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Identifying Preservice Teachers' Belief Profiles and their Performance in a Web-based Training for Writing Instruction

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A B S T R A C T

This research aims to fill the need to provide writing education to preservice teachers by using web-based instruction. The novel contribution of this work lies in the consideration of beliefs as a methodological prerequisite when measuring the effects of a web-based program. For this purpose, latent profile analysis was conducted to explore unique profiles of preservice teachers' beliefs about writing before the web-based instruction. Participants were classified into three profiles: eclectic profile (n = 129), socio-cultural profile (n = 85), and person-environment profile (n = 105). Linear mixed-effects models were employed to assess if belief profiles experienced changes in beliefs and knowledge after the training. Results showed that belief profiles differed from each other in the degree of attribution of the different beliefs but remarkably all of them experienced significant differences in content knowledge acquisition. Finally, educational implications for preservice teachers' education are highlighted.

La identificación de los perfiles de creencias de maestros y maestras en formación y su desempeño en un programa web de enseñanza de la escritura

Palabras clave:
Análisis de perfil latente
Maestros y maestras en formación
Formación web
Creencias
Conocimiento de contenidos
Escritura

R E S U M E N

Esta investigación tiene como objetivo cubrir la necesidad de proporcionar formación en la enseñanza de la escritura a maestros y maestras en formación mediante el uso de un programa web. La aportación novedosa de este trabajo radica en la consideración de las creencias como prerrequisito metodológico a la hora de medir los efectos de un programa web. Con este fin, antes de la instrucción web se realizó un análisis de perfiles latentes con el fin de explorar perfiles únicos de creencias sobre la escritura en maestros y maestras en formación. Se clasificó a los participantes en tres perfiles: perfil ecléctico (n = 129), sociocultural (n = 85) y persona-ambiente (n = 105). Se emplearon modelos mixtos lineales para evaluar si los perfiles de creencias experimentaban cambios en las creencias y el conocimiento después de la formación. Los resultados muestran que los perfiles de creencias difieren entre si en el grado de atribución de las diferentes creencias, pero todos ellos experimentan diferencias significativas en la adquisición del conocimiento de contenidos. Finalmente, se destacan las implicaciones educativas para la formación de futuros docentes.

Preservice teachers (PTs) training is essential for successful teaching (Johansson & Myrberg, 2019; Myrberg et al., 2019). This is especially relevant when it comes to teaching writing due to the fact that mastery of writing skills is related to success in the job market (Kolin, 2022). Recent studies have shown that university training courses did not provide complete information on language constructs for teaching writing (Brenner & McQuirk, 2019; Hodges et al., 2019; Oliveira et al., 2019; Scott et al., 2018) and future teachers did not feel prepared for teaching writing (Hodges et al., 2019). Hence, exploring new ways of training PTs to teach writing may hold great promise for promoting long-term impact on their teaching practice.

Given that professional development begins in university, implementation of high-quality writing programs in university will be one of the most viable solutions to prevent future teachers from being unprepared to teach writing. Different studies show that web platforms are a good resource to promote the professional development of teacher candidates (Birisci, 2017; Saine & West, 2017). Furthermore, the potential use and analysis of online education regarding student achievement has skyrocketed after the pandemic (Ulum, 2022). According to well-known models for professional development, quality marks for web-based programs may be users' knowledge acquisition (Dunst et al., 2019) and changes

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in their beliefs (Blömeke et al., 2015; Desimone, 2009; Santagata & Yeh, 2016). Building on these models, when creating a high-quality program, a joint approach that includes knowledge and beliefs will be needed because (1) teachers will require "content knowledge" to understand the subject they teach (i.e., specific knowledge about how the writing ability develops in children and the language skills involved) and (2) their teaching practices will be mediated by their own "beliefs" (i.e., ideas on how children learn to write and how they may be taught accordingly). An example of the former is the fact that the mastery of handwriting skills is a prerequisite for fluent transcription. An example of the latter is the idea that children have the ability to learn to write on their own without instruction. While knowledge is characterized as being objective, beliefs may be subjective (Pajares, 1992; Richardson, 1996; Rodrigo et al., 1993). Accordingly, it seems necessary to provide future teachers with content knowledge about the field of study and to explore their beliefs about the teaching and learning process to ensure that their practices are as aligned as possible with the evidence.

