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REVIEW OF TRENDS IN PHYSICS EDUCATION RESEARCH USING TOPIC MODELING

Eunjeong Yun

Abstract. *For both physicists who teach students in university and physics educators, how physics should be taught is a vital question. This study reviewed the trends of research in the field of physics education to identify the status of physics education research and help researchers in future studies. 2,959 articles were collected from the American Journal of Physics (AJP) and 745 articles from the Physics Review Physics Education Research (PRPER). Abstracts of the collected articles were used for the study. After preprocessing the texts of the abstracts, topics were extracted from the texts using topic modeling. The Late Dirichlet Allocation (LDA) model of Mallet was used for topic modeling. A total of 13 topics were extracted from the two journals. In recent years, "pedagogical content of knowledge (PCK)," "assessment" of achievement and "gender" of student have been topics of increasing interest; "teacher education" and "students' reasoning process" have been topics with continuous high interest, and "introductory physics" and "problem solving" in physics have been topics with decreasing interest.*

Keywords: *physics education research, physics education, research trend, topic modeling.*

Eunjeong Yun
Kyungpook National University, Korea

Introduction

Many physicists teach students in university and physics educators teach preservice physics teachers. Therefore, for both groups, the question of how physics should be taught is an important issue. In terms of research, however, physics education research seems to have a split personality (Wittmann, 2018). It embodies two things: physics education as a branch of the physics community and as a branch of the science education community. While the first is focused more on the content of physics, the second is more focused on pedagogical aspect. However, even if they are split from the point of view of research, the students who are subject to physics education are not, so it will be necessary to consider both aspects of research in terms of their results in the classroom. Up until now, in the field of science education, research studies looking at trends have been conducted frequently (Cavas, 2015; Lee et al., 2009; Piburn et al., 2003; Tsai & Wen, 2005). However, research on trends that is limited to physics education has been rare. It can be seen as organizing the history of a field by revealing what topics researchers have studied from the past to present, what topics received more or less attention, and how changes in interest took place over time. The study examined trends in research within the field of physics education by extracting topics from past to present and examining changes in interest. In particular, the community in which physicists and physics educators coexist was studied to address the interface of interests in both areas.

Organizing and examining research trends can help us identify the trends of interest from the past as well as serve as a milestone for future research directions (Cavas, 2015). First, researchers can examine important issues in the field of physics education by identifying the extent to which they are addressed in pedagogical research. Second, information can be obtained on physics education research trends by studying how interest in topics change over time. Third topics can be explored that have been relatively marginalized or neglected and these can then be utilized in determining future research topics.

In order to examine the trends in research on physics education, AJP and PRPER were selected as representative journals shared by physicists and physics educators alike and that are deemed to encompass both the scientific content and pedagogical aspects of physics. The American Journal of Physics (AJP) is an academic journal that has published numerous articles on the educational and cultural aspects of physics since it was established in the 1930s (Henderson, 2009). Pedagogical issues at the undergraduate and graduate levels are one of the main concerns of AJP; therefore, many studies

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have been published to educate students more effectively and efficiently about physics content. Moreover, AJP created the PER section during the early 2000s and it continued up to 2018, when AJP decided to stop publishing the section. Physical Review Physics Education Research (PRPER), by contrast, was created exclusively for physics education research beginning in the 2000s.

Although AJP and PRPER are representative journals in the field of physics education, there can be differences in topics depending on the characteristics of each journal or the nature of its community members. Therefore, this study examined research topics from the beginning of the publication of each journal, 1930s in case of AJP and 2005 in case of PRPER, to the present day. The purpose of evaluating the topics for each journal separately was to look more broadly at the research topics that researchers in the field of physics education have been addressing. The accuracy of topic selection was refined by discussions about the objectives, methods and results of the paper, with the text of the abstract of the papers as the object of analysis.

Admittedly, these two journals do not cover the whole of physics education research around the world. However, AJP covers long period of physics education research that is nearly 90 years, and PRPER is journal only focusing on physics education research. Therefore, they can be regarded as appropriate for identifying the characteristics of physics education research as distinct from research in science education generally.

Topic Modeling

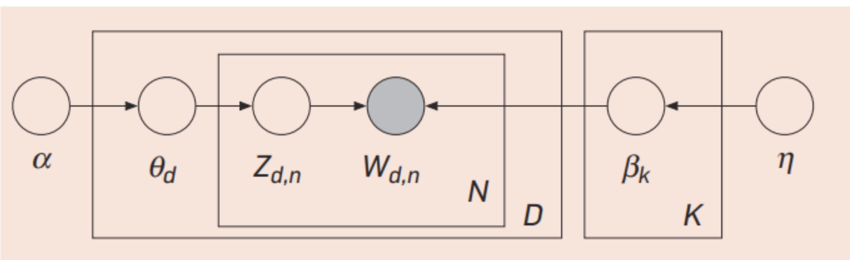
Instead of manually and individually examining numerous papers, the topic modeling method, an algorithm for extracting topics from large texts, was used. Topic modeling easily quantitatively analyzed the large amounts of data from the past several decades and summarized the results to help identify trends at a glance (Blei, 2012). Topic modeling is considered a more suitable technique than a clustering technique for modeling the real world, since a single document can correspond to multiple topics at the same time, instead of assigning each document to a single topic (Alghamdi & Alfalqi, 2015).

