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To cite this article:

Mataka, L.M. & Taibu, R.N. (2025). Preservice elementary teacher readiness to teach using inquiry after a blended science content and methods course. *International Journal of Research in Education and Science (IJRES), 11*(4), 850-870. https://doi.org/10.46328/ijres.3748

International Journal of Research in Education and Science
2025, Vol. 11, No. 4, 850-870 https://doi.org/10.46328/ijres.3748

Preservice Elementary Teacher Readiness to Teach Using Inquiry After a Blended Science Content and Methods Course

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Article Info

Article History
Received:
20 April 2025
Accepted:
30 August 2025

Keywords
Blended learning
Inquiry-based learning
Readiness to teach
Open-ended surveys

Abstract

A mixed methods study was used to investigate the influence of blended learning on preservice teachers' readiness to teach using inquiry-based learning. Online science teaching methods activities were added to a face-to-face science content class for the preservice teachers to improve their readiness to teach using inquiry-based learning. An instrument, the Teacher Readiness Survey, was developed and validated, and then used to collect pre- and post-test scores. Four factors related to teaching were observed using confirmatory factor analysis. Inferential statistics, t-tests, two-way ANOVA, and regressions were used. Cohen's d effect sizes were also used. An open-ended survey was used to obtain qualitative data. A significant improvement in teacher readiness to use inquiry-based learning was observed. Regression analysis indicated that some of the four factors obtained during the confirmatory factor analysis had a predictive influence on each other, while others did not. The qualitative data provided more information on why this improvement was observed. These results inform targeted recommendations for teacher training and suggest avenues for further investigation.

Introduction

Teachers have been encouraged to teach science in a way that focuses on students' deeper understanding instead of rote memorization (NGSS, 2013). Teaching deeper understanding will depend on the teachers' content and pedagogical knowledge. Institutions that prepare elementary teachers have the task of ensuring that the teachers are ready to teach students for deeper understanding.

Inquiry teaching and learning can be a strong tool for teaching deeper understanding because students interact with the learning, communicate their understanding, and defend their positions to their teachers and peers (Zilka, 2021). In this case, students are afforded opportunities to deal with a concept in multiple ways, which increases understanding. Inquiry activities also demonstrate knowledge application because the students interact with the materials (De Jong, 2006). Therefore, colleges and universities must ensure that preservice elementary teachers are well-prepared to teach science through inquiry.

In universities, elementary teachers take science courses and methods courses separately. They usually start with science courses before entering the education programs to focus on methods courses and education foundation courses. While this has been a tradition, there is a need for courses combining science and methods in the same course in teacher preparatory programs. This combination allows the faculty to provide modeling of science teaching methods while teaching the content. This will enable preservice teachers to observe the teaching methods they are learning applied in real life. It should be noted that some institutions, such as Western Michigan University, especially the Mallison Institute for Science Education, have incorporated ‘methods’ in some science courses (i.e., have modeled student-centered, inquiry-based teaching). One course named “Physics: Inquiry and Insights” is taught by presenting content in a way that models inquiry-based teaching. Such courses are taught mostly by graduate assistants who are usually inexperienced in teaching methods. It is also unclear if such courses have been assessed to determine their effect on teacher readiness to teach using inquiry.

Learning resources such as Physics by Inquiry (McDermott, 1995) and Physics and Everyday Thinking (Goldberg et al., 2008) seem to exhibit features of the content/methods mixed approach. While these learning resources may seem consistent with our proposed approach, they are intended for a general student population and not preservice educators, and hence, they miss the opportunity to have preservice teachers explicitly discuss the teaching methods for a particular concept/topic. Further, such materials broadly focus on introductory physics, not conceptual physics, which is relevant to preservice elementary and middle school teachers.

Methods course or science course? If the idea is to incorporate methods into a science course, what should we call the course? Calling it a ‘methods course’ might imply that it is solely or predominantly a course focused on methods, while calling it a science course might mean that it is a course that is focused on science content. A science course that incorporates methods throughout the topics may assume names such as ‘Science Content and Methods’. The obvious department such a course may be offered is a science education department. Oftentimes, some institutions do not have this ‘middle ground’ department. This was the case in this study. The ‘methods’ were incorporated in a physical science course, such that the overall course ideally resembled a “Science Content and Methods’ course.

Howitt, C. (2007) surveyed 28 preservice elementary teachers about what they believed contributed to their confidence in science and the teaching of science, where a holistic teaching/learning approach was taken. By ‘holistic’, the authors considered six significant factors to be important influences on the confidence of the preservice teacher (i.e., pedagogical content knowledge, teacher educator, learning environment, reflection, school placement, and assessment). The paper emphasizes that if preservice teachers are to develop great confidence in science content and teaching, they need to undergo school placement. While we fully agree with this, we would like to mention that school placement poses many logistical challenges for preservice teachers.

As science educators, we need to try as much as possible to instill confidence in our preservice teachers early during the science education program using the available resources. Combining science content and methods in one course is one way we can develop preservice teachers’ confidence in teaching science. This study discusses the impact of a science content class that incorporates teaching methods and activities on preservice teachers’ readiness to teach using inquiry. This was done through blended learning, where physical science content was taught using face-to-face methods and the teaching methods were taught through online videos and assignments.

