INTRODUCTION
The second quantum revolution has revealed the need of a competent workforce in Quantum Information Science (QIS).

Additionally, a formal introduction to physics is incomplete without an exploration of the quantum realm.

The teaching and learning of Quantum Mechanics (QM) in secondary school is receiving increasing attention form education researchers but is still an understudied area with a limited body of research on this topic.

Here we present an analysis of this body of research by bibliometric analysis.

We present a quantitative analysis of the bibliometrics, an assessment of publication trends in teaching and learning, and an analysis of research gaps and opportunities for further investigation is discussed.

RESEARCH QUESTIONS
1. How have publications on the teaching and learning of QM in secondary schools developed over time in terms of number of publications and citations?
2. What sources are contributing to physics education research on QM in secondary schools in terms of country and publishing venue?
3. What research trends can be witnessed throughout the collected body of work focusing on the teaching and learning of QM in secondary schools?

METHODS

Bibliometric Analysis

This method of analysis is used to display the research pattern and research activity on a certain topic.

- The academic search engines SCOPUS and Web of Science were used to obtain publications associated with the topic of focus.
- For this study, the topic of focus is the teaching and learning of quantum physics at the secondary level.
- The search queries used resulted in 45 total publications for analysis.
- Articles were accessed on March 8th, 2022.

TRENDS IN RESEARCH

A quantitative analysis of publications was pursued to analyze trends associated with yearly output, publishing venue, citation index, national affiliation of authors, and research methodology. Additionally, trends in research regarding orientation, teaching and learning, and instructional content is analyzed.

Orientation
Publications were identified as research-oriented or practitioner-oriented. We consider research-oriented publications as intending to assist in further research development and practitioner-oriented publications as intending to enhance instruction.

53% of publications were identified as research-oriented while 47% of publications were identified as practitioner-oriented.

Teaching & Learning
64% of the articles of focus were instructor-based, analyzing instructors, teaching, and/or instructional design, while 26% of articles were identified as student-based. 11% of articles presented a combined focus.

Instructional Content
Most articles isolated specific QM instructional content (91%) Wave-particle duality (24%) & Heisenberg’s Uncertainty Principle (22%) were most common.

These topics seem to have increase in focus only after 2017, having only been isolated in a study twice each prior to this year. 74% of publications after 2017 included one of these topics.

DISCUSSION

Gaps in Research
Two important lines of inquiry that we did not find within the research involve bridging instruction from classical physics to QM and when to introduce QM into the curriculum for optimal conceptual comprehension.

Additionally, more student-focused articles would likely benefit the field by providing insight into students’ conceptual development, learning challenges, and epistemological resources. A thorough investigation of student cognition during QM instruction would certainly aid in the development of teaching resources and appropriate pedagogical approaches to best address QM at the secondary level and increase the efficiency and effectiveness of lessons addressing this topic.

Lastly, an increase in quantitative methods of data analysis could serve as a great opportunity to expand this field of research and form strong conclusions. The common qualitative methods used in this field of research have led to the development of many useful and relevant hypotheses, as well as the identification of basic challenges and needs of students and teachers. However, now is the time to expand this research using quantitative methods to form strong conclusions and identify successful modes of inquiry through teaching and learning QM.

Future Directions
Dissertation study planned for Fall 2022.
Type of Study:
Descriptive Case Study
Population:
Secondary AP Physics class
Constructs of Focus:
Secondary student reasoning and epistemic framing during introductory instruction on quantum mechanics

"If you are not completely confused by quantum mechanics, you do not understand it." - John Wheeler