concept and analyze its historical development from a Kuhnian (or some other) perspective.

Before you begin to write, but after you have some plans, you will submit your ideas (in paragraph or outline form, your choice) to me for feedback. The outline of the paper should be on the order of 250 words, or 1 single-spaced page. The final version of the paper should be 8-pages long, not including the References and Appendix sections (double-spaced, and aligned to APA guidelines).

Reading, Writing, and Discussion Guide

The reading load for this course is challenging. However, I consider the ideas important for a literate science educator to know and understand. I encourage you to search for the most important ideas in the readings. I provide several recommendations and tools for you in this process.

First, I recommend that you manage your time so as to read and reread the selections in time for discussion. Reading questions will be provided on line and focus your reading. When you find difficult parts, use strategies of good readers—reread, skip it, come back to it later, ask someone. You should also determine if that difficult part is key to understanding the author's main points as you decide how much time to devote to making sense of it.

Secondly, I recommend you write as you read. Take notes, make diagrams, answer guiding questions, and write your own questions.
Third, actively participate in discussion. As you discuss you will be able to clarify your own ideas in comparison with your peer.

Finally, after discussion revisit what you wrote and write more. This will further help you clarify your ideas.

A generic reading guide

Overview

- What, in 1-2 sentences, is the author's thesis about the nature of science?
- How is this thesis developed?
- What are the points of significance?
- How are these points supported? What kinds of evidence are provided?
- What points seem reasonable and well supported? □ What points seem dubious?

Synthesis

- How do these ideas compare with other things you have read?
- Which ideas expressed in the reading fit with your current thinking about the nature of science?
- What ideas run counter to your current thinking about the nature of science?
- Is there anything in this reading that you would like further clarification or discussion?

Academic Policies

Attendance Policy: Attendance is taken by monitoring your work and participation online. You are responsible for doing all the work and reviewing the online lectures every week. The instructor reserves the right to drop students from the course who have not participated during two weeks of classes.

Assignment Submission: Your assignments are due on the scheduled day and time; submit them according to the prescribed format (e.g., written report). Late work will not be accepted for full credit unless you have evidence of extenuating circumstances. Assignments not turned in will receive a grade of zero. I will only agree to grade late work for the first week following the due date, and deducting 25% off the total grade. No assignments will be accepted past one week late. Plan carefully to ensure you meet the deadlines. Create your time management plan and stick to it, so you can get everything done on time.

Make-up Work: There are no make-up assignments unless in case of serious bodily harm of death in family. You must bring a document issued by a health service provider or institution in order to turn in late work of make up an exam.

Assigned Reading Materials: Readings will be assigned for each week. You will be responsible for reading and understanding these materials.

Plagiarism: Cheating is unethical and not acceptable. Plagiarism is using information or original wording in a paper without giving credit to the source of that information or wording: it is also not acceptable. Do not submit work under your name that you did not do yourself. You may not submit work for this class that you did for another class. If you are found to be cheating or plagiarizing, you will be subject to disciplinary action, per UTEP catalog policy. Refer to http://www.utep.edu/dos/acadintg.htm for further information.

Multiple Submissions: When turning in assignments, students may not resubmit work done for other courses. No credit will be given for a resubmission of a project or paper given in another class.

Incomplete Grades: An incomplete may be given only during the term and if a student provides evidence of a documented illness or family crisis that precludes successful completion of the course.