Blended Learning to Accommodate Science Teaching Methods

According to Alammary et al. (2017), blended learning "(i) integrates different instructional methods such as: lectures, discussion groups, self-paced activities; and (ii) contains both face-to-face and online portions." Cao (2021) indicates that blended learning integrates physical and learning conditions by combining two learning models: traditional and distance learning. Rahim (2019) states that blended learning as an integrative approach benefits both the teacher and students. Further, Baquero and Escortell (2022) assert that blended learning helps yield the best outcomes due to its flexibility in time and location. Blended learning considers the author of the materials, the teacher teaching the materials, and the student learning them (Kashefi et al, 2017; Tong et al., 2022). Alammary et al. (2017) identified several types of blended learning: "(1) face-to-face instructor-led, (2) online instructor-led, (3) face-to-face collaborative work, (4) online collaborative work, and (5) online self-paced" (p. 2).

In face-to-face and online instructor-led, student-student interaction and hands-on experiences are not encouraged. Face-to-face and online collaborative work encourages interaction between students and between students and instructors. The online self-paced approach allows students freedom to work on the activities at their own pace, time of choice, and in any mode of accessing the material. Other authors have also described different forms of blended learning: (1) flex-blending (Davis, 2019), and flipped classroom blending (Wibawa & Kardipah, 2018) where a huge chunk of work is done outside while the class activities are used to strengthen the online learning, (2) self-directed blending where an instructor acts as an adviser while the students mostly work on their own (Karmakar & Bhattacharjee, 2023), and (4) mastery blending where understanding of the material is the focus before moving on (Madou & Iserbyt, 2020), and (5) supplemental blending (Shishigu, 2022) where either face-to-face supplement online activities or online activities supplement face-to-face activities. For instance, Alexandrova et al. (2019) designed supplemental blended learning where they used a "traditional professionally oriented textbook for classroom learning supplemented with an electronic grammar textbook for out-of-class activities" (p. 642). In this case, the online activities supplemented the traditional classroom.

Blended learning is being widely adopted in higher education because of the support that students feel they get from this approach (Dahlstrom & Bichsel, 2014). In blended learning, digital technology is used for lectures, assignments, quizzes, videos, etc. (Hanafi et al., 2024). Some studies have shown the success of blended learning while acknowledging the challenges it poses. For example, Kenney and Newcombe (2011) found that blended-learning students had higher academic scores than those who learned through traditional nonblended environments. Garrison and Kanuka (2004) observed that blended learning encouraged students to complete their courses at a higher rate than those in the conventional environment. Some studies did not observe any advantages or disadvantages in academic achievement and grade distribution between traditional and blended learning environments (Demirkol & Kazu, 2014). Hill et al. (2017) found that students who learned through blended learning had higher outcomes than those who learned using face-to-face only and online only. Other studies found that blended learning promoted intrinsic motivation, self-efficacy (Thai et al., 2017), and higher-order skills: problem-solving and reasoning skills (Liu, 2016).

Teachers’ Readiness to Use Inquiry-Based Learning

The word inquiry-based learning is attributed to Dewey, who advocated learning as a research process: question or problem identification, data collection, data analysis, and data presentation (Dewey, 1938; Zilka, 2021). Inquiry can involve using several steps outlined above or part of the research process (Zilka, 2021). Inquiry learning encourages students to learn as collaborators, team members, or group members (Argyris & Schon, 1996; Weick, 1997; Zilka, 2021). Vygotsky posited that learning comprises cognitive and interpersonal processes and thus encourages interactions among students (Pea, 1993, Vygotsky, 1989; Zilka, 2021). During the inquiry process, students ask questions, direct their own learning, and collaborate (De Jong, 2006; Dorier & Maaß, 2012; Pedaste et al., 2015) and these stimulate critical thinking and problem-solving abilities (Dorier & Maaß, 2012, Silm et al., 2017). Teachers, in this case, play a role as guides, advisors, and stimulants of curiosity. The teachers ensure that students are asking the right questions, have formulated the right methods to answer those questions, and have the right approach to presenting the material (Zilka, 2021). Neathery et al. (2001) argued that using well-formulated activities such as “inquiry-based activities and interactive discussions” (p. 216) can assist in developing teachers’ perception of science teaching. These authors advocated using a learning cycle through the 5E model: i.e., engagement, exploration, explanation, elaboration, and evaluation to improve higher-order thinking and problem-solving. They, thus, advocated using a method course that improves both curiosity and attitudes about scientific inquiry. Furthermore, Zilka (2021) and Zilka and Zeichner (2019) have asserted that preservice teachers must experience inquiry-based pedagogical models to enable smooth translation into their teaching philosophy. Curriculum reforms have focused on inquiry-based learning because of its many reported advantages (Silm et al. 2017).