In the field of early literacy, previous research supports the use of web-based programs for teacher professional development, supporting improvements in content knowledge and changes in beliefs (Jiménez & O'Shanahan, 2016; Jiménez et al., 2021). Building on previous references, the present study aims to provide a new insight in the field by proposing the identification of belief profiles (through the analysis of latent profiles) to better understand the performance of future teachers in web-based training. To the best of our knowledge, this is the first time that preservice teachers' beliefs about writing have been considered a prerequisite within the methodological design and evaluation of a WBT assessment. This rationality goes hand in hand with the previous evidence that supports the identification of belief profiles to understand the performance of PTs (Reichert & Torney-Purta, 2019; Smidt et al., 2015). Below, three key components of this research are deeply introduced: (1) latent profile analysis, (2) content knowledge, and (3) beliefs.

Person-centered approaches are characterized by identifying subgroups within populations based on their profiles of responses to particular variables (in this work beliefs about learning to write) (McLarnon & O' Neill, 2018). Person-centered approaches place more emphasis on an individual's experience with the potential to provide insight into different patterns of strengths and weaknesses in learning processes (Hickendorff et al., 2018), allowing for a deeper understanding of PTs performance. "Latent profile analysis" is an example of a person-centered approach. Latent profile analysis will be used in the present work with the purpose to shed light on participants' belief profiles and how they relate to the level of achievement in the designed WBT. Consequently, the effects of WBT on PTs' content knowledge and beliefs will be measured by incorporating latent profile analysis.

"Content knowledge" refers to the knowledge of the subject (Shulman, 1987) and its relevance is because teacher candidates must understand the subject they will teach. Within the specific area that this research is dealing, it refers to knowledge about how writing ability develops in children. Theoretical writing models must be taken into consideration when it comes to providing content knowledge about writing. Those are a potential source of understanding of what is writing, which are the processes involved and how they interact with each other (Hayes & Olinghouse, 2015). Specifically, triangular writing models postulate that mastering transcription skills (i.e., handwriting, typing, and spelling) is necessary to achieve text generation (Berninger, 2000; Berninger & Winn, 2006). Executive functions condition the success of this process (e.g., self-regulation, planning, review) and working memory supports information retrieval and review. Digital education allows the content of these models to be brought closer to PTs in a simple way.

"Beliefs" on writing have been defined as assumptions about learning and teaching writing (Graham et al., 2002). The focus on beliefs related to teaching and learning is especially relevant in early literacy. Ideas about the nature, acquisition, and development of written language have been consolidated around learning theories with different educational implications (Çakıroğlu, 2019). As a consequence, there is a growing corpus of research investigating teachers' beliefs about writing (see Rietdijk et al., 2018 for a snapshot of teachers beliefs about writing) but there is a small amount focused on teacher candidates beliefs. In this study, it is considered that the analysis of preservice teachers' beliefs can be understood as a preventive approach in the field of teacher education. Besides, the use of multiple learning theories for exploring the writing process could provide a wider perspective of future writing practices. Following this line of thought, Seoane et al. (2020) developed the Questionnaire of Pre-service Teachers' Beliefs on Learning to Write for measuring beliefs associated with six learning theories applied to writing. The questionnaire is composed of six factors: (1) "behaviourist" (i.e., holds that learners undergo some kind of conditioning and the learning process is the result of changes in behavior through instruction or correction), (2) "constructivist" (i.e., emphasizes the active construction of knowledge through the integration of new knowledge based on children own activities), (3) "psycholinguistic" (i.e., presumes that written language builds on the foundation of oral language), (4) "maturation" (i.e., holds that learning success is related to achieve the degree of cognitive development with maturation), (5) "socio-cultural" (i.e., advocates that learning emerges due to effective interaction and social communication in the environment), and (6) "nativist" (holds that humans are born with the predisposition to learn).