There are several techniques of topic modeling such as Probabilistic Latent Semantic Analysis (Hofmann, 1999), Latent Dirichlet Allocation (LDA) (Blei et al., 2003), Hierarchical Dirichlet Processes (Teh et al., 2004), Correlated Topic Models (Blei & Laerty, 2006), and Pachinko Allocation (Li & Mccallum, 2006). While some are more recent than LDA, it is the most widely used topic modeling (Morstatter & Liu, 2018).

The LDA technique is designed to identify a topic by extracting a group of words used at high probability and frequency from the document, based on the fact that the words related to the subject are used uniquely in the document compared to other documents (Blei et al., 2003).

Figure 1 shows the graphical model for the LDA model (Blei, 2012). B_k is a distribution over the vocabulary, θ_d is the topic proportion for the topic in document d, $Z_{d,n}$ is the topic assignment for the nth word in document d, $W_{d,n}$ is the n^{th} word in document d, which is an element from the fixed vocabulary, while α is the proportions parameter and η is the topic parameter.

Figure 1
The graphical model for LDA (Latent Dirichlet Allocation)



Each document is represented by potential topics, and each topic is represented by the group of words. As a result, LDA can identify topics in the entire document group and the percentage of topics in each document, based on the probability that each word will be included in the topic (Foster & Inglis, 2019).

In short, this study aimed to extract topics covered in journals specialized in physics education using topic modeling. The changing trends of the extracted topics by year was analyzed. Considering that physicists are relatively less involved in science education journals, the results of this study are expected to give a variety of information

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to science educators based in physics. It is important to share information and strive for collaboration between physicists and physics educators.

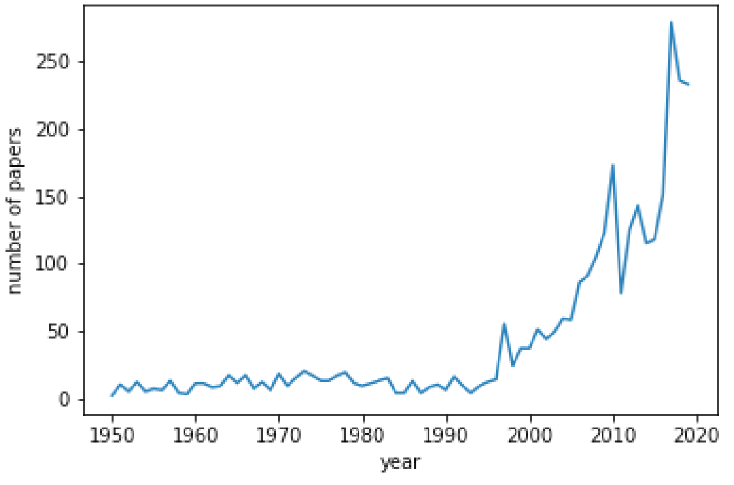
Research Methodology

Data

Papers of AJP

The AJP divides papers into subsections by 'topic.' The 'topic' is a distinction of subfield or specific theme in physics. Topics are different from the keywords of the paper and have more comprehensive distinctions. Among the topics identified by the AJP, the topics 'educational aid' and 'teaching' were selected for physics education papers. As a result, the abstracts of 13,801 papers on those two topics were retrieved that had been published from 1934 to 2019 in AJP. All abstracts were collected from website of the journal. Most of the papers with topics classified under 'educational aid' had also been classified under 'teaching,' so there were many duplicates. Therefore, all the duplicated papers were removed. Moreover, there were many cases in which the extracted papers focused on academic rather than educational content, even though they were divided into these topics. Since the purpose of this study is to analyze research trends on physics education topics, papers focusing on academic content were excluded from the study. Using the word 'student' as the second search term, papers containing the word 'student' in the extracted abstract were extracted and included in the study data. Finally, a total of 2,959 papers were selected for the study. The year-by-year distribution of the 2,959 papers is shown in Figure 2. There was a sharp increase in the papers on teaching topics that include 'student' in the abstract of the paper from the mid-to-late 1990s. This phenomenon can be interpreted as the influence of creation of the PER section in AJP that started in the late 1990s. Since 2018, AJP no longer publishes papers on physics education, but more than 2,000 papers were published over a period of about 80 years, which is considered the best data to examine trends in physics education research.

Figure 2
Number of PER papers in AJP (American Journal of Physics)



Papers of PRPER

Unlike the AJP, all papers in the PRPER can be considered educational papers; so, the abstracts of all the papers have been collected, since its inception in 2005, from the website of the journal. From 2005 to 2019, a total of 745 papers were published. The distribution by year is shown by year in Figure 3, where it can be seen that the number or papers in PRPER has been steadily and rapidly growing since its inception. Considering this trend together with the rapid increase in the number of AJP's educational papers since the 2000s, we can see that the overall number of papers in physics education research is steadily increasing.