With the aforementioned advantages of inquiry learning, studies have shown that teachers are reluctant to embrace inquiry-based instruction methods (Capps & Crawford, 2013). Furthermore, until recently, not many teachers' training institutions have focused on teaching inquiry-based learning to preservice teachers and providing skills for these future teachers to use inquiry in their teaching (Silm et al., 2017). Coburn (2000) attributes this to teachers’ lack of understanding of what inquiry is and the expectations involved. Crawford (2000) and Davis and Krajcik (2005) argue that teachers must first understand the material they teach and then learn how to teach these materials effectively. Some of the barriers to using inquiry include the inability to assess inquiry activities and manage group activities (Anderson, 2002), and teachers’ beliefs and values and commitment to prepare students for the next level of education” (Silm et al., 2017, p. 316). Bhattacharyya et al. (2007) observed an increase in teachers’ personal beliefs when they used inquiry instruction and these authors argue that “there is a spiral relationship among teachers’ ability to establish communicative relationships with students, desire for personal growth and improvement, ability to implement multiple instructional strategies, and possession of substantive content knowledge” (p. 199). Personal beliefs or self-efficacy have been deemed as predictors of carrying out inquiry activities (Voet & De Wever, 2017). Thus, Voet and De Wever (2017) recommended training that stimulates active learning, changes beliefs, and offers guidance on conducting inquiry. Further, Syafrizal (2024) argues that when individuals develop better teaching skills, they become more confident about their job as teachers who can teach using various methods to accommodate students’ needs. Silm et al. (2017) pointed out that well-prepared training programs positively impact preservice teachers’ preparedness to teach using an inquiry approach. Perez and Furman (2016) indicated that preservice teachers exposed to inquiry and given a chance to try the inquiry activities are likely to change their beliefs.

Subject Knowledge Versus Pedagogical Knowledge

Just like textbooks and other instructional materials, teachers are also sources of student knowledge. Through teaching, new generations of scientists are trained and our view of science as a social and cultural activity is enriched (Bensaude-Vincent, 2006). Teachers are known to be the most influential factor in educational change such that the success of curriculum innovation depends among others (like students and culture) on the teachers' conceptions and beliefs about teaching and learning (Van Driel et al., 1997). Therefore, instructional design should be built with teachers' knowledge of content and teaching practice since they are the ones to implement the classroom lessons.

Shulman (1986) introduced the idea of PCK to describe the knowledge that a teacher needs for teaching. Shulman (1986) conceptualized PCK as including ''the most powerful analogies, illustrations, examples, explanations, and demonstrations, the ways of representing and formulating the subject that makes it comprehensible for others'' (1986, p. 9). It appears that the most outstanding aspects of Shulman's PCK model are (1) teachers' content knowledge (subject knowledge) and (2) teachers' conceptions of teaching (pedagogical knowledge), and this view has the support of several researchers (Loughran et al., 2004; Major & Palmer, 2006). In other words, PCK deals with how teachers understand what they are teaching and how to teach it to students' understanding (Myers & Gray, 2017).

Parker and Heywood (2000) conducted a study to explore the tension between subject knowledge and pedagogic content knowledge in primary teacher education within the context of the topic "floating and sinking". This study was situated in a project aimed at developing preservice and in-service teachers' subject knowledge to meet the demands of a national curriculum for primary school science. The participants undertook several activities involving floating and sinking designed to help them experience the forces involved, deduce factors that influence floating and sinking, and develop their own hypotheses about the phenomena of floating and sinking. Through these activities, the researchers learned significant features of the learning process, including difficulties experienced by the learners. This paper made a strong argument for the need to demonstrate to teachers the importance of both subject matter and pedagogical knowledge.

Further, Wilberforce and Pratt (2019) point out that being an expert in content knowledge does not translate to being an expert in teaching that knowledge. These authors investigated how preservice teachers viewed the following before and after undergoing subject knowledge activities: "science curriculum knowledge, subject knowledge of key ideas, inquiry-based approaches, scientific inquiry skills, confidence with scientific vocabulary, use a range of teaching strategies" (p. 63). The researchers found that inquiry-based learning was the least selected response to pre- and post-tests when asked how the knowledge activities helped them. Therefore, this calls for preservice teacher training that incorporates both subject and pedagogical knowledge to maximize outcomes from this training fully.

This Study

Most science education programs demarcate a line between science content and science methods courses. Furthermore, teacher training institutions have not focused on inquiry-based learning (Slim et al., 2017). Students usually complete the content courses in the science department before completing the methods courses in the education department. Sometimes, there is a time gap between these two courses, which undermines preservice teachers' ability to connect them. In this study, we took a different approach where supplemental blended learning was used to teach both science content and science teaching methods in one class. Therefore, this study investigates how science content/methods influenced preservice teachers' readiness to teach using inquiry-based approaches. The study answered two research questions as follows:

1. To what extent did participation in the blended course impact preservice teachers' readiness to teach using inquiry, as measured by pre- and post-test scores?
2. What were the preservice teachers' perceptions of their comfort with teaching after the blended course?

Method

The Class

The class focuses on physical science topics, which comprise forces and motion, energy and work, electricity, matter and its properties, atoms and the periodic table, chemical bonding and chemical reactions, and water. The class uses the blended teaching model as follows. All the science content activities are done through face-to-face meetings, while all science teaching methods activities are done through online activities. For the science teaching methods activities, students are given weekly online videos with a video assignment to ensure that they watch the videos. The videos cover topics such as the 5E model and guided inquiry, NGSS science standards, NGSS lesson plans using the 5E model, making meaningful conferences, assessments, and teaching through inquiry. Then students are assigned to write two lesson plans within the semester.

The assignment on the first lesson plan is written in two parts. The first part focuses on the NGSS standards, the lesson objectives, and the integration of the three dimensions of NGSS: Scientific and engineering practices, disciplinary core ideas, and cross-cutting ideas. The second phase of the lesson plan focuses on adding 5E model activities to the first part to make a full lesson plan. The 5E model comprises Engage, Explore, Explain, Elaborate (Extend), and Evaluate. Using the corrections on the first complete lesson plan, students write another lesson plan on different content. The second lesson plan includes a making meaning activity. In this activity, students state how they are going to engage students at different levels: individual, small groups, and whole class.

