

## Research article

# Mathematics self-belief comparison and examination of pre-service teacher (PST) through a flipped-open calculation based on numbers (ABN) learning method



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## ABSTRACT

Teaching mathematics in higher education has been followed traditionally by teacher-centered methodology. With this methodology, there are always certain difficulties in mathematics learning, revealing students are not capable of dealing properly with calculations and/or problems. This research presents the comparison and examination of two different instruction methodologies, traditional-classroom methodology (TCM) and flipped-classroom methodology (FCM) about self-belief of pre-service teacher (PST) in a mathematics course. Here, an open calculation based on numbers (ABN) method originally from the Spanish teaching methodology (abierto basado en números) was used in both teaching methodologies. The 274 PSTs participated in the course: 131 students to T-ABN and 143 students to F-ABN. The results after applying the questionnaire (Cronbach's  $\alpha = 0.897$ ) showed F-ABN had significant influences in PSTs' self-belief toward the course and made classes more interactive based on parametric-statistical tests. PSTs' self-belief for four studied groups (pre- and post-test in control and experimental group) indicated significant differences found by ANOVA test. Additionally, significant differences were only observed in educational background not in gender of PSTs' self-belief according to factorial ANOVA. In all cases, when significant differences were found, effect size and post-hoc tests were conducted. Therefore, more student-centered methodology allowed to build positive teaching/learning environment for PSTs as future teachers, which consequently expects better learning outputs for children as their future students.

## 1. Introduction

To overcome learning difficulties in mathematics education, traditional teaching methodology, as current standard method in higher education, demonstrates that it is not a solution for the students' learning, which various research has also pointed out (Hill et al., 2008; Thames and Ball, 2010; Zawilinski et al., 2016). Although new teaching methodologies suggested to solve current situations and problems, many students still have difficulties to deal with mathematical learnings, particularly when dealing with calculations and/or problems (Martín-Montero and Sánchez, 2013; Jeong and González-Gómez, 2020). Thus, recent research reveals the difficulties of mathematics learning that appear much before than formal education (Aunio et al., 2015; European Commission, 2015; Radović et al., 2018). Here, particularly, to solve the drawbacks of traditional teaching methods with non-routine calculations, the open calculation based on numbers (ABN) originally from the Spanish teaching methodology (abierto basado en números) can be one

of numerous alternatives, permitting students to solve a problem dissimilarly, instead of the closed algorithm based on ciphers (CBC) methodology (Ablewhite, 1971; Martínez-Montero, 2011; Martínez-Montero and Sánchez, 2021). Therefore, the process-based instruction must be used that it can foster an inquiry-based learning approach, which promotes more students-centered enhancing cooperative learning for mathematics activities (Butterworth et al., 2011; van Aalderen-Smeets and van der Molen, 2015). Besides, instruction process followed in a course can be the interplay of cognitive and affective domains that must foster a connection of students' learning process (Boekaerts, 2007; Li and Kulm, 2008; Jaber and Hammer, 2016).

In the science, technology, engineering and mathematics (STEM) education, the flipped-classroom method, as the process-based instruction methodology, stipulates a more suitable environment to attain a substantial learning regarding students' cognitive and affective domains (Roach, 2014; Blair et al., 2016). Since this methodology is based on the social-behaviorist and constructivism learning theory, students will have

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more responsibility than the direct lecture in the learning process (Bishop and Verleger, 2013; Sams and Bergmann, 2013; O'Flaherty and Phillips, 2015). Together with the ABN methodology aforementioned, teachers can employ the method inside of flipped-classroom environments, which was considered as an active and alternative instruction ratifying the contents in mathematics education (Li et al., 2019; Cerda et al., 2018; Piñero and Canto, 2019; Jeong and González-Gómez, 2020). Particularly, students can have more in-class time while they focus on student-centered and collaborative activities addressing just-in-time lectures, which turn into competent learnings (Mattis, 2015; Moraros et al., 2015; Akçayir and Akçayir, 2018). In mathematics subjects, this active and alternative model can support to construct better mathematics concepts and increase the interest and satisfaction of students for the course (Martínez-Montero, 2011, 2013; Li et al., 2019). Thus, while students are having enough in-class time and more responsibility as a constructivist learning, this methodology specifies to achieve a significant learning such as own belief and attitude when an ABN-flipped-classroom methodology is followed in a mathematics course (Sams and Bergmann, 2013; Aragón et al., 2017; Jeong and González-Gómez, 2020).

In mathematics disciplines, flipped-classroom can increase students' self-belief as a learner (Bandura, 1986; Zimmerman, 2000; Ketelhut, 2007). Here, self-belief delineated as a person's feeling or attitude recognized by a significant mediator affects students' learning patterns with own capability (Ketelhut, 2007; Aşıksoy and Özdamli, 2016; González-Gómez et al., 2022). Various research reiterates its effect that it is relatively durable and can be answered in a continuously favorable/unfavorable manner in terms of a certain object given (Fishbein and Ajzen, 1975; Petty and Cacioppo, 1981; Koballa, 1988). In the flipped-classroom with the ABN method, their self-belief toward learning activities of mathematics education have been recognized as a great consequence on students' attitude, tendency, and achievement (Ma and Kishor, 1997; Burrus and Moore, 2016; Lo et al., 2021). Thus, the self-belief of instructors can influence to his/her teaching competence, which will consequently impact to pre-service teacher (PST) confidence that can reflect their future teaching practice (Saçkes et al., 2012; Oppermann et al., 2019). Improving the self-belief of PSTs as previous research have indicated demonstrated that PSTs with better self-belief were more willing to change educational situations and were more enthusiastic to employ innovative practices to the class (Tschannen-Moran and Woolfolk-Hoy, 2001; Charalambous and Philippou, 2010; Saçkes et al., 2012). Therefore, the appropriate self-belief in mathematics education is a requirement for correctly incorporating flipped-classroom (Burrus and Moore, 2016). However, although there are some investigations studying about it, it is still not examined neither in-service teachers' nor PSTs' self-belief in this particular area and method.