This study is part of a larger project whose main objective is to provide web-based training for teaching writing, and different effects are explored in a single sample. Within this project, Seoane et al. (2020) developed the questionnaire with the goal to measure PTs level of attribution of different learning theories. The present study explores unique belief profiles of PTs who completed the cited questionnaire prior to the WBT (N = 319; Seoane et al., 2020). To the best of our knowledge, there has been no prior research linking the effects of online training on writing education (i.e., changes in content knowledge and beliefs) with prior latent belief profiles in preservice teachers. As such, we pose research questions rather than objectives. A quasi-experimental design and a person-centered approach were used to address the following specific research questions.

RQ1: What distinct latent belief profiles emerge after measuring attribution levels of learning theories related to writing (behaviorist, constructivist, psycholinguistic, maturation, socio-cultural theory, and nativist theories) before the WBT?

RQ2: Do belief profiles reveal different changes in attribution levels in each learning theory after the WBT?

RQ3: Do belief profiles reveal different changes in average content knowledge after the WBT?

Method

Participants

The participants in this study were 319 PTs (age M = 22.90, SD = 5.51; women = 248, men = 70), 179 were Early Childhood Education PTs from Universidad de Las Palmas de Gran Canaria, and 140 were Primary School PTs from Universidad de La Laguna. Participant recruitment was carried out through the website where the program is hosted. Recruitment efforts also drew on talks aimed at PTs at both universities. Participants had already completed their first year of college. The PTs were enrolled between the 2nd and the 4th year of university.

Instruments

Previous Sources for Learning

Participants were asked to mark from a list of eight different sources for learning the ones they had used before starting the training. The response options available were: initial training, specialty courses, professional experience, informative programs, books and articles, specific laws, experiences of other professionals, and online resources.

Previous Experience with Children with Learning Disabilities in Writing

Users were asked to rate their degree of experience working with children with learning disabilities in writing on an ordinal scale of four categories (i.e., none, little, enough, much).

Knowledge Questionnaire (Jiménez et al., 2021)

This is a knowledge questionnaire designed to measure the content knowledge provided in the web-based program using six sections: (1) general writing knowledge (α = .78), (2) handwriting knowledge (α = .82), (3) spelling knowledge (α = .81), (4) writing by pen and keyboard modes (α = .86), (5) writing composition knowledge (α = .85), and (6) RtI framework (α = .85). Each section included a total of 20 items. For each item, four potential response alternatives were presented from which the correct one had to be selected (e.g., "Which are the main components of handwriting fluency: a) spacing and alignment, b) legibility and spacing, c) legibility and speed, d) speed and handwriting?"). Reliability analysis of these scales was explored in the cited study (Jiménez et al., 2021).

Beliefs Survey (Seoane et al., 2020)

This survey is made up of 30 statements corresponding to basic postulates of different learning theories: (1) behaviorist theory (α = .88), (2) constructivist theory (α = .78), (3) psycholinguistic theory (α = .63), (4) maturation theory (α = .72), (5) socio-cultural theory (α = .86), and (6) nativist theory (α = .77) (total scale, α = .84, ω = .89). PTs expressed their degree of agreement and disagreement on a Likert-like scale ranging from *strongly disagree* (score = 0) to *strongly agree* (score = 10) (e.g., "I consider that the immediate correction of errors is very helpful in learning to write").