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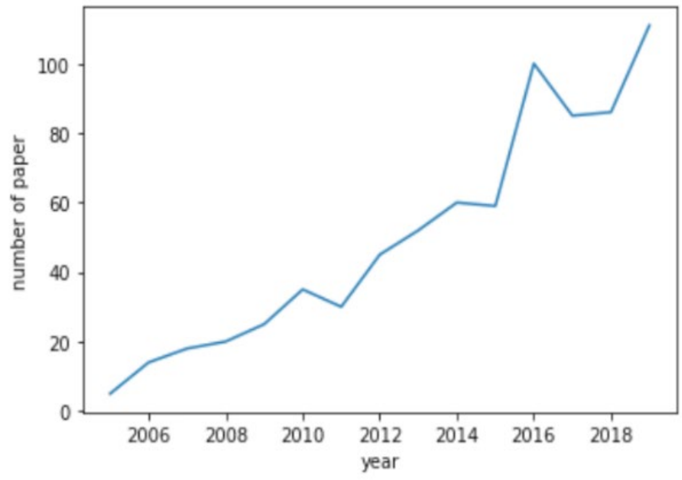
Figure 3
Number of papers in PRPER (Physical Review Physics Education Research)



Preprocess of Data

The abstract texts were extracted from a total of 3,704 papers, and each one was considered to be a document for the unit of analysis. Prior to performing topic modeling, text preprocessing was performed to increase the reliability of the results. First, we refined the collected texts using the Natural Language Toolkit (NLTK), which is a tool for natural language processing in Python (Bird et al., 2009). All characters were converted to lowercase and any special characters or stop words, such as postpositions and articles, were removed. Any grammatically marked such as plural forms of nouns or past tense forms of verbs, were converted into their basic forms.

Topic Modeling

Text processing and topic modeling were both accomplished using Python 3, and topic modeling was done using the LDA model of Mallet (McCallum, 2002). The LDA model provides a set of words corresponding to the topic, according to the number of topics that you specify, so it is important to explore the appropriate number of topics. In general, perplexity value is used to decide the number of topics (Foster & Inglis, 2019). However, the use of perplexity has a number of limitations, and a method called topic coherence produces better results than perplexity (Newman et al., 2010). In this study, topic coherence value was used to determine the appropriate number of topics in each journal. There are several ways to get topic coherence (Newman et al., 2010), however, method provided by Mallet was used in the present study. This value is based on the degree of co-occurrences between words extracted from the topic, as calculated for the top 10 words for each topic as follows (McCallum, 2002). In the formula below, means the number of documents containing the word), which is the top 10 in the topic.

$$\sum_{i} \sum_{j<i} \log \frac{D(w_j, w_i) + \beta}{D(w_i)}$$

In this way, the number of topics was entered sequentially from 2 to 40 to calculate the coherence value. The number of topics with the largest coherence value was chosen as the appropriate number of topics.

Topic modeling provides a set of 10 words to embody a topic, and theme was generated by qualitatively examining the groups of words presented in the topic modeling results. At this time, the top five papers with the highest weight for each topic were examined and referenced to create the topic title, or theme.

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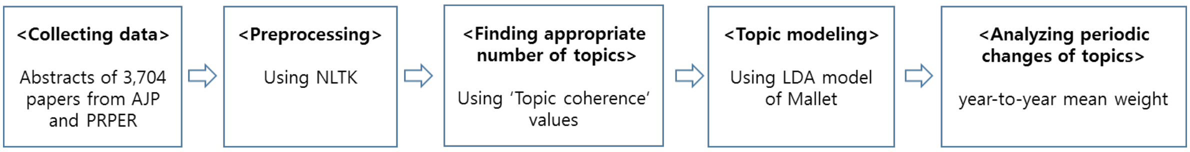
Periodic Changes in Topics

By targeting individual topics extracted as a result of topic modeling, changes were examined in the degree to which these topics were studied over time. The weight values of all the analyzed papers were obtained, and year-to-year mean weight was graphed. The research process is presented below in Figure 4.

Figure 4
Study process



Research Results

Appropriate Number of Topics

Topic modeling was performed by changing the number of topics from 2 to 40 and calculating coherence scores by number of topics, as illustrated in Figs. 5–6. Generally, a higher coherence value means the number of topics that could describe the entire data more reliably. According to Figs. 5 and 6, the coherence score was highest using eight topics in both of journals; therefore, it was determined that eight is the appropriate number of topics in both of journals.