The main objective of this research was to compare and examine the PSTs' self-belief toward two different teaching methodologies along with ABN method followed in a general mathematics course at Teaching Training School in a Spanish University. A total of 274 PSTs participated in the course (control group with 131 students for 2020/21 and experimental group with 143 students for 2019/20, respectively) with a 5-point Likert-type scale in pre- and post-test questionnaire. Here, it can be expected that it will improve the mathematics self-belief of PSTs as well as fostering positive feeling towards mathematics.

## 2. Materials and methods

This research was conducted throughout the second semester of 2020/21 and 2019/20 course in a general mathematics subject. This subject syllabus contains general units about mathematics education alongside didactic approaches to teach PSTs for primary education students. With a total of 274 participants, they were involved in a traditional-ABN (T-ABN) as the first group employed and a flipped-ABN (F-ABN) as the second group followed. Then, the results obtained in a pre- and post-test questionnaire manner with a 5-point

Likert-type scale were analyzed through various statistical analyses (see Figure 1).

### 2.1. Sample and course context

A total of 274 PSTs contributed to the course with 131 PSTs to T-ABN as a control group for the course 2020/21 and 143 PSTs to F-ABN as an experimental group for the course 2019/20, respectively. Before starting the course, PSTs did not have any knowledge about the instruction methodology followed by the whole course. Here, Table 1 indicates the main PSTs' demographic and descriptive information of two groups compared and examined. As shown in the table, 60% of the PSTs' educational background in both groups was social sciences. Also, only 13.1% and 15.7% of the participants in both groups believed that mathematics was an easy subject.

Following the general mathematics topics, the syllabus of this subject contains didactic approaches for PSTs to teach primary education students. In detail, it covers various characterizations, themes, and principles for mathematics education in six units, expressly for the arithmetic teaching. Accordingly, this subject was training the PST, which demanded general mathematics subjects' comprehension, and teaching/learning disciplines and investigations for their future primary education students.

### 2.2. T-ABN and F-ABN to compare and examine PSTs' self-belief

At the initiation of the second semester, the two different instruction methodologies were presented to PSTs alongside the general course flowchart where all the key dates and course activities were programmed. Particularly, the third unit among the six in which this course was structured, was used for this research to measure the PSTs' self-belief changes towards mathematics learning (see Table 2). In the T-ABN, along with the introduction of course flowchart at the semester initiation to the students, normal lectures were given and were stopped whenever it was necessary during the in-class time. Particularly, it happened when PSTs required extra clarifications and/or to implement in-class small problems and/or tasks. In the virtual campus of the University (Moodle), they could access all the presentation files and other instruction materials available utilized of ABN contents in the classes at least one week in advance. In the F-ABN, the PSTs can access to the various flipped-classroom materials such as video lessons, flash simulators, written materials, etc. of ABN contents at least a week before commencing the new activity through the Moodle along with the course flowchart as same as the T-ABN group.

Figure 2 indicated the ABN activities with an example of addition algorithm in T-ABN and F-ABN environments comparing with the traditional methods. With the ABN method in four different algorithms (addition, subtraction, multiplication, and division), it gives various alternatives to get the final solution although the traditional method has a sole way to resolve the calculations and/or problems given. Thus, this somewhat new method can emphasize the flexible feature that is not required to have former trainings, which PSTs have to facilitate solving the basic calculations achieving in responding them. Furthermore, it dealt with more various approaches, which could offer numerous methods depending on students' abilities and studying forms and practicing more sources and materials in a course. Particularly, in the case of F-ABN, students can practice more activities and solve the problems just-in-time since they already learned the theoretical concept through the flipped materials. It will allow more student-centered and collaborative class addressing just-in-time lectures and competent learnings.

The comparison and examination research between the two instruction methodologies was realized by means of on-line questionnaire survey that PSTs participated in pre- and post-test. Here, based on formerly published research works, the questionnaire was adapted to the objectives proposed (Auzmendi, 1992; Baroody and Coslick, 1998). The questionnaire, as an instrument, and its protocols were permitted by the