In the face-to-face activities, the instructor uses the same methods that students are learning in the videos and video assignments to teach science content. The classes are taught using the 5E model, and the instructor posts plans showing all the components of an NGSS lesson plan. The instructor models how to engage students, what exploration activities students are given, how to explain the activities using a making meaning conference, how to elaborate on the activities, and how to evaluate a lesson. In this case, students have a chance to learn about the activities in the science teaching methods section and at the same time observe them being applied in the content section. There are several opportunities where scientific process skills are emphasized. Students are usually given a question, and they use that to make a hypothesis and a prediction. They then use their hypothesis to create a method, carry out the experiment, and interpret and report the results.

The Instrumentation

After observing what is needed in an inquiry classroom, the two authors developed an instrument to measure preservice teachers' readiness to teach using inquiry. For instance, an inquiry classroom requires students to: communicate in their groups or teams, be independent and creative, have positive group interactions, answer questions, and learn critical thinking and problem-solving (De Jong, 2006; Dorier & Maaß, 2012; Pedaste et al., 2015, Zilka, 2021). Zilka (2021) encourages teachers to promote students' questions in an inquiry classroom. Neathery et al. (2001) encourage interactive discussions and the use of the 5E model. Anderson (2002) indicated that the barriers to inquiry-based learning include how to assess the inquiry activities and how to manage group activities. Bhattacharyya et al. (2007) indicate that teachers must be able to use varied teaching strategies and improve communication with students. Therefore, the instrument covers items on the preservice teachers' comfort to enhance communication skills among students, use classroom discussions and other active teaching strategies, and encourage effective questioning from students and students' understanding.

The instrument also included items investigating preservice teachers' comfort in applying formative and summative assessments in their classrooms. The instrument also had items related to teaching strategies that cater to students with different learning styles. Lesson planning is also important for a good inquiry lesson (Rahmawan et al., 2019). Therefore, the instruments had questions related to lesson planning. The ultimate goal of inquiry-based teaching and indeed any teaching is to ensure students' understanding. Houghton (2004) argued that teachers must set "clear goals and intellectual challenge; independence, control, and active engagement; and learning from students" (p. 6) while Backer et al. (2018) recommend that teachers increase student engagement for proper understanding. Therefore, the instrument has included questions related to teaching for understanding.

The first author developed the first draft of the instrument and then sent it to the second author for comments, corrections, and additions. At the suggestion of the second author, some items were changed and others removed. The second draft was sent to another science education researcher for suggestions and improvements. The two researchers looked at the suggestions, which included changing the wording of some questions for clarification. The instrument was then sent to two science educators for face validity. After addressing the concerns of the validators, the instrument was used to collect data for this study during Fall 2020, Spring 2021, and Fall 2021.

All the Institutional Review Board (IRB) processes were addressed. After administering the instrument to the participants, confirmatory factor analysis was used to identify factors in the instrument. Varimax rotation, which is both popular and maximizes the variance of the loadings (Abdi, 2003) was used. From the confirmatory factor analysis, four factors were observed: teaching strategies (TS), teaching various skills (TVS), general teaching and assessment (GTA), and planning an effective lesson (PEL). The varimax rotation loaded nine items on factor 1 (TS), four items on factor 2 (TVS), six items on factor 3 (GTA), and three items on factor 4 (PEL).

Table 1. Factor Analysis of the Teacher Readiness Survey

Item#	TS	TVS	GTA	PEL
1			0.752	
2				0.762
3				0.797
4		0.796		
5		0.827		
6		0.771		
7				0.628
8	0.51			
9	0.509			
10			0.501	
11		0.589		
12			0.709	
13			0.804	
14	0.747			
15	0.735			
16	0.71			
17	0.632			
18	0.534			
19			0.736	
20	0.62			
21	0.734			
22			0.554	
Alpha	0.93	0.90	0.92	0.90
Alpha for all			0.97	

Cronbach's alpha for the instrument's reliability was 0.97, which shows high reliability. The reliability of each factor was tested using Cronbach's alpha, which resulted in alpha values of 0.93, 0.90, 0.92, and 0.90 for factors 1, 2, and 4, respectively (see Table 1).

Participants

To participate in this study, a student needed to be a preservice teacher taking the blended physical science course, hence a convenient sample. Fifty-six preservice elementary teachers from Northwestern USA College participated in the study. Over 90 percent of the participants were female. Participants were from the following semesters: Spring 2019 (16), Fall 2019 (17), Spring 2020 (9), and Spring 22 (13). Spring 2020 students took only the pretest but not the post-test. Therefore, only 46 students have pre- and post-test scores. 13 participants in Spring 22 also completed an open-ended survey to augment the quantitative data. The participants had taken science courses in middle and high school but had little background in college science. The human subject review process was done according to our institutional requirements.

Data Analysis

Factor analyses were done using an online open (http://www.wessa.net/rwasp_factor_analysis.wasp) software. T-tests and Two-Way ANOVA were calculated using Microsoft Excel, and the post hoc Tukey's D tests were calculated using another online software (https://www.socscistatistics.com/tests/anova/default2.aspx). The open-ended survey questions were analyzed by looking at the responses to different questions by students and then selecting major themes from the responses. We, the two researchers, analyzed the survey question responses individually and came up with codes. Then we met to look at and discuss the codes and develop themes from the codes. There was over 80% code agreement between us, which we hashed out through a discussion. We then developed important themes from the codes. We, further, agreed on the quotations from students to include in this paper.

Results

To fulfill the requirements of parametric tests Kolmogorov-Smirnov (KS) test was used to check for the normality of data. KS value for the pretest was 0.094 ($p = 0.77$) while that for the posttest was 0.17 ($p = 0.12$), indicating normal distribution. Then a paired sample t-test was used to compare the mean scores of the pre- and post-tests (see Table 2). The t-test was used to answer the research question "*To what extent did participation in the blended course impact preservice teachers' readiness to teach using inquiry, as measured by pre- and post-test scores?*"

From Table 2, the t-value was 8.67 with a p-value of 0.000. Since the p-value is less than the alpha value of 0.05, the teacher readiness survey scores significantly improved between the pre and post-tests. To test the practicality of this improvement in the scores, Cohen's *d* was calculated. The large Cohen's *d* value ($d = 1.19$) indicates that this improvement was practically significant. The effect size observed indicates that the difference between the pre and post-test is equal to just above one standard deviation.

Table 2. Pre and Post-test Teacher Readiness Scores' Analysis

Test	N	Mean (out of 5)	SD	T	p	d
Pretest	46	3.15	0.80	8.67	0.000	1.19
Posttest	46	3.98	0.58			

Two-way ANOVA was used to answer the following questions:

1. Do the mean test scores change between the pre- and posttests?
2. Is there a difference in test scores among the four factors?
3. Does the change in test scores from pre-test to post-test differ among the four factors?

Table 3 shows the results of the two-way ANOVA test.

Table 3. Two-Way ANOVA of the Teacher Readiness Survey Scores

Source	DF	SS	MS	F Statistic	p
Pre-Post	1	67.0749	67.0749	106.917	0.000
Factors	3	25.648	8.5493	13.6276	0.000
Pre-Post x Factors	3	1.0672	0.3557	0.567	0.640
Error	360	225.8476	0.6274		
Total	367	316.6377	0.8709		

As expected, a significant difference was observed between the pre- and post-test mean scores (p = 0.000). In addition, a significant difference (p = 0.000) was also observed among the mean scores of the responses to the four factors on this instrument. The significant difference in Teacher Readiness Survey scores among the different factors (p = 0.000) indicates that there is a significant difference among the factors at either the pre-test or post-test measurement, or possibly at both. As a reminder, the four factors are as follows: teaching strategies (TS), teaching various skills (TVS), general teaching and assessment (GTA), and planning an effective lesson (PEL). This implies that the mean score difference of at least one factor is different from the other mean score differences. To determine whether the two levels of analysis (pre- and post-test) affected the factors, we used the results of the Pre-Post x Factors from the two-way ANOVA model. The model indicated no interaction (p > 0.05) between pre-post mean scores and the four factors. This indicates that the mean trends were statistically the same for the factors between the pre- and the post-test. In other words, a statistically similar change in mean scores was observed among the four factors, which kept the trend similar between the pre- and the post-test.

Post Hoc Tukey's test of the pretest indicated that the mean score of factor 3 (GTA) is significantly smaller than that of factor 1 (TS, p = 0.002) and factor 2 (TVS, p = 0.000). The Post Hoc test of the post-test scores shows that factor 3 (GTA) is significantly smaller than factor 1 (TS, p = 0.025), factor 2 (TVS, p = 0.000), and factor 4 (PEL, p = 0.033).

When the categories were compared, pre- and post-test, in each category, the post-test score was significantly higher than the pretest score at an alpha level of 0.05 (see Table 4). All the changes also had large effect sizes based on Cohen's *d* values, the largest being general teaching and assessment (GTA).

Table 4. Pre- and Post-test Comparison of Different Factors

Factors	Pretest	Posttest	p-value from t-test	d
TS	3.33±0.8	4.06±0.59	<0.05	1.05
TVS	3.49±0.94	4.26±0.58	<0.05	0.83
GTA	2.69±0.83	3.65±0.79	<0 .05	1.29
PEL	3.12±0.90	4.04±0.76	<0.05	1.00

Predictive Relationships

Regression analyses were conducted (for both pre- and posttest scores) to answer the following questions.

1. What predictors significantly affect PSTs' confidence in general teaching and assessment (GTA)?
2. What predictors significantly affect PSTs' confidence in using the best teaching strategies (TS)?
3. What predictors significantly affect PSTs' confidence in teaching various skills (TVS)?
4. What predictors significantly affect PSTs' confidence in planning an effective lesson (PEL)?

Using multiple regression, several models were developed to answer the above questions. To answer the question, *"What predictors significantly affect PSTs' confidence in general teaching and assessment (GTA)?"*, GTA was made a dependent variable of the regression model, and the predictors TS, TVS, and PL were made independent variables. Table 5 shows the results of the regression model for confidence in teaching and assessment, where teaching strategies, teaching various skills, and planning a lesson are predictors. The adjusted R-squared (R^2 = 0.74) for the pretest indicates that the combined effects of confidence in using better teaching strategies, teaching various skills, and planning an effective lesson plan accounted for 74 % of the variance in confidence in teaching and assessment. This percentage decreased to 62% (R^2 = 0.62) during the post-test. In the pretest, a significant beta coefficient was observed for TS only. For instance, the beta coefficient for TS (β = 0.59, p = 0.000) shows that for every unit increase in confidence in using better teaching strategies (TS), confidence in teaching and assessment (GTA) increases by 0.59 units. However, during the post-test, a significant beta coefficient was found for the contribution of TVS (β = 0.50, p = 0.012) and PEL (β = 0.55, p = 0.000). No significant contribution was found for TS during the post-test. In summary, only TS contributed significantly to GTA during the pretest while TVS and PEL contributed to GTA during the post-test.