Figure 5
Coherence score graph of AJP

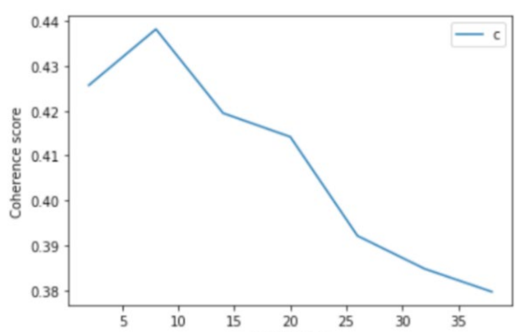
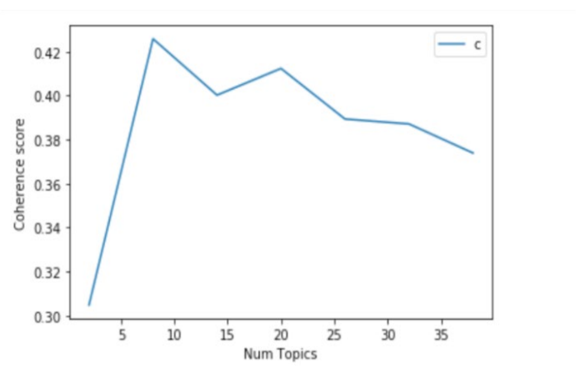


Figure 6
Coherence score graph of PRPER



Making the Title of Each Topic

After qualitatively examining the words that comprise the topics and the top five papers of each topic, a title was created for each topic. These are presented in Tables 1 and 2. After observing the titles of the top five papers by topic, it became clear that the topic modeling had been successful, and the papers had been appropriately extracted for each topic. Overall, each of the eight topics contained between 10% and 18% of all analyzed papers. There were some differences between the topics in the two journals. The topics with the most papers were 'pedagogical content of knowledge' (PCK) in AJP, but 'assessment' and 'students' reasoning process' in PRPER. 'Problem solving,' 'school program,' and 'introductory physics' were common topics between both journals.

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Table 1
Theme of topics and most related papers of AJP.

Topic number	Theme	Topic words	Number of papers (ratio)	Top 5 weighted papers in each topic
1	Introductory physics	Introductory, physics, instruction, student, conceptual	336 (0.11)	• Assessment of difficulties of some conceptual areas from electricity and magnetism using the Conceptual Survey of Electricity and Magnetism • Chronicling a successful secondary implementation of Studio Physics • Additional evidence of far transfer of scientific reasoning skills acquired in a CLASP reformed physics course • Does stereotype threat affect female students' performance in introductory physics? • Impact of the FIU PhysTEC Reform of introductory physics labs
2	Teaching models	Model, research, learn, result, test,	306 (0.10)	• Effect of project-based learning model assisted by student worksheet on critical thinking abilities of high school students • Development of the evaluation instrument use CIPP on the implementation of project assessment topic optic • The influence of Moodle-based e-learning on self-directed learning of senior high school students • Inexpensive electrolysis of batik wastewater: Project-based learning (PjBL) in MA Salafiyah Simbang Kulon Pekalongan, Indonesia • The development of form two mathematics i-Think module (Mi-T2)
3	Force and motion	Force, motion, object, equation, measure	370 (0.13)	• The added mass of a spherical projectile • A 3D-printed wheel with constant mass and variable moment of inertia for lab and demonstration • Coefficient of rolling friction - Lab experiment • Misconception concerning the dynamics of the impact ball apparatus • Can a string's tension exert a torque on a pulley?
4	School program	Physics university, high school, college, program,	326 (0.11)	• Diversity in physics • Underrepresented minorities among physics family members • Venerable Virginia science academy welcomes new one • Women in physics in South Africa: The story to 2008 • Consortium for the Advancement of Physics Education: Three Years of Activity
5	Problem solving	Problem, question, provide, find, give,	401 (0.14)	• Helping students learn effective problem -solving strategies by reflecting with peers • Using reflection with peers to help students learn effective problem- solving strategies • Effect of self- diagnosis on subsequent problem- solving performance • The effect of grading incentive on student discourse in Peer Instruction • Self -diagnosis, scaffolding, and transfer in a more conventional introductory physics problem
6	Pedagogical content knowledge (PCK)	Knowledge, content, teacher, teaching, activity,	531 (0.18)	• Lesson learned of building up community of practice for STEM education in Thailand • Developing pre-service science teachers' pedagogical content knowledge by using training program • Should we learn culture in chemistry classroom? Integration ethnochemistry in culturally responsive teaching • Capturing and portraying science student teachers' pedagogical content knowledge through CoRe construction • Understanding primary school science teachers' pedagogical content knowledge: The case of teaching global warming

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Topic number	Theme	Topic words	Number of papers (ratio)	Top 5 weighted papers in each topic
7	Student's learning strategy	Student, concept, understand-ing, method, mathematics	295 (0.10)	• Strategic competence of senior secondary school students in solving mathematics problem based on cognitive style • The analysis of probability task completion; Taxonomy of probabilistic thinking-based across gender in elementary school students • Students' mental models on the solubility and solubility product concept • A study of students' learning styles and mathematics anxiety among form four students in Kerian Perak • Mathematical disposition of junior high school students viewed from learning styles
8	Experiment	Experiment, laboratory, demonstration, describe, system,	394 (0.13)	• An electrochromic film device to teach polymer electrochemical physics • New experiments on wave physics with a simply modified ripple tank • Modern optical signal processing experiments demonstrating intensity and pulse-width modulation using an acousto-optic modulator • Interferometric measurement of the resonant absorption and refractive index in rubidium gas • Student laboratory demonstration of the Josephson effects with Clarke Slugs

Table 2
Theme and most related papers of PRPER

Topic number	Theme	Topic words	Number of papers (ratio)	Top 5 weighted papers in each topic
1	Assess-ment	Assessment, test, question, response, item,	102 (0.14)	• Test equity in developing short version conceptual inventories: A case study on the Con-ceptual Survey of Electricity and Magnetism • Dividing the Force Concept Inventory into two equivalent half-length tests • Multidimensional item response theory and the Force Concept Inventory • Classical test theory and item response theory comparison of the brief electricity and magnetism assessment and the conceptual survey of electricity and magnetism • Linking and comparing short and full-length concept inventories of electricity and magnet-ism using item response theory
2	Gender	Gender, woman, attitude, experience, belief,	93 (0.13)	• Sexual harassment reported by undergraduate female physicists • Women in physics: A comparison to science, technology, engineering, and math education over four decades • Gender disparities in second-semester college physics: The incremental effects of a "smog of bias" • Gender, experience, and self-efficacy in introductory physics • Factors that affect the physical science career interest of female students: Testing five common hypotheses
3	Student's concept	Concept, knowledge, understand, representa-tion, theory,	73 (0.10)	• Interference between electric and magnetic concepts in introductory physics • Textbook presentations of weight: Conceptual difficulties and language ambiguities • Student conceptual resources for understanding mechanical wave propagation • Qualitative investigation into students' use of divergence and curl in electromagnetism • Students' conclusions from measurement data: The more decimal places, the better?

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Topic number	Theme	Topic words	Number of papers (ratio)	Top 5 weighted papers in each topic
4	Teacher education	Instructor, teaching, classroom, faculty, research	94 (0.13)	• Pedagogical sensemaking or "doing school": In well-designed workshop sessions, facilitation makes the difference • Faculty online learning communities: A model for sustained teaching transformation • Use of research-based instructional strategies: How to avoid faculty quitting • Learning from avatars: Learning assistants practice physics pedagogy in a classroom simulator • How faculty learn about and implement research-based instructional strategies: The case of Peer Instruction
5	Student's reasoning process	Reasoning, model, framework, process, develop	102 (0.14)	• Ontological metaphors for negative energy in an interdisciplinary context • How substance-based ontologies for gravity can be productive: A case study • Students' flexible use of ontologies and the value of tentative reasoning: Examples of conceptual understanding in three canonical topics of quantum mechanics • Developing the use of visual representations to explain basic astronomy phenomena • Students' reasoning about "high-energy bonds" and ATP: A vision of interdisciplinary education
6	School program	Program, teacher, provide, develop, school	90 (0.12)	• Characteristics of effective astronomer-educator partnerships in formal urban middle school science classrooms • Postsecondary physics curricula and Universal Design for Learning: Planning for diverse learners • Motivations of educators for participating in an authentic astronomy research experience professional development program • Organizing physics teacher professional education around productive habit development: A way to meet reform challenges • Analysis of secondary school quantum physics curricula of 15 different countries: Different perspectives on a challenging topic
7	Introductory physics	Introductory, class, instruction, score, learn	92 (0.12)	• Exploring physics students' engagement with online instructional videos in an introductory mechanics course • Benefits of completing homework for students with different aptitudes in an introductory electricity and magnetism course • Talking and learning physics: Predicting future grades from network measures and Force Concept Inventory pretest scores • Student effort expectations and their learning in first-year introductory physics: A case study in Thailand • Peer Instruction in introductory physics: A method to bring about positive changes in students' attitudes and beliefs
8	Problem solving	Problem, problem-solving, difficulty, solve, task	95 (0.13)	• Can short-duration visual cues influence students' reasoning and eye movements in physics problems? • How students process equations in solving quantitative synthesis problems? Role of mathematical complexity in students' mathematical performance • Student understanding of graph slope and area under a graph: A comparison of physics and non-physics students • Students' conceptual performance on synthesis physics problems with varying mathematical complexity • Tenth graders' problem-solving performance, self-efficacy, and perceptions of physics problems with different representational formats

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Changing Interest in Each Topic by Year

Figure 7 shows the graphs of the mean year-to-year weight of articles from the 1930s to 2019 for each topic of AJP. Research of "teaching model" and "PCK" have been on the rise since the 2000s, and research of "introductory physics," "physics program," and "experiment" have been gradually decreasing. Research of "learning strategy" and "and motion" have been continuously conducted with a very weak increasing trend. Research of "problem solving" show an upward trend overall, with ups and downs, but with a clear decrease from 2010 to 2019. Taken together, research on school programs at the macroscopic level as well as academic content such as experiments, or concepts declined over time. In contrast, research aimed at improving pedagogical expertise in teaching physics, such as development of a teaching model or PCK, increased.