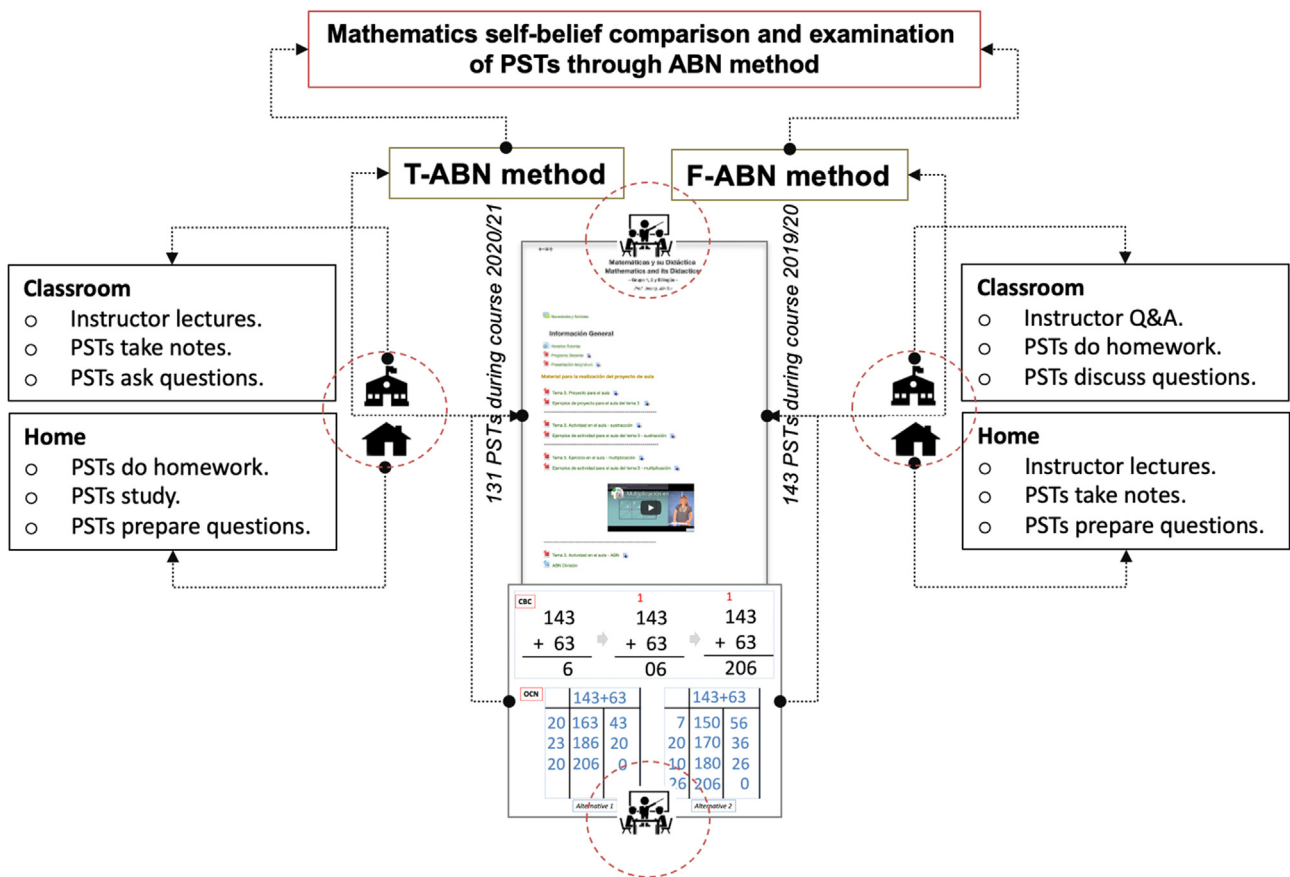


Figure 1. General scheme comparison to examine mathematics self-belief of pre-service teachers (PST) through an open calculation based on numbers (ABN) learning method.

Table 1. Participants' demographic and descriptive information compared and examined between T-ABN and F-ABN groups.

| Group | N   | Age  | GPA (max. 10) | Gender (%) |        | Educational Background (%) |                |            | PST considers mathematics as an easy subject (%) |
|-------|-----|------|---------------|------------|--------|----------------------------|----------------|------------|--|
|       |     |      |               | Male       | Female | Science                    | Social Science | Technology |  |
| T-ABN | 131 | 20.0 | 7.54          | 41.9       | 58.1   | 31.3                       | 61.8           | 6.9        | 15.7   |
| F-ABN | 143 | 20.4 | 7.27          | 48.3       | 51.7   | 25.2                       | 65.7           | 9.1        | 13.1   |

Table 2. Unit 3 of subject syllabus applied to the research proposed.

| Chapter               | Course context  |        |
|-----------------------|---|--------|
|                       | Description   | Hours  |
| Arithmetic operations | Operations' significance and mechanism.<br>Additions and subtractions w/o compensation.<br>Multiplications w/o regrouping.<br>Divisions with one and/or several figures.<br>Empowerment and filing.<br>Troubleshooting.<br>Abacuses and multi-base<br>Blocks as teaching materials. | 30/150 |

bioethics committee of University of Extremadura (94/2018) to gather the PSTs' data before commencing the research. In the actual survey, respondents consented for using questionnaire to collect data. The questionnaire consisted of nine questions categorized in two parts. The first part was comprised of four questions targeted to measure the PSTs' self-belief in positive scale about mathematics learning and the second part was comprised of five questions targeted to measure the PSTs' self-belief in negative scale about mathematics learning. A 5-point

Likert-type scale was respected by the questionnaire, 'strongly-disagreed' (SD), 'disagreed' (D), 'neutral' (N), 'agreed' (A), and 'strongly-agreed' (SA). The list of questions is demonstrated and structured in Figure 3.