Table 5. GTA Scores Using Predictors TS, TVS, and PEL

Term	Pretest coefficients	p	Posttest coefficient	p
Constant	-0.3138	0.256	-0.9265	0.107
TS	0.5906	0.000	0.0820	0.684
TVS	0.1049	0.296	0.5020	0.012
PL	0.204	0.086	0.5521	0.000
Adjusted R^2	0.74		0.62	

To answer the second question, *"What predictors significantly affect PSTs' confidence in using best teaching strategies (TS)?"*, TS was made a dependent variable while TSV, GTA, and PEL were made independent variables of the regression model. Table 6 shows the results of the model for the pre and post-test. The adjusted R-squared showed that the combined effect of all three predictors decreased from 76% in the pretest to 60% in the posttest. While the predictor GTA (β = 0.56, p = 0.000) significantly contributed to TS, PEL's (β = 0.23, p = 0.046) contribution was barely significant, while TVS did not significantly contribute to changes in TS. During the post-test, the significant predictor of TS was TVS (β = 0.61, p = 0.000) only. This indicates that during the pretest for every one-unit increase in GTA, TS increased by 0.56 while for every unit increase in PEL, TS increased by 0.23. During the post-test, only TVS contributed to the TS, increasing from β of 0.14 (pretest) to 0.61 (post-test). In summary, GTA and PEL significantly predicted TS in the pretest, but only TVS significantly predicted TS in the posttest.

Table 6. TS Scores Using Predictors TVS, GTA, and PEL

Term	Pretest coefficient	p	Posttest coefficient	p
Constant	0.6147	0.020	0.6116	0.1684
TVS	0.1439	0.139	0.6109	0.000
GTA	0.5631	0.000	0.0484	0.684
PEL	0.2304	0.046	0.1916	0.0812
Adjusted R^2	0.76		0.60	

To answer the fourth question, *"What predictors significantly affect PSTs' confidence in planning an effective lesson (PL)?"*, PEL was made a dependent variable while TS, TVS, and GTA were made independent variables of the regression model. Table 7 shows the results of the model for pre and post-test. The adjusted R-squared showed that the combined effect of all three predictors decreased from 63 % in the pretest to 54 % in the posttest. A barely significant beta coefficient was observed for the contribution of TS to PL on the pretest ($\beta = 0.40$, $p = 0.046$) but not during the post-test. Although no significant contribution to PL was observed from GTA during the pretest, it became substantial ($\beta = 0.59$, $p = 0.000$) during the post-test.

Table 7. PEL Scores Using Predictors TS, TVS, and GTA

Term	Pretest coefficient	p	Posttest coefficient	p
Constant	0.2779	0.435	0.9664	0.114
TS	0.3968	0.046	0.3668	0.082
TVS	0.1806	0.158	-0.1325	0.219
GTA	0.3360	0.086	0.5895	0.000
Adjusted R^2	0.63		0.54	

To answer the third question, "*What predictors significantly affect PSTs' confidence in teaching various skills (TVS)?*" For this question, confidence in teaching various skills (TVS) was made a dependent variable with TS, GTA, and PEL as predictors. Table 8 shows that no significant contribution from the three predictors was observed during the pretest, and a significant contribution was observed from TS ($\beta = 0.55$, p = 000) and GTA ($\beta = 0.28$, $p = 0.012$) during the post-test.

Table 8. TVS Scores Using Predictors TS, GTA, and PEL

Term	Pretest coefficient	p	Posttest coefficient	p
Constant	0.8215	0.407	1.2655	0.045
TS	0.357	0.237	0.551	0.000
GTA	0.2480	0.234	0.280	0.012
PEL	0.2602	0.181	-0.0652	0.549
Adjusted R^2	0.51		0.61	

For the last question, *"What predictors significantly affect PSTs' confidence in planning an effective lesson*

(PEL)?", PEL was made a dependent variable while TS, TVS, and GTA were made independent variables of the regression model. Table x shows the results of the model for pre and post-test. The adjusted R-squared showed that the combined effect of all three predictors decreased from 63 % in the pretest to 54 % in the posttest. A barely significant beta coefficient was observed for the contribution of TS to PEL on the pretest ($\beta = 0.40$, $p = 0.046$) but not during the post-test. Although no significant contribution to PEL was observed from the GTA score during the pretest, it became substantial ($\beta = 0.59$, $p = 0.000$) during the post-test.