Students with Disabilities: I will make any reasonable accommodations for students with limitations due to disabilities, including learning disabilities. Please contact me to discuss any special needs you might have. If you have a documented disability and require specific accommodations, you will need to contact the Disabled Student Services Office in the East Union

Bldg., Room 106 within the first two weeks of classes. The Disabled Student Services Office can also be reached in the following ways:

E-mail: dss@utep.edu
Web: http://www.utep.edu/dsso
Phone: (915) 747-5148
Fax: (915) 747-8712

Inclusiveness and Equity

Learning happens only when we feel respected as a whole human being. My top priority in our course is to cultivate relationships of trust and respect and a sense that we see each other as whole, complex human beings. That you experience this in our class is important for the sake of your learning in our course *and* for the sake of your future students' learning, so that you feel able to cultivate such relationships with them. To that end, I want you to know that all of you are welcome in our classroom environment—all the parts of you as a person are welcome in our discussions, our activities, our assignments, and in our assessments. We are all complex people with a variety of perspectives, experiences, challenges, assets, and resources—our gender identities, our sexual orientations, our religions, our races, our ethnicities, our economic statuses, our immigration statuses, our parenthoods, our veteran statuses, our ages, languages, our abilities and disabilities. All the parts of you are welcome in our learning community to the extent that you feel comfortable bringing them in. I strive to show respect for the variety and wholeness in each of you, and I expect that each of you shows respect for each other as well. If you feel marginalized in our class, and you feel comfortable discussing it, I would like to know so that I can support you, protect you, and make changes that feel more inclusive and equitable. You can also talk with our Department Chair and/or you can report a complaint of discrimination to the University's Equal Opportunity Office, Kelly Hall, Third Floor, 915-747- 5662 or eoaa@utep.edu. our

Course Schedule and/or Assignment Changes: The course instructor reserves the right to adjust the course syllabus or change assignments as needed. While every effort will be made to adhere to the calendar and the course outlines, there will undoubtedly be changes due to unexpected situations or pacing that may arise during the semester. Every attempt will be made for advance 'warning.' These modifications will be based on the specific needs of all the students in the course, but not to exceed difficulty or the due dates of the originally proposed assignment.

Communicating Effectively Online: When we talk face-to-face, we expect other people to observe certain rules of behavior. The same is true online. Here are a few pointers to help you communicate more effectively via e-mail and discussion boards:

- Clearly summarize the contents of your message in the subject line of your e-mail and your discussion board postings.
- Avoid using all capital letters. USING ALL CAPS MAKES IT LOOK LIKE YOU ARE SHOUTING! IT'S ALSO MORE DIFFICULT TO READ.
- Avoid using sarcasm in your postings and e-mail messages. Sarcasm does not translate well in the online world.
- More information on Netiquette can be found at: www.albion.com/netiquette.
- Think before you push the "Send" button. During group discussions, did you clearly say what you meant to say? How will the person on the other end read the words? While

you can't anticipate all reactions, do read over what you have written before you send it.

Course Calendar

Week	Date	Topic	Assignments Due
1	June 8 to June 14	• Rationales for the Nature of Science in Science Instruction • **Pre-Survey**: Nature of Science	Read the syllabus, and make sure to fill out and submit the Student Profile form with questions you may have about the course content. ***Reading Set 1.*** ***Discussion 1*** ***SOCS 1 [on a publication from reading set 1]***
2	June 15 to June 21	• Some Ideas Worth Teaching about the Nature of Science	***Reading Set 2*** ***Discussion 2*** ***SOCS 2 [on a publication from reading set 2]***
3	June 22 to June 28	• Effectively Teaching Students about the Nature of Science (part A)	***Reading Set 3*** ***Discussion 3*** ***SOCS3 [on a publication from reading set 3]*** ***Synthesis Paper Outline***
4	June 29 to July 2	• Effectively Teaching Students about the Nature of Science (part B) *July 2—last day of classes*	***SOCS 4 [on a publication from any reading set]***
5	July 6 to July 12	• **Post-Survey** Nature of Science	***Synthesis Paper*** ***Lesson Modifications***

Reading List

Reading Set 1 *Rationales for Accurately Portraying the Nature of Science*

- Very Abstract Questions: The Philosophy of Science (Gregory Derry)
- Evidence, Reason, and Critical Evaluation (Gregory Derry)
- The Principal Elements of the Nature of Science: Dispelling the Myths (William McComas).
- Theories as Structures I: Kuhn's Paradigms (A. F. Chalmers).
- The Many Routes to Science Discovery (Gregory Derry).
- The Nature of Science: Understanding how the "Game" of Science is Played (Michael P. Clough).
- Observation as Practical Intervention (A. F. Chalmers).