### 2.3. Data statistical analysis

With regard to the data statistical analysis performed for this research, the effect of the two different instruction methodologies were assessed in terms of PSTs' self-belief about mathematic learning, in terms of pre- and post-test in a control and experimental group (the whole data used are available for researchers upon request). Firstly, the reliability of the instrument used in this study was checked by means of the Cronbach alpha test, as a measurement of the instrument internal consistency. The result was 0.89, which indicated the instrument could be considered as reliable. Besides, the Kolmogorov–Smirnov test for normality was used to check whether data collected were normally distributed or not. Because the data was normally distributed, parametric-statistical tests were applied. To test the existence of significant differences between the mean values of the PSTs' self-belief for the four studied groups (pre- and post-test of control and experimental group), an analysis of variance (ANOVA) test was conducted. When significant differences were found, the effect

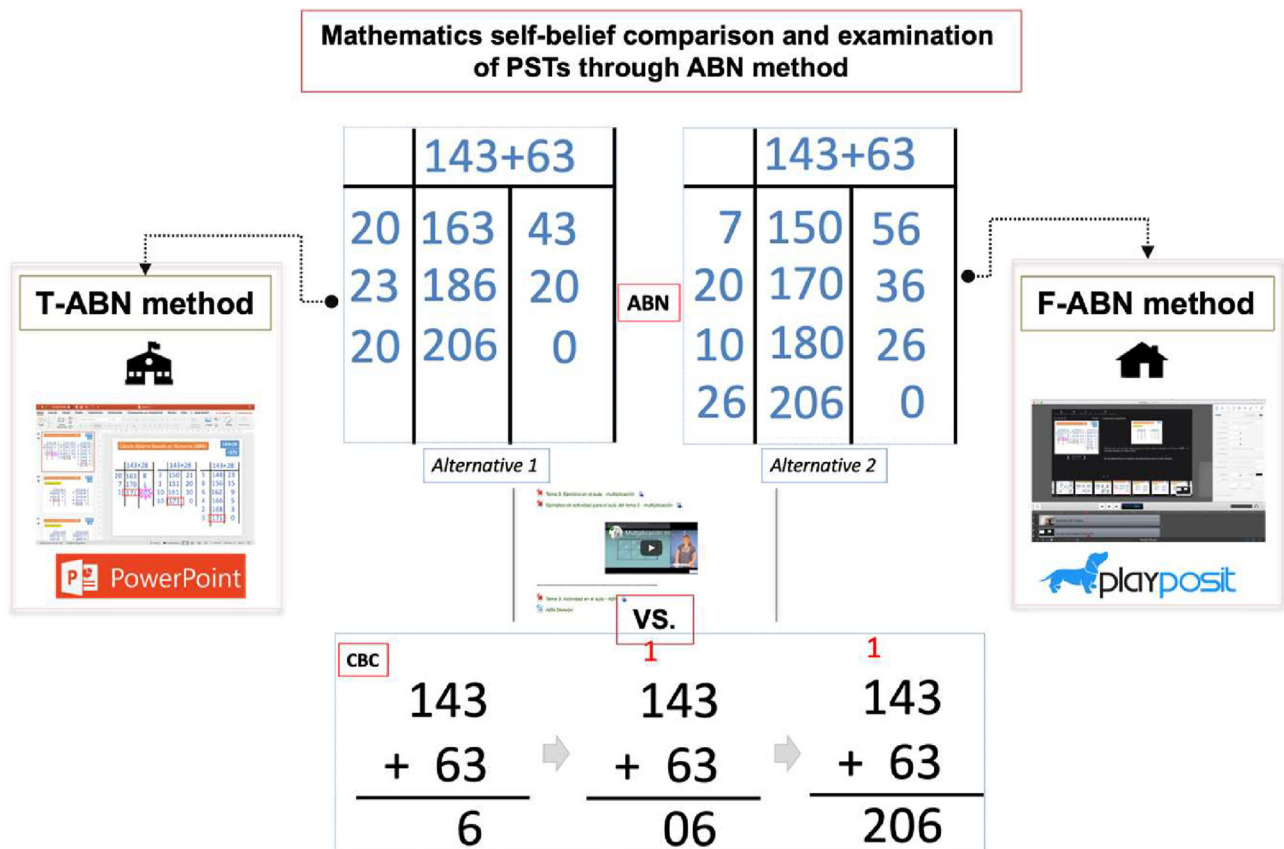


Figure 2. The ABN methodology for the mathematics course proposed in T-ABN and F-ABN comparing with closed algorithm based on ciphers (CBC).

size was measured ( $\eta^2$ ). In addition, post-hoc test was also conducted to establish the possible significant differences between groups. When the post-hoc analysis revealed the existence of significant differences, the effect size was measured in terms of Cohen's *d*. Finally, to assess possible interaction that the PSTs' educational background and gender that might have over the self-belief of PSTs toward mathematics learning, a factorial ANVOA test was applied as well. When significant differences were observed, the effect size additionally measured also ( $\eta^2$ ).

### 3. Results and discussion

To assess the influence of the instruction methodology on the PSTs' self-belief (SB) toward mathematic learning, participants were asked to complete a pre- and post-questionnaire survey. The mean values of the SB scores gathered for each item are summarized in Figure 4a. According to the structure of the instrument used and taking into consideration its internal consistency, a global SB indicator (see Figure 4b) was constructed ( $SB_{Total}$ ), Eq. (1), as summatory of each individual item taking into consideration its positive or negative correlation with the total scale as follows:

$$SB_{Total} = (SB_1 + SB_2 + SB_6 + SB_7) - (SB_3 + SB_4 + SB_5 + SB_8 + SB_9) \quad (1)$$

Figure 4b represents the calculated scores for this global variable ( $SB_{Total}$ ) for the control and experimental groups of before (pre-) and after (post-) intervention. The figure shows that in both groups it is observed the  $SB_{Total}$  increased after the intervention, being in the experimental group more highlighted.