Table 9. PEL Scores Using Predictors TS, TVS, and GTA

Term	Pretest coefficient	p	Posttest coefficient	p
Constant	0.2779	0.435	0.9664	0.114
TS	0.3968	0.046	0.3668	0.082
TVS	0.1806	0.158	-0.1325	0.219
GTA	0.3360	0.086	0.5895	0.000
Adjusted R^2	0.63		0.54	

Open-Ended Survey

We used an open-ended survey to get more information about why, if there was any change, students became more confident in teaching science after taking this course. We asked four open-ended questions shown below:

1. What have you learned about teaching science from this course?
2. Based on what you have learned from this course, can you describe yourself as a more confident or less confident preservice science teacher after taking the course? Please explain why you describe yourself as such.
3. How has this course affected your view about science teaching?
4. What important things have you learned about planning a lesson?

Answering the first question, *"What have you learned about teaching science from this course?*", participants emphasized the use of 5E model as important to their confidence in teaching. They also emphasized creativity and learning prior knowledge and alternative conceptions (misconceptions) that students have. Further, they indicated their understanding that science teaching and learning need exploration. One participant writes:

> *I have learned that when teaching science, it involves a lot about what the student knows and building off of that. I learned that science includes a lot of "participant involvement" and that many levels can and should go into teaching science. Students need to be able to explore science with not only their minds but their hands as well. I have learned that science includes asking a lot of questions, a lot, investigating, experimenting, and then asking more questions.*

Another student writes:

> *The other thing that I have learned when teaching science is using the 5E model lesson plans to create your lessons and be able to include everything about what may come up when you are teaching a lesson. 5E lesson plans also allow your students to engage in a way that other lesson plans don't really allow.*

> *Other lesson plans mainly just have the teacher lecture for a long time and then include some sort of assignment based on the lesson.*

The second question is as follows: *Based on what you have learned from this course, can you describe yourself as a more confident or less confident preservice science teacher after taking the course? Please explain why you describe yourself as such.* To this question, most participants indicated that they were more confident to teach a science class after taking the course. One student writes:

> *After taking this course, I feel like I can describe myself as a more confident preservice science teacher because before taking this course, I did not know how to create lesson plans for science, and I did not know how to go about teaching science. I have helped teach a science lesson before; however, I did not create the lesson and I was directed by my mentor teacher. From this class, I feel as though I can create my own lesson plan and teach without direction from another teacher.*

Another participant writes:

> *I would, definitely, say that I am much more confident going out than when I was coming in. Working in a school for several years, I have watched students filling out science notebooks, making predictions, and testing hypotheses. This course has given me the background on all these things, why they are important, and what they are used for. I understand more why small group, whole group, and individual aspects are important and how each of these elements fits into the big picture of teaching science.*

The third question is as follows: *How has this course affected your view about science teaching?* One participant writes:

> *I am more excited to teach science now. I have more confidence now in the different strategies that are important to use when teaching. Gaining knowledge into the components that build a successful science curriculum has given me the tools that I need to be confident in my teaching.*

Another participant writes:

> *This course has improved my thoughts about science and changed them from being nervous or intimidated to feeling optimistic and more creative. There are plenty of ways to create a fun and educational way of teaching and learning science. This course has helped refresh my memory of basic science methods and has improved my thought process on how to be able to teach it.*

The fourth question is as follows: *What important things have you learned about planning a lesson?* One participant writes:

> *I had never heard of the 5E's lesson model before but am excited to make sure each of my science lessons are in this format. Having students not just engage in listening, discussing, and watching, but being able to be fully engaged in the lesson is so important. Making sure that I have the correct assessment types in my lessons is as important as the lesson itself. I need to know, through my lesson, that my students understand what has been taught.*

Another participant writes:

> *When it comes to lesson planning, it is very important to have a clear, in-depth step-by-step plan for a lesson. The lesson planning process should be done ahead of time to give enough time to plan every little detail, including the transition times or downtimes. The lesson plan should state questions the teacher will be asking the class, clear directions to follow for the experiment, have the proper standards listed to refer to, a list of materials the teacher should need, also include extensions of the lesson in case something was not working out from the original plan. After a lesson is completed, it is very important to reflect on the lesson to see how it went. This helps the teacher plan for future lessons as well as to make any changes to that lesson plan to help it go smoother and be more effective.*

Discussion

Answering the question, "Is there a difference between the pretest and posttest scores of the teacher readiness survey after a blended content and methods course?", a significant improvement was observed, showing that passing through a blended course improved preservice teachers' readiness to teach using an inquiry-based learning approach. This makes sense because students were able to see inquiry activities during the content section of the course while learning about them during the methods section of the course. First, during the inquiry process in class, students were able to collaborate and work as team members; they were able to ask questions; and they were able to explore. Since Neathery et al. (2001) have indicated that well-formulated activities such as "inquiry-based activities and interactive discussions" (p. 216) can assist in developing teachers' perception of science teaching, we observe that the activities in the blended course did that. Furthermore, these authors advocated a learning cycle using the 5E model, which was used in this course. Capps and Crawford (2013) showed that teachers were reluctant to embrace inquiry-based instruction methods, while Coburn (2000) indicated that teachers lack an understanding of what inquiry is and the expectations involved. We believe that doing inquiry-based activities in the science content section and then learning about teaching inquiry through online activities enabled the students to link the activities in class with inquiry-based learning. This is important because Ledger et al. (2019) found that preservice teachers who had low confidence to teach mostly used direct instruction in a TeachLive virtual learning environment. Furthermore, teaching science content to the preservice teachers enabled them to understand what they were supposed to teach, while the online methods section taught them how to teach. This agrees with Crawford (2000) and Davis and Krajcik (2005), who argued that teachers must first understand the material they teach and then learn how to teach these materials effectively. Shishigu (2022) also found that blended learning enhanced competency-based education.