Figure 7
Graphs of mean weight of articles by topic of AJP

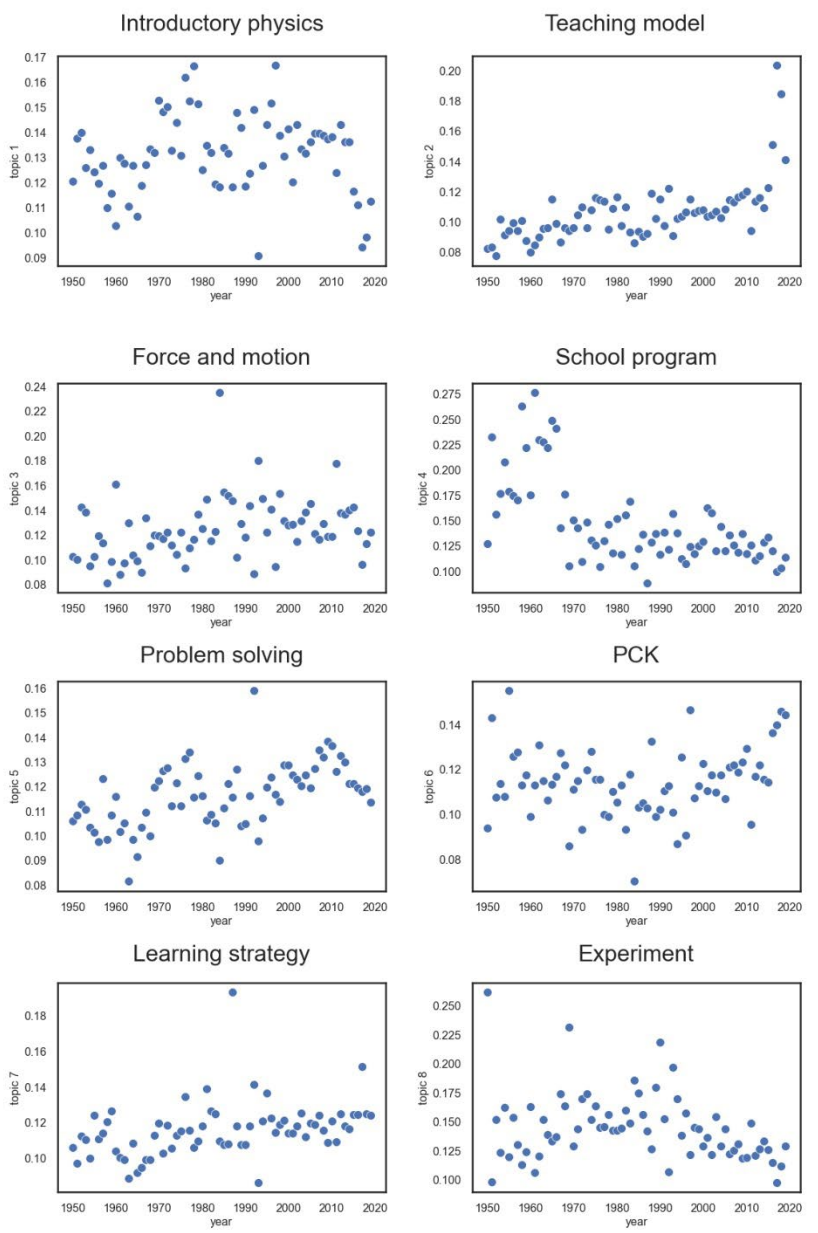

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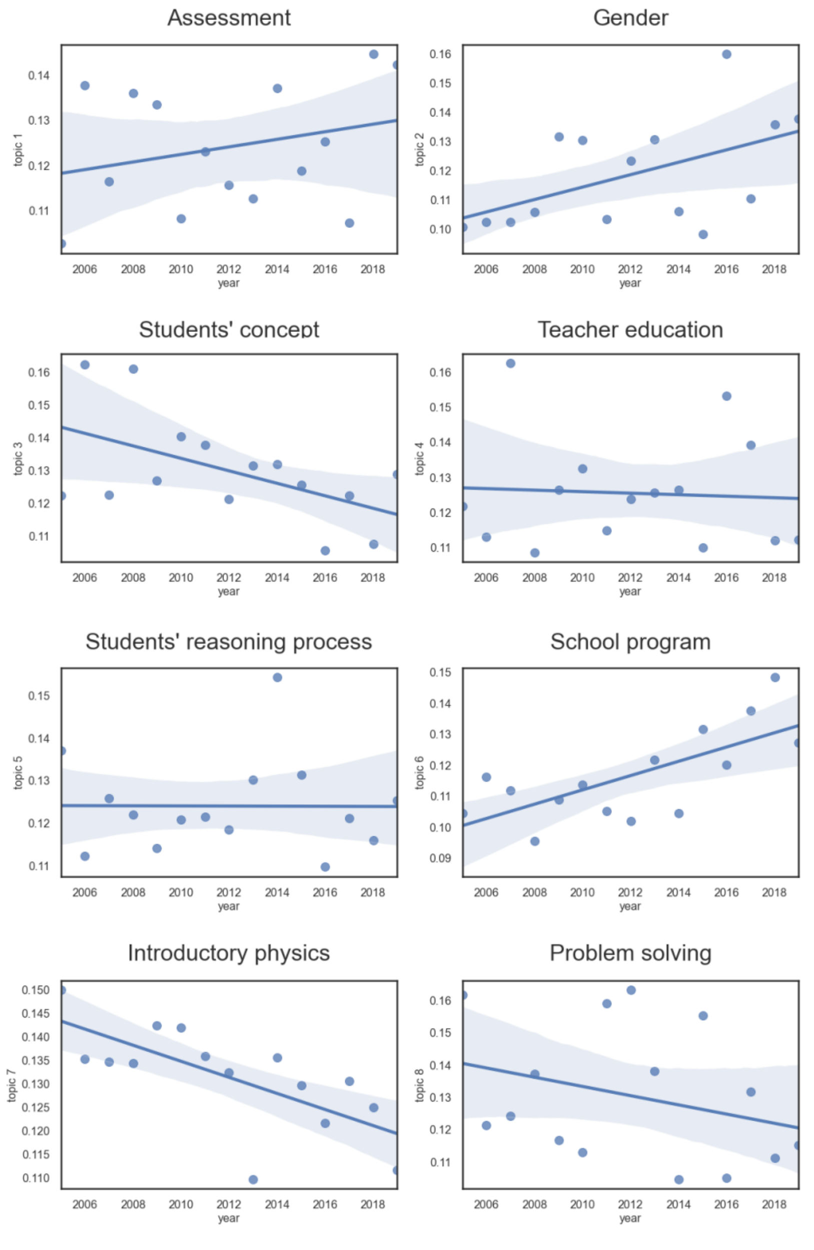
Figure 8 shows the graphs of the mean year-to-year weight of articles from 2005 to 2019 for each topic of PRPER. In the case of PRPER, there were not enough points to discern a tendency; therefore, the regression line was added to the graph so the changing tendency could be seen. Research of "assessment," "gender," and "school program" have been on the rise, and research of "students' concept," "introductory physics," and "problem solving" have been decreasing. It was unusual that the number of papers on "school program" was shown in contrast to the AJP.

Figure 8
Graphs of mean weight of articles by topic of PRPER



Some topics are found in common in both journals, but some are not. Figure 9 shows the overall research trend of PER. In Fig. 9, red bars indicate the topics of decreasing interest and blue bars denote the topics of increasing interest. Colorless bars are the topics of constant interest. Rather than emphasizing the difference between the

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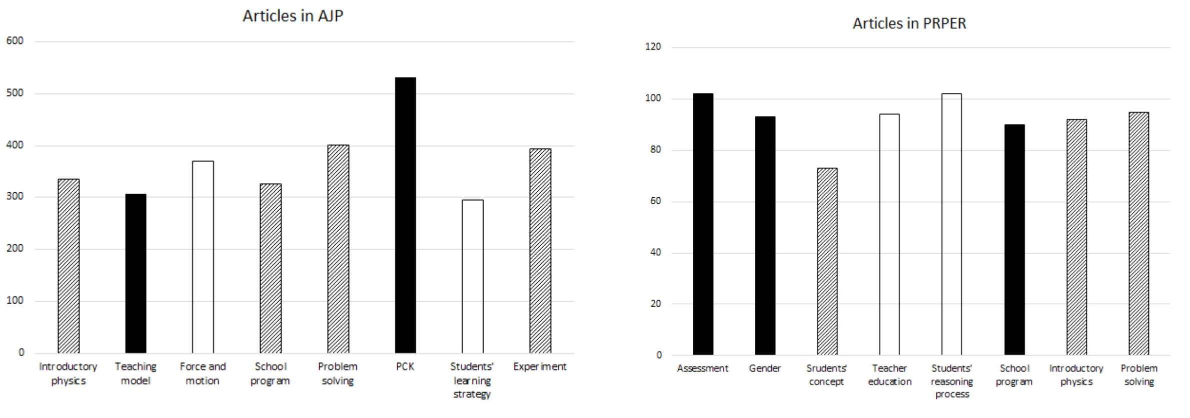
two journals here, it seems appropriate to aggregate the results of the two journals and explore the overall trends. The 13 topics represented in Figure 9 may be regarded as the main research topics in physics education that both physicists and physics educators are paying attention to. Of these, 'PCK' and 'assessment' were the two topics that have received not only the most but increasing attention.

Figure 9
Overall research trend of PER



Discussion

First of all, it is evident that interest in physics education has been increasing rapidly since the 2000s. The sharp increase in the number of physics education papers since 2000 can be attributed both to the opening of AJP's PER session and to the beginning of the PRPER journal. Both of these developments reflect the desire of the academic community for additional research in the area of physics education. The rapid increase in the number of papers in physics education in these two journals over the past 20 years is also evidence of an increased interest in physics education. As mentioned in the introduction, AJP and PRPER can be viewed as academic communities involving both physicists and physics educators. The results of this study can, therefore, be understood as part of the growing interest of physicists in education and of physics educators in the application of science education theory. It is particularly important to note that the interest in research on education is increasing among physicists. This helps to provide academic support for the field of physics education. It is a very positive sign that the two groups, which have in the past often acted independently, can indeed collaborate with each other for the common goal of better physics education for students.