Here, an ANOVA test was conducted with the aim to determine if the instruction intervention had a significant influence. Then, according to the results obtained, the ANOVA showed a significant effect of the intervention on the PSTs' self-belief ( $SB_{Total}$ ) ( $F(3.544) = 128, p < .001$ ). The size effect ( $\eta^2$ ) measured in the ANOVA was of 0.413 and, therefore,

it could be assumed that the effect of the intervention was large. As significant differences were observed, a post-hoc test was conducted intending to reveal the existence of significant differences in each group. Table 3 summarized the results of pairwise t-test as post-hoc comparisons. As it is shown in the table, no significant differences were observed between control and experimental group before the intervention ( $p = .661$ ). That could be understood as both groups showed homogeneity in terms of self-belief toward mathematics learning in terms of  $SB_{Total}$ . On the other hand, the intervention made a significant increase of the  $SB_{Total}$  (Post\_E) regarding the control (Pre\_C) and experimental (Pre\_E) group (in both cases,  $p < .001$ ). Precisely, Pre\_C and Post\_E comparison ( $p < .001$ ) had a size effect of 2.047 (Cohen's *d*) that corresponded with a huge effect. Similar results were obtained when Pre\_E and Post\_E  $SB_{Total}$  comparison ( $p < .001$ ) had 2.000 (Cohen's *d*), which represented again a huge effect. Graphically, that is also observed in Figure 4b, where the  $SB_{Total}$  increased drastically after the F-ABN intervention in the experimental group (Post\_E).

Finally, targeting to get information about how other variables might have an influence in the PSTs' self-belief toward mathematics learning, an interaction study was conducted by means of factorial ANOVA. Here, the influence of PSTs' their educational background and gender were considered. Results are summarized in Table 4. According to the results obtained from the factorial ANOVA, a significant main effect of the group (control and experimental groups) was observed ( $F_{3,524} = 117.764, p < .001$ ), as well as a main effect of the PSTs' educational background ( $F_{2,524} = 26.576, p < .001$ ) (see Figure 5). On the other hand, no significant influence was observed considering the PSTs' gender difference. Regarding the interaction, there was a significant interaction between these two main effects, group\*background ( $F_{6,524} = 19.134, p < .001$ ), while there was a no significant interaction appreciated with their gender. According to the effect size ( $\eta^2$ ), the effect "group" accounted for 40% of the variance ( $\eta^2 = 0.40$ ) in PSTs' self-belief, whereas PSTs'



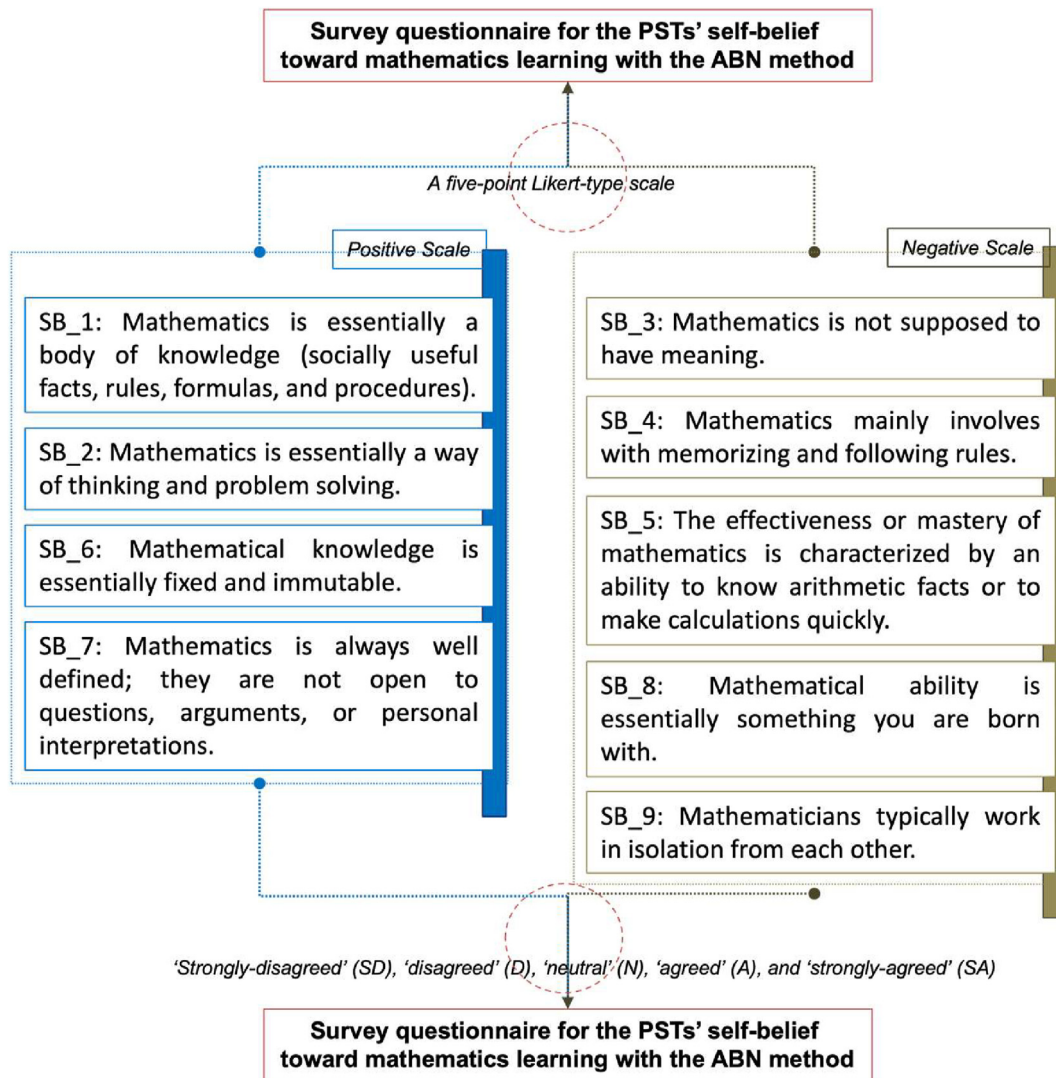


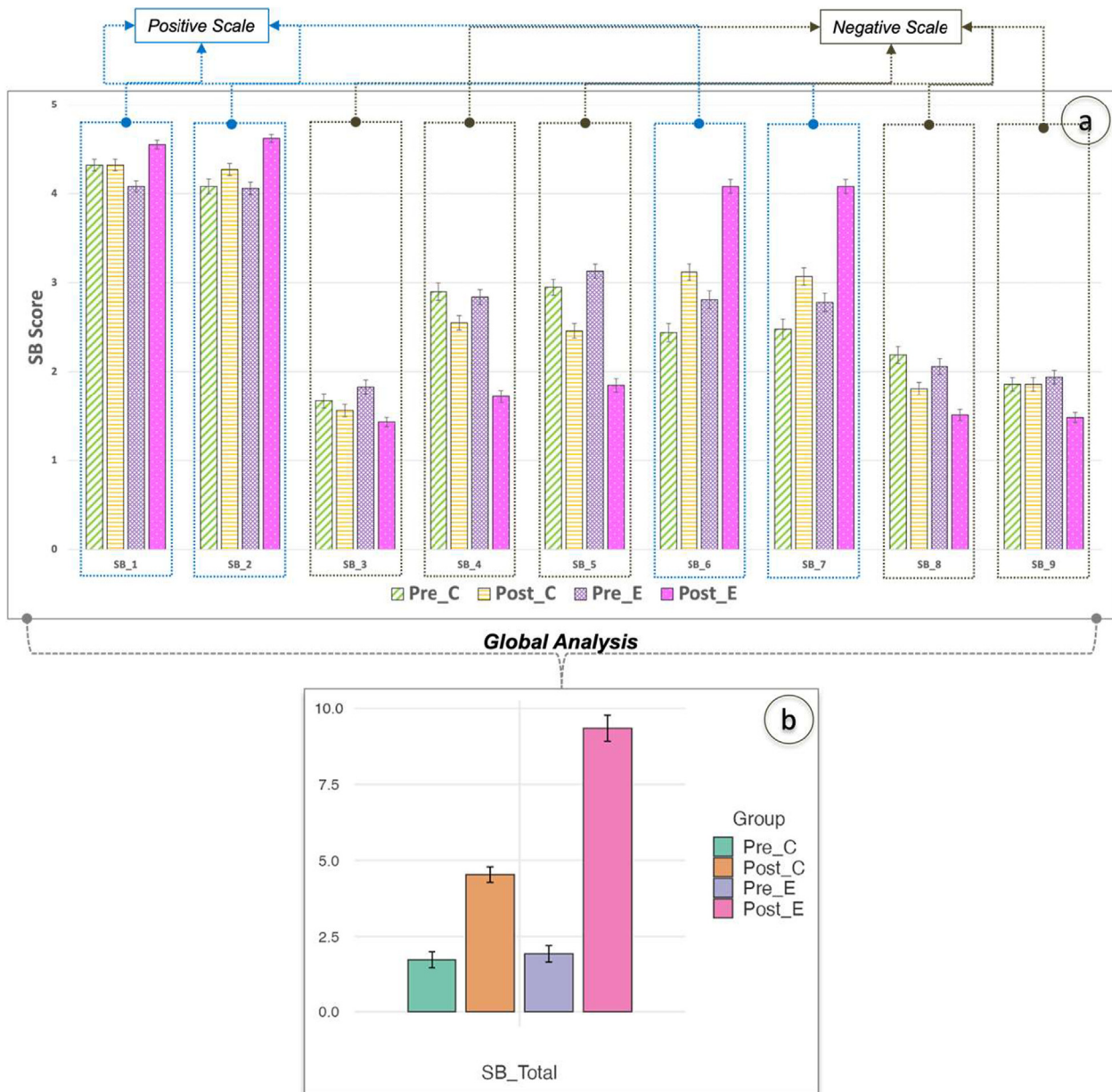
Figure 3. Survey questionnaire for the PSTs' self-belief toward mathematics learning with the ABN method.

“educational background” only accounted for the 9.2% ( $\eta^2 = 0.092$ ). Finally, the interaction group\*background accounted for the 18% ( $\eta^2 = 0.18$ ) of the variance. Again, Figure 5 displays a descriptive interaction plot in ANOVA, showing the bigger differences, in terms of  $SB_{Total}$  are found in the Post\_E group in terms of their educational background not in their gender difference.

With the results compared and examined, the PSTs' confidence in their capabilities to instruct mathematics was studied as an essential predictor for their future practice and teaching. Thus, different research previously sharpened the affirmative connection between teachers' and PSTs' mathematics self-belief and their mathematics instruction practice (Ma and Kishor, 1997), and students' enthusiasm to mathematics learning (Charalambous and Philippou, 2010). The PSTs with improved the self-belief were also more willing to adapt educational environments and were more passionate to engage innovative practices to the class (Tschannen-Moran and Woolfolk-Hoy, 2001; Charalambous and Philippou, 2010; Saçkes et al., 2012). It, subsequently, was critical to realize a proper instruction methodology in the classroom that could promote more self-efficacious PSTs in mathematics because it was challenging to alter their self-belief after self-belief was shaped (Jeong and González-Gómez, 2020; Lo et al., 2021).