Using the results of post hoc analyses, we found that preservice teachers in this study had significantly lower scores on their confidence in general teaching and assessment (GTA) during the pre- and post-test. Items in this category included their confidence in improving students' understanding of scientific concepts and confidence in explaining difficult science concepts. Teacher self-efficacy mechanism includes self-efficacy for student engagement, and self-efficacy for instructional strategies (Ledger et al., 2019; Tschannen-Moran & Woolfolk Hoy, 2001). It seems like the preservice teachers were not confident in how to engage students to improve conceptual understanding. We also observe that confidence in general teaching and assessment had the highest improvement as indicated by the largest Cohen's d (d = 1.29) among the four factors. This implied that this study's blended learning enhanced this confidence by a larger margin, although it could not flip the confidence in the other factors. Ledger et al. (2019) argue that science education programs must emphasize improving preservice teachers' confidence to engage students and use different teaching strategies. Our blended learning course has attempted to address that, hence the increase in TS, TVS, GTA, and PEL scores. Also, we believe that the blended content-method course has developed better teaching skills, which has increased preservice teachers' confidence as observed by Syafrizal (2024).

Further, the four open-ended questions have provided insight into what caused this improvement. Students mentioned the use of the 5E model lesson plan, the emphasis on creative ways to engage students, and explicitly teaching through inquiry-based learning, which includes making predictions and testing hypotheses. We observed that some of the participants had never had a method course that emphasized what they learned in this course, while others had some interaction with teaching before; this blended course opened their eyes to inquiry activities. This just shows that those who had previous classroom experience did not observe an inquiry class, as indicated by Capps and Crawford (2013), who showed that teachers were reluctant to embrace inquiry-based learning. This further shows that teacher preparation colleges need to provide enough opportunities for students to experience inquiry-based learning, as was the aim of this blended classroom. The open-ended questions further show that the preservice teachers became less intimidated by teaching science in terms of using different strategies and creating fun for students. The questions further show that students were confident in creating a 5E model lesson plan, which is a recipe for an inquiry-based lesson. The Australian Society for Evidence-Based Teaching emphasizes that teachers must be clear with their learning goals and focus of their lesson, engage students using prior knowledge and good questioning strategies, and encourage group or teamwork (Ledger et al., 2019). Furthermore, inquiry-based learning requires students to work as collaborators (Argyris & Schon, 1996; Weick, 1997; Zilka, 2021). This was displayed by quotes from students in this study. For instance, one participant indicated, "When it comes to lesson planning, it is very important to have a clear, in-depth step-by-step plan for a lesson." Another participant writes: *"I learned that science includes a lot of participant involvement and that many levels can and should go into teaching science. Students need to be able to explore science with not only their minds but their hands as well."* All these demonstrate that students were allowed to both experience inquiry-based learning and learn about inquiry-based learning at the same time. Therefore, the results of the open-ended questions must encourage teacher preparation colleges to get preservice teachers ready to teach using inquiry-based learning.

Results from the predictive test among the factors showed that TS and TVS scores predicted confidence in GTA scores in the pretest while only TVS and PL significantly influenced confidence in GTA in the post-test. It is not clear why confidence in TS no longer predicted confidence in GTA during the post-test. The post-test results, however, show that confidence in teaching various skills and confidence in planning an effective lesson will likely influence confidence in general teaching and assessment. The predictive influence test also showed that the predictors GTA and PEL significantly predicted TS during the pre-test. In the post-test only TVS significantly predicted TS. Results of the post-test indicated that confidence in teaching various skills can influence teaching strategies to use. The predictive influence test showed that only GTA significantly influenced PEL during the post-test while only TS and GTA influenced TVS during the post-test only. In general, we believe that there is a predictive connection among the four factors on this instrument and thus teaching in general. This agrees with the observation by previous authors who argued that teachers' self-efficacy mechanism includes self-efficacy for student engagement, and self-efficacy for instructional strategies (Ledger et al., 2019; Tschannen-Moran & Woolfolk Hoy, 2001).

Conclusions and Implications

This study demonstrates the need to combine content and science in a single course by using a hybrid model. Preservice teachers need to observe what they are learning about science methods in the science content section of the course. Educators agree that preservice teachers first need to understand what to teach before teaching it. Therefore, we believe that a blended course that combines content and teaching methods will have a recency effect where preservice teachers immediately encounter the teaching methods of the science content they learn in class. The study also emphasizes the need to teach preservice teachers using inquiry-based learning if we want them to teach the same way. Therefore, we recommend using blended learning that combines science content and online science teaching methods. We further recommend teaching preservice teachers using inquiry-based learning. These two recommendations will likely produce teachers who are ready to teach through inquiry-based methods.

Limitations and Future Studies

The study did not include a comparison group, which limits our ability to suggest a causal effect. Therefore, for future Studies, we would like to administer the same survey to a group of students who take content and teaching methods separately to see if there will be any difference between a group that goes through a combined content and methods course and a group that learns content separately from methods. However, the open-ended interviews provided information that strengthened our findings. In addition, future studies will involve the use of the Pedagogy of Science Teaching Tests (POSTT) by Cobern et al. (2014) to formatively assess preservice science teaching orientations.

Acknowledgments

We would like to thank the participants and faculty at the host college who provided valuable assistance.

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