Program Design and Procedure

Trazo is a web-based program http://trazo.iaas.ull.es/ designed to offer digital education about writing instruction to teach typical beginner writers and beginners who struggle with writing acquisition. The multimedia design represents a virtual environment where the user sees different modules to create different spaces in the same e-learning environment containing all the necessary content and resources for teacher training. The content on the platform relies on the theoretical framework of triangular writing models (Berninger, 2000; Berninger & Winn, 2006). The first module is divided into asynchronous instructional videos (screencasts and animation-action footage) that provide step-by-step content knowledge (see the Appendix A for specific content knowledge provided). The second module contains teaching materials for teachers and students. The third volume focuses on teacher training in the IPAE (*Indicadores de Progreso de Aprendizaje en Escritura* [Indicators of Basic Early Writing Skills]; Jiménez & Gil, 2019) a curriculum-based measurement (CBM). In the fourth volume video, recordings are presented on how to implement good teaching practices, and in the last section, supplemental resources to support instruction are included.

The WBT syllabus design is provided in Appendix A. Trazo is a 120 h WBT program organized in a gap of 16 weeks plus two weeks devoted to pre-post questionnaires. Before starting the WBT, participants had to complete the previous questionnaires. They did not have a limit of time but only an opportunity to take the surveys. PTs had to follow the schedule and instructions for each module. For the first module (i.e., content knowledge) users were able to repeat each tutorial up to three times, and each of these was accompanied by a pretest and posttest evaluation. Nevertheless, when PTs were not able to complete within the basic unit of time, they were allowed 2 to 3 days to complete the activity. The second module was then activated, and this process continued until the completion of the remaining modules. After completion of the program, users were invited to complete the beliefs survey.

Data Analysis

To answer the first research question (i.e., "What distinct latent belief profiles emerge after measuring attribution levels of learning theories related to writing [behaviorist, constructivist, psycholinguistic, maturation, socio-cultural theory, and nativist theories] before the WBT?"), a latent profile analysis was conducted to identify PTs' unique belief profiles before the WBT (N = 319). Given the continuous nature of the observed measures in this study (i.e., attribution levels on the six learning theories measured with the beliefs survey), a latent profile analysis modeled the joint distribution of all the observed measures using Gaussian mixture models (GMMs) (Hickendorff et al., 2018). The adjusted Lo-Mendell-Rubin likelihood ratio test (ALMR) and the bootstrapped likelihood ratio test (BLRT) were explored to test the statistical differences in the fit of a k profile (or class) model compared to a k - 1 profile (or class) model. In addition, three comparative fit indices, Akaike information criterion (AIC), Bayesian information criterion (BIC), and sample-adjusted BIC (sBIC), were considered. The entropy of the model indicates the precision with which the cases are classified into the profiles, with larger values (closer to 1) indicating clear separation of the classes; values higher than .60 indicate a good class separation and excellent higher than .80 (Asparouhov & Muthén, 2013). Posterior probabilities describe how likely a participant is to belong to each profile and can be obtained by applying Bayes' theorem (Lanza et al., 2013). A good rule of thumb is that a useful model has an average posterior classification probability higher than .70 in each profile (Nagin, 2005, cited in Wang & Wang, 2019). The analysis was carried out using a demo version of Mplus 8 (Muthén & Muthén, 1998/2017).

We also explored further the characteristics of the participants who completed the WBT (n = 158). We analyzed differences in terms of previous informal training and experience with children with learning disabilities in writing, which could influence the effectiveness of the program. The dropout rate per belief profile was analyzed.

To answer the second research question (i.e., "Do belief profiles reveal different changes in attribution levels in each learning theory after the WBT?") a linear mixed-effects model was conducted. The steps taken were as follows: (1) fixed effects terms included a triple interaction between belief profile (i.e., eclectic profile, socio-cultural profile, person-environment profile), time (i.e., pre-test and post-test), and learning theory (i.e., behaviorist, constructivist, psycholinguistic, maturation, socio-cultural theory, and nativist). Participant was included as a random effect with time as a random slope to allow the growth rate to vary randomly across participants (Finch et al., 2019); (2) in order to test for the significance of

the factors, we performed a sequential decomposition of the contributions of the fixed-effects using the ANOVA function from the ImerTest package (Kuznetsova et al., 2017), using type III hypothesis test; