	THE UNIVERSITY OF TEXAS AT EL PASO **College of Education- Department of Teacher Education**

Title of Course: STEM 6305 (28223) Philosophy, History, and Nature of Mathematics and Science MTED 5326 (28104) Cultural-Historical Epistemology and Didactics of Mathematics	**Credits:** 3
Semester: Spring 2021	**Instructor Information:** **Professor:** Dr. David J. Carrejo, Ph.D. **Office:** College of Education, EDUC 802 **Phone:** 747-5856 **E-mail:** dcarrejo@utep.edu (**best means of contact**) **Office Hours:** By appointment
Class meeting time: ONLINE **Class meeting place:** ONLINE Any scheduled meetings will take place virtually.	

This syllabus is subject to change as needed. Any changes to the syllabus will be announced in class.

I. Course Description

These courses examine cultural, epistemological, and historical issues and influences in the development of mathematics and science and their implications for learning and teaching. They will also identify and discuss methods and design materials intended to support teaching history and nature of mathematics and science while maintaining the content goals of the curriculum.

II. Course Framework

The purpose of these courses is for students to encounter a variety of historical situations and philosophies which have given rise to mathematical and scientific concepts that now form the basis of our required EC-12 math and science curricula. These courses place special focus on the Nature of Science (NOS) and its implications for teaching and learning in EC-12 classrooms. There is a special emphasis on the mathematical and scientific developments that occurred in seventeenth century Europe, the period of the Scientific Revolution. Students will be given readings and a variety of activities which will allow them to investigate critical mathematics and science content from this period and draw their own conclusions about the direction of the historical genesis and evolution of this content. Students will be afforded the opportunity to examine and analyze current EC-12 STEM curricula through philosophy, history, and nature of mathematics and science, thereby influencing their current perspectives of both mathematics and science content and associated pedagogical practices.

III. Course Objectives and Learning Outcomes

1) To increase student understanding of epistemology and its role in the evolution and development of mathematical and scientific knowledge;
2) To increase student understanding of cultural-historical influences on the evolution and development of mathematical and scientific knowledge;
3) To increase student understanding of research and scholarly work in the history of mathematics and science and its relevance to EC-12 STEM education;
4) To allow students to engage in class discussions and assignments which require an examination of both scientific (including mathematical) content knowledge and pedagogical content knowledge.

Upon completion of this course, students will be able to:

1) Communicate, both orally and through writing, in a scholarly way;
2) Examine current mathematics and science curricula from both critical-historical and epistemological perspectives;
3) Create and nurture personal philosophical and epistemological perspectives of a domain in STEM education;
4) Examine and re-design pedagogical approaches in mathematics and science education from both a critical-historical and epistemological perspective.

IV. Learning Modules:

This course is designed using a **modular format**—that is, each week is "packaged" as a single module so that all the materials, lecture notes, submission areas, discussion posts are in one area for a given week.

V. Required Text & Readings:

- Required readings for all students will be available through open-source websites, through Blackboard, and through electronic journals accessible through the UTEP library website. Below is a **partial list** of required readings for all students (both doctoral and master's students).

    - Cusick, J. (2007). *Copernicus and Scientific Revolutions*. Polytechnic University.

    - Dennis, D. (2000). The role of historical studies in mathematics and science educational research. In Kelly & Lesh, R. (Eds.), *Research Design in Mathematics and Science Education (pp. 799-813)*. Lawrence Erlbaum Associates.
      Download this chapter: http://www.quadrivium.info/MathInt/MathIntentions.html

    - Dennis, D. (1997) Rene Descartes' curve-drawing devices: Experiments in the relations between mechanical motion and symbolic language.
      Download this article: http://www.quadrivium.info/MathHistoryIndex.html

    - Dennis, D., & Confrey, J. (1996). The creation of continuous exponents: A study of the methods and epistemology of John Wallis.
      Download this article: http://www.quadrivium.info/mathhistory/Wallis.pdf

    - Ernest, P. (2002). Empowerment in mathematics education. *Philosophy of Mathematics Education Journal, 15*.
      Download this article: http://people.exeter.ac.uk/PErnest/pome15/contents.htm

- McComas, W.F., Almazroa, H. & Clough, M.P. (1998) The Nature of Science in Science Education: An Introduction. *Science & Education, 7*, 511–532.

- Pengelley, D. (2009). Pascal's treatise on the arithmetical triangle: Mathematical induction, combinations, the Binomial Theorem and Fermat's Theorem. *MAA Notes (no. 74).* 185 – 196.

- Quinn, C.M., Reid, J.W., & Gardner, G.E. (2020). S+T+M=E as a convergent model for the nature of STEM. *Science & Education, 29*, 881-898.

- Sepkoski, D. (2005). Nominalism and constructivism in seventeenth-century mathematics. *Historia Mathematica, 32*, 33-59.

- Straulino, S. (2008). Reconstruction of Galileo Galilei's experiment: The inclined plane. *Physics Education, 43(*3), 316-321.

Additional readings for students will come from the **Mathematical Intentions** website: www.quadrivium.info

- *GeoGebra Classic 6: Dynamic Software for Everyone*. Available: www.geogebra.org. This is FREE, open-source software for both Mac and Windows platforms.

- ***ALL ADDITIONAL COURSE READING & HANDOUTS WILL BE MADE AVAILABLE ON Blackboard (through my.utep.edu). You MUST have a valid UTEP login and password to access my.utep.edu, Blackboard, and many other relevant UTEP websites.*** A UTEP e-mail address is required for all e-correspondence and more effective communication.

VI. Technology Requirements

Course content is delivered via the Internet through the Blackboard learning management system. Ensure your UTEP e-mail account is working and that you have access to the Web and a stable web browser. Google Chrome and Mozilla Firefox are the best browsers for Blackboard; other browsers may cause complications. When having technical difficulties, update your browser, clear your cache, or try switching to another browser.

You will need to have access to a computer/laptop, scanner, a webcam, and a microphone. You will need to download or update the following software: Microsoft Office, Adobe Acrobat Reader, Windows Media Player, QuickTime, and Java. Check that your computer hardware and software are up-to-date and able to access all parts of the course.

If you do not have a word-processing software, you can download Word and other Microsoft Office programs (including Excel, PowerPoint, Outlook and more) for free via UTEP's Microsoft Office Portal. Click the following link for more information about Microsoft Office 365 and follow the instructions.

IMPORTANT: If you encounter technical difficulties beyond your scope of troubleshooting, please contact the UTEP Help Desk as they are trained specifically in assisting with technological needs of students. Please do not contact me for this type of assistance. The Help Desk is much better equipped than I am to assist you!

VII. Statement Regarding COVID-19 Precautions

The University of Texas at El Paso requires everyone to wear a mask in common spaces, or where two or more individuals are located, including, but not limited to, classrooms. You must wear a mask covering your nose and mouth at all times in this class. If you choose not to wear a mask, you may not enter the classroom. If you remove your mask, you will be asked to put it on and/or leave the classroom. Students who refuse to wear a mask and/or follow preventive COVID-19 guidelines will be dismissed from the class and will be subject to disciplinary action according to Section 1.2.3 Health and Safety and Section 1.2.2.5 Disruptions as defined in the UTEP Handbook of Operating Procedure.

For each day that you attend campus—for any reason—you must complete the questions on the UTEP screening website (https://screening.utep.edu). The website will verify if you are permitted to attend class in-person. Under no circumstances should anyone come to class when feeling ill or exhibiting any of the known COVID-19 symptoms. If you are feeling unwell, please let me know as soon as possible, and alternative instruction will be provided. Students are advised to minimize the number of encounters with others to avoid infection. Please note that if COVID-19 conditions deteriorate in the City of El Paso, all course and lab activities will be transitioned to remote delivery.

VIII. Inclusiveness and Equity

Learning happens only when we feel respected as a whole human being. My top priority in our classroom 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 classroom 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 is welcome in our classroom space—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, our 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.

IX. Standards of Academic Integrity

Students are expected to uphold the highest standards of academic integrity. Any form of scholastic dishonesty is an affront to the pursuit of knowledge and jeopardizes the quality of the degree awarded to all graduates of UTEP. Any student who commits an act of scholastic dishonesty is subject to discipline. Scholastic dishonesty includes, but is not limited to cheating, plagiarism, collusion, the submission for credit of any work or materials that are not attributable in whole or in part to another person, taking an examination for another person, any act designed to give unfair advantage to a student or the attempt to commit such acts. Proven violations of the detailed regulations, as printed in the Handbook of Operating Procedures (HOP) and available in the Office of the Dean of Students, may result in sanctions ranging from disciplinary probation, to failing grades on the work in question, to failing grades in the course, to suspension or dismissal among others.