To promote the self-belief of PSTs in mathematics disciplines, Akçayir and Akçayir (2018) and Burrus and Moore (2016) have

pointed out the appropriateness of the flipped-classroom methodology in which PSTs' major implication in the mathematics classroom related to self-belief's major increases. In the flipped-classroom, theoretical lectures from the classroom were changed to class materials that made more available in-class time and just-in-time, which allowed students to realize hands-on approach in mathematics learning and to put theoretical mathematics information in practice (Mattis, 2015; Piñero and Canto, 2019; Jeong and González-Gómez, 2020). Due to appear difficulties of learning much before than formal education (Aunio et al., 2015; European Commission, 2015; Radović et al., 2018), Baroody and Coslick (1998) discovered that PSTs showed opinions about the absence of active methodologies during the period of teaching training. As a result, the absence of confidence in mathematics teaching was a prevalent aspect amongst others. In this situation, flipped-classroom instruction methodology with the ABN method could be reflected to being an effectual instruction methodology to strengthen PSTs' self-belief towards mathematics learning. Thus, the PSTs with improved competency and maturity as a primary teacher training students would form logical and critical thinking and progress in mathematics for their future students due to not have a strong mathematics educational background (Thames and Ball, 2010; Radović et al., 2018). Although Pajares (2005) mentioned there was a gender differences in mathematics self-belief, it was not showing any significant difference in the results attained.



**Figure 4.** (a) Mean values of scores given for the participants ( $n = 274$ ) for the pre- and post-questionnaire for the control and experimental group, regarding the PSTs' self-belief toward mathematics learning. (b) Mean values of global scores calculated for the PSTs' self-beliefs toward mathematics learning considering its positive or negative correlation with the total scale ( $SB_{Total}$ ).

**Table 3.** Pairwise t-test as post-hoc comparisons of the control and experimental groups, before (pre-) and after (post-) intervention and the influence on the on the PSTs' self-belief ( $SB_{Total}$ ). The effect size (Cohen's  $d$ ) is included when significant differences were found in the  $SB_{Total}$  mean values between groups.

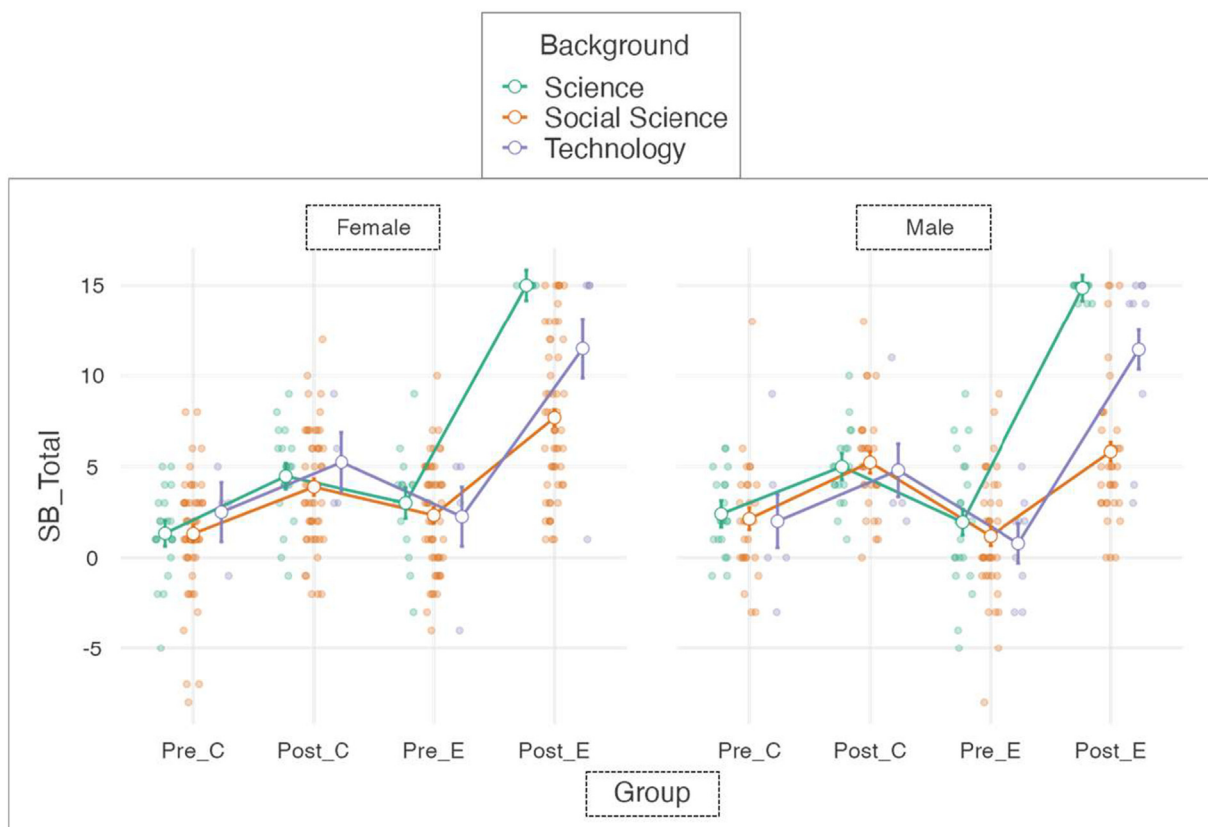
| Comparison | Mean Difference | SE     | df    | t   | p       | Cohen's $d$ |       |
|------------|-----------------|--------|-------|-----|---------|-------------|-------|
| Group      | Group           |        |       |     |         |             |       |
| Pre_C      | Pre_E           | -0.197 | 0.45  | 544 | -0.439  | 0.661       | -     |
| Pre_C      | Post_C          | -2.802 | 0.459 | 544 | -6.098  | <.001       | 0.753 |
| Pre_C      | Post_E          | -7.610 | 0.45  | 544 | -16.922 | <.001       | 2.047 |
| Post_C     | Pre_E           | 2.604  | 0.45  | 544 | 5.791   | <.001       | 0.700 |
| Post_C     | Post_E          | -4.808 | 0.45  | 544 | -10.692 | <.001       | 1.293 |
| Pre_E      | Post_E          | -7.413 | 0.44  | 544 | -16.856 | <.001       | 2.000 |