Second, 13 topics that have been actively studied for some time in the field of physics education have now been extracted from these two journals. Some were topics of common interest for both journals, others not. The fact that these 13 topics have received a lot of attention from researchers in the field of physics education could be taken to mean that physics education is having a lot of problems around these topics. Topics commonly extracted from the two journals were 'introductory physics,' 'problem solving' and 'school program.' 'Introductory physics' is an important step in building an academic foundation at the beginning of learning physics. However, the fact that there are many papers for introductory physics means that despite the continuing research over the last 80 years, there are still many difficulties and issues for students at this level. It can be interpreted that 'problem solving' is receiving a lot of attention because teaching problem-solving for physics is difficult, and that any number of physics classes have been spent on problem solving from the past down to the present. The 'school program' topic may be related to the particular era or social situation, but the need for a new program may be reduced if a satisfactory and stable program is put in place. Therefore, meta-studies are needed to look at and analyze the current research results in more detail for each of the three topics, 'introductory physics,' 'problem solving' and 'school program' and to address in-depth discussions on problems, improvements and future research.

The 13 topics identified in this study reveal some differences from previous research that also identified topics of science education research. Previous research on topics of 'learning' found things such as conceptual change and misconception, which received a lot of attention (Lee, Wo, & Tsai, 2009; Cavas et al., 2012; Cavas, 2015; Tsai &

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Wen, 2005). In the present study, just focusing on physics education journals, there are only three topics, 'learning strategy,' 'concept' and 'reasoning process,' out of the thirteen identified, that are about 'learning.' Meanwhile, trending topics in the science education research of the 2000's, such as TPACK and STEM (Usak, 2018) do not appear in the present study. These two sets of facts could be interpreted as indicating that physics education research and the science education community are simply interested in different things. It might also be productive to investigate why these differences exist and explore ways of integrating research in the two fields.

Third, it is important to follow up on the changes in the topics of interest over the years and to study the cause of changes. Looking at the changes of interest regarding topics in AJP, research into PCK still accounts for a high percentage of the total and still shows a steady increase, despite the recent interruption of the PER session. This suggests that PCK may be the closest point of common interest for physicists and physics educators, and that therefore it is an area that should be studied more actively in the future.

Contrast this with the situation in science education. It was noted at least as long as five years ago that research into PCK was on the decline in science education (Cavas, 2015). Whereas research on PCK was once conducted actively in science education, now there has been a shift of interest to TPACK or STEM (Usak, 2018). Research in the field of science education tends to be somewhat ahead of actual classroom changes. This sequence makes sense, because theoretical research must be verified before it can be applied in the classroom. It may be necessary for science educators to look back to the fact that it has not been adequately addressed in science education, while there is still a high demand for research into PCK in physics classrooms.

Studies on 'gender' and 'assessment' have recently increased, while studies on 'experiment' have decreased. It will be necessary to identify the causes of these changes in interest and to examine the direction of research in light of social changes in general. In particular, it is necessary to look deeply into the reasons why interest in and research on experiments are declining, even though experiments are still important to physics teaching and learning.

Conclusions

13 topics that have received a lot of attention over time have been extracted from two journals and are important to the physics community. These topics were distinct from those previously identified in reviews of general science education research. Relatively less attention was paid to learning, and trending topics within the science education community were not actively addressed. Teaching and assessment programs were given more attention than learning, though classic topics were given regular attention. While STEM and TPACK are very actively studied in the science education research, these topics did not appear in the physics education research. Physics education research recently showed a steep upward trend in the topics of teaching model, PCK, assessment, and gender.

From the perspective of the science education community, these differences may be thought of as having two main implications. First, they provide information on what topics to approach in order to communicate with the physics education journal. Second, it suggests the need for science educators to think about the causes of the divided research trend of physics education, and to further explore ways for the two groups to collaborate for the sake of all students who receive teaching in the physics. It may be useful to consider the fact that the science education community has a high percentage of experts in their ranks who train science teachers including physics teachers, and that the physics education community as a branch of physics society has a high percentage of experts who teach physics directly in classrooms of secondary schools or universities. The same is undoubtedly true for the numerous professionally trained biologists and chemists and other professional scientists and science educators who spend the bulk of their time teaching. It is important for physicists and physics educators to actively interact and collaborate for our mutual professional development and the benefit of students who receive education in the sciences.

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Eunjeong Yun PhD, Research Professor, Kyungpook National University, 41566 Daegu, Korea.
E-mail: ejyun@knu.ac.kr
Website: https://www.researchgate.net/profile/Eunjeong_Yun
ORCID: 0000-0002-8077-7308