Reading Set 2

Some Ideas worth Teaching about the Nature of Science

- National Science Teachers Association (NSTA) Position Statement on the Nature of Science.
- The Nature of Science in the Next Generation Science Education Standards: Analysis and Critique (William McComas & Noushin Nouri).
- The Nature of Science in the Next Generation Science Standards (NGSS).
- Key Ideas to Teach about the Nature of Science (William McComas).
- Using Critical Thinking to Counter Misinformation (Andrew Zucker).
- The Scientific Method: Reality of Myth? (Ronald A. Brown & Alok Kumar)
- Understanding How Science Works: The Nature of Science as the Foundation for Science Teaching and Learning (William McComas).
- The Science and Religion Wars (Mano Singham).
- The Necessity of Teaching Evolution (Patty McGuinnis).
- Authentic Scientific Inquiry as Context for Teaching Nature of Science (Renné Schwartz & Barbara A. Crawford).
- It's Not Just a Theory (DeWayne Backhus).
- Perusing Pandora's Box (RandyL. Bell).

Reading Set 3

NOS Activities for Elementary and High School Classrooms

- Activities that Promote Understandings of the Nature of Science (Norman Lederman & Fouad Abd-El-khalick).
- Teaching the Nature of Science through Scientific Errors (Douglas Allchin).
- Anecdotes from Popular Books on the Nature of Science (William McComas).

Elementary Grade Levels

- More than a Human Endeavor (Joanne Olson).
- The NOS Challenge (Cassie Quigley, Gayle Buck, & Valarie Akerson).
- The Nature of Science in Early Childhood (Peggy Ashbrook).
- Understanding the True Meaning of the Nature of Science (David Crowther, Norman Lederman, & Judith Lederman).

- Integrating the Nature of Science (Ingrid Weiland, Katherine Blieden, & Valarie Akerson).
- How Do Scientists Work? (Amy Gilbert & Catherine Jones).
- Demystifying the Nature of Science (Judith Lederman, Selina Bartels, Norman Lederman, & Dionysius Gnanakkan).
- Inspiring Future Scientists (Patt Betteley & Richard Lee).
- Is it a Theory? Speaking the Language of Science (Page Keeley).
- Three, Two, One…Blast Off! Third Grade Students Learn about the Nature of Science through a Rocket Engineering Challenge (Susan Hawkins & Meredith Park Rogers).
- Sculpt-a-Scientist (Julie Jackson & Ann Rich).

High School Grade Levels

- The Nature of Science and the Next Generation of Biology Education (William McComas).
- Look Before You Leap (William McComas).
- Nurturing the Nature of Science (Carolyn Reeves, Debby Chessin, & Martha Chambless).
- Revising Instruction to Teach the Nature of Science (Norman Lederman & Judith Lederman).
- The Nature of Science: Always Part of the Science Story (Joanne Olson & Michael Clough).
- The Nature of Science and Perceptual Frameworks (Erica Michaels & Randy Bell).
- Using Biographical Letters to Draw on the Nature of Science (William Medina-Jerez, Wayne Melville, & Dale Walker).
- Integrating the Nature of Science throughout the Entire School Year (Jerrid Kruse).
- Exploring the History of Science with Movies (Ashley Campbell).
- Editor's Corner: The Nature of Science (Steve Metz).
- Light Students' Interest in the Nature of Science (Joanne K. Olson).
- Teaching and Assessing the Nature of Science (Michael Clough).
- Focusing Labs on the Nature of Science (Allan Colburn).
- What's in a Word? (Renee Schwartz).