**Table 4.** Results for the full factorial analysis of variance (ANOVA) model regarding the influence on the PSTs' self-belief ( $SB_{Total}$ ), including the interaction components of group\*gender, group\*background, background\*gender and group\*background\*gender.

| Interaction                                   | Sum of Squares | df  | Mean Square | F       | p     | $\eta^2$ |
|---|----------------|-----|-------------|---------|-------|----------|
| Group (pre-, post-, control and experimental) | 3761.32        | 3   | 1253.77     | 117.764 | <.001 | 0.403    |
| Background                                    | 565.87         | 2   | 282.94      | 26.576  | <.001 | 0.092    |
| Gender  | 3.82           | 1   | 3.82        | 0.359   | 0.549 | 0.001    |
| Group * Background                            | 1222.27        | 6   | 203.71      | 19.134  | <.001 | 0.180    |
| Group * Gender                                | 35.09          | 3   | 11.70       | 1.098   | 0.349 | 0.006    |
| Background * Gender                           | 4.85           | 2   | 2.42        | 0.228   | 0.796 | 0.001    |
| Group * Background * Gender                   | 33.71          | 6   | 5.62        | 0.528   | 0.787 | 0.006    |
| Residuals                                     | 5578.76        | 524 | 10.65       | -       | -     | -        |

between Pre\_C and Pre\_E indicating homogeneity in terms of self-belief toward mathematics learning in terms of  $SB_{Total}$ . Particularly, Pre\_C and Post\_E comparison ( $p < .001$ ) presented a huge size effect of 2.047 (Cohen's  $d$ ) and Pre\_E and Post\_E  $SB_{Total}$  ( $p < .001$ ) demonstrated 2.000 the Cohen's  $d$ , that represented again a huge effect. Finally, regarding with other variables' influence on PSTs' self-belief toward mathematics learning, the interactive study of factorial ANOVA summarized that a significant main effect between the control and experimental group was observed ( $F_{3,524} = 117.764, p < .001$ ) with ( $\eta^2 = 0.40$ ) and in the PSTs' educational background ( $F_{2,524} = 26.576, p < .001$ ) with ( $\eta^2 = 0.092$ ), but not in the PSTs' gender difference. In the interaction matter, group\*background exhibited a significant interaction, group\*background ( $F_{6,524} = 19.134, p < .001$ ) with ( $\eta^2 = 0.18$ ), while no with gender difference. A descriptive interaction plot in ANOVA showed the bigger changes, in terms of  $SB_{Total}$  that found in the Post\_E group.

Since many PSTs had not taken mathematics in previous educational stages and pondered it as not an easy course, this research pointed out that using more student-centered instruction methodology, as the F-ABN,



**Figure 5.** A descriptive interaction plot in ANOVA of the results for the full factorial ANOVA model regarding the influence on the on the PSTs' self-belief ( $SB_{Total}$ ), including the interaction components of group\*gender, group\*background, background\*gender and group\*background\*gender.

**4. Conclusions**

Based on the results attained from the research, it concludes the comparison and examination of two different instruction methodologies with ABN method in a mathematics course. With 274 participants, instruction methodology realized with F-ABN method as experimental group for PST in primary education had a significant difference as a positive effect in the self-belief with the individual and total scale ( $SB_{Total}$ ) and made classes more interactive towards mathematics learnings. Thus, the ANOVA test confirmed that there was a significant effect of the intervention on the PSTs' self-belief ( $SB_{Total}$ ) as ( $F_{3,544} = 128, p < .001$ ) with the large size effect ( $\eta^2$ ), 0.413. Due to observe significant differences, a post-hoc test showed the existence of significant differences in each group except

acknowledged to shape a more positive teaching-learning environment. Here, the PSTs' self-belief concerning the course were improved, and therefore better learning outcomes should be projected. Thus, the PSTs with enriched competency and experience as a primary teacher training students would build rational and critical thinking and advance in mathematics for their future students due to not have a strong mathematics educational background regardless of gender difference. Here, more student-centered and inquiry-based methodologies allowed to build positive teaching/learning environment for PSTs, which expects better learning outcomes for children.

Although the F-ABN method could contribute the mathematics learning for PSTs as the consequences of the results in the educational scenery, more research as future works would be necessary to be done to



entirely appreciate the probabilities and restrictions of this instruction methodology proposed, and applications as an alternative of the traditional instruction methodology. Also, it still needs to extend the investigation not only PSTs' level but also in-service teachers' level. Finally, the possible limitations of this research could be the lack of other variables' analysis along with bigger sample size, which might affect the results. They could be also the future works as a possible recommendation.

## Declarations

### Author contribution statement

Jin Su Jeong; David Gonzalez Gomez: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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### Data availability statement

Data will be made available on request.

### Declaration of interests statement

The authors declare no conflict of interest.

### Additional information

Supplementary content related to this article has been published online at <https://doi.org/10.1016/j.heliyon.2022.e09806>.

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