X. Students with Disabilities Statement

If you have or believe you have a disability, you may wish to self-identify. You can do so by providing documentation to the Center for Accommodations and Support Services (CASS) located in Union E Room 106. Students who have been designated as having a disability must reactivate their standing with CASS on a yearly basis. Failure to report to this office will place a student on the inactive list and nullify benefits received. If you have a condition which may affect your ability to exit safely from the premises in an emergency or which may cause an emergency during class, you are encouraged to discuss this in confidence with the instructor and/or the director of CASS. You may call 915-747-5148 for general information about the Americans with Disabilities Act (ADA).

XI. Evaluation & Coursework Requirements of Students:

Coursework Requirements	Points
Homework Assignments – 4 x 20 pts	80
Original papers – 3 x 20 pts	60
Final paper/project	60
TOTAL	200

How Grades are Determined	
Grade	**Percentage (%)**
A	90 - 100
B	80 - 89.9
C	70 - 79.9
D	60 - 69.9
F	Below 60

XII. Course Assignments

1. Original Papers

a) STEM 6305 Doctoral Students

You will complete 3 short writing assignments over the course of the semester (see calendar). Guidelines for each will be provided for you. The purpose of these assignments is to help you develop your personal philosophy and epistemology for a domain in STEM education. My hope is that this will be of benefit to you throughout your course of study, but, more importantly, when you come to conduct your own research.

b) MTED 5326 Graduate Students

At several points throughout the semester (see calendar), you will be asked to prepare a short (1-2 page) written reflection on an essay question that I will post on Blackboard. The question will focus on a topic or topics presented in class and associated readings.

2. Homework Assignments (All students)

During this course you will work on historically-based mathematics and science activities provided by me. You will be assigned homework assignments based on these activities. The homework assignments and due dates will be announced in class; typically, the homework will be due the following class day. All homework assignments will be posted on Blackboard. You will submit these in electronic format.

3. Final Project

a) STEM 6305 Doctoral Students

The focus of the final project is to write a synthesis paper aligned well with the student's developing research interest(s) in mathematics or science education. Some examples include, but are not limited to the following:

- Ask a question about mathematics or 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 mathematics or science? What are commonly held teacher (or student) beliefs about the nature of science? Write a review of the literature and develop your own set of recommendations grounded in the literature.

- Pick a particular mathematical or scientific concept and analyze its historical development. Include a theoretical framework that focuses on student/teacher learning for your given concept (i.e. why it is important for students and teachers to learn this topic or topics and why they should learn it based on your understanding of philosophy,

history, and nature of mathematics and science) and design a lesson (or lessons) based on your research of the concept.

You will be responsible for writing a **minimum 15 page** paper. For your paper, you must include an introduction section and a theoretical framework (i.e. why it is important for students and teachers to learn this topic or topics and why they should learn it based on your understanding of philosophy, nature, and history of mathematics and/or science). You are required to have **a minimum of ten solid references** from peer-reviewed journals or edited books.

b) MTED 5326 Graduate Students

The focus of the final project is to choose a specific mathematics topic from an historical perspective, refined by an epistemological and didactic perspective, and design a short sequence of lessons based on your choice of topic. You want to focus on how your topic is relevant to mathematics education research, given that we have examined the didactics and epistemology relevant to our current mathematics curriculum as well as a specific, highly relevant era of the history of mathematics.

Part 1: You will be responsible for writing a **minimum 10 page** paper supporting your choice of topic from a history of mathematics (i.e. a paper that justifies why you believe the topic you've chosen is important and how it is based on a sound understanding of the history of 17^{th} century mathematics, its epistemology and didactics). You are free to choose any era or time period within the history of mathematics. However, be sure that your choice of topic can be aligned with our current studies of the current mathematics curriculum.

For your paper, you must include an introduction section that introduces the content and the significance of the topic for mathematics education. Include a theoretical framework that focuses on student/teacher learning for your given topic (i.e. why it is important for students and teachers to learn this topic or topics and why they should learn it based on your understanding of 17^{th} century mathematics and the historical context that we analyze). You are required to have **a minimum of five solid references** from peer-reviewed journals or edited books.

Part 2: You are required to construct a sequence of activities (**a minimum of two**) based on your research. Topics will receive final approval from me. The completed sequence must involve either a technology (computer) component and/or two "hands-on" components (which can involve technology).

Further details about the project will be given in class along with continuing guidance from me. You will submit your project **on Wednesday, May 12th**, the final exam day. All materials related to the final project **must be** submitted on that day.

XIII. Course Requirements

1. **Participation**: It is expected that students will actively participate in working on projects and class discussions. With the emphasis on collegiality it is important that all group members be in class to contribute to the group's effort in developing an understanding of the course material.

2. **Due dates:** Assignments are due on the specified dates. Type or word-process written assignments. All assignments should be double spaced with a 12-point font. Number your pages.

3. **Calendar changes:** The schedule of topics and reading assignments may change over the course of the semester. Any changes to the syllabus will be announced. Every student is responsible for these changes.

XIV. Class Schedule: Please note that the schedule below is subject to change.

All assignments are DUE ON THE DATE INDICATED. ***MI*** *= Mathematical Intentions reading (www.quadrivium.info)*

DATE	TOPIC	ASSIGNMENT
Week 1 **January 20 (Zoom)**	• Historical study in math and science education research • STEM education research goals	**All students:** Dennis, D. (2000) Ernest P. (2002)
Week 2 **January 27**	• Nature of science as the foundation for STEM learning • NOS in math, engineering, and technology	**All students:** McComas et al. (1998)
Week 3 **February 3**	• Copernicus challenges 16th century science • Johannes Kepler's universe	**All students:** Cusick, J. (2007)
Week 4 **February 10**	• Geometry in the 17th century	**All students:** **MI:** Dennis & Addington (2009) Similarity, geometric arithmetic, and the geometric mean • **Paper 1 due**
Week 5 **February 17**	• Galileo Galilei and modeling nature	**Readings TBD** **All students:** Straulino, S. (2008); Dennis, D. (2015) (Video); Al-Khalili, J. (2019) (Video) • **Homework 1 due**
Week 6 **February 24**	• The mathematical way during the Scientific Revolution • Kepler's Proofs	**Doctoral students:** Sepkoski, D. (2005) **All students:** **MI:** Dennis & Addington (2009) Slide Rules & Logarithm Tables
Week 7 **March 3**	• Euclid fades away: Rene Descartes modeling nature	**All students:** **MI:** Dennis & Addington (2009) Descartes's logarithm machine • **Homework 2 due**
Week 8 **March 10**	• Euclid fades away: Rene Descartes modeling nature ○ The conic sections	**Doctoral students:** Dennis, D. (1997) **All students:** **MI:** Dennis & Addington (2009) Parabolas and coordinates; Drawing ellipses and finding tangents

Week 9
March 24 (Zoom)
	• Algebra that makes you think: The work of John Wallis
	  ○ Pascal's triangle
	  ○ Alhazen's summation formulas
		All students:
		Pengelley (2009)
		Dennis, D. & Confrey, J. (1996)
		• **Paper 2 due**

Week 10 **March 31 (Zoom)**	• Algebra that makes you think: The work of John Wallis ○ Isaac Newton and area	**All students:** Dennis, D. & Confrey, J. (1996)
Week 11 **April 7**	• On the shoulders of a giant: The work of Isaac Newton	**All students:** **MI:** Dennis & Addington (2009) Newton's binomial series **MI:** Dennis & Addington (2009) Newton and empirical interpolation • **Homework 3 due**
Week 12 **April 14**	• On the shoulders of a giant: The work of Isaac Newton • The great debate: The work of Gottfried W. Leibniz	**Doctoral students:** **MI:** Dennis & Addington (2009) The Cycloid; Sines, Circles, and Transmutations • **Homework 4 due**
Week 13 **April 21 (Zoom)**	• The great debate: The work of Gottfried W. Leibniz • Trigonometry: A Unifying Mathematics?	**All students:** • **Paper 3 due**
Week 14 **April 28**	• 18th century science and the Enlightenment	**All students:** Quinn, et al. (2020)
Week 15 **May 5**	• 18th century science and the Enlightenment	**Readings TBD**
Week 16 **May 12**	**Exam week**	**All students: Final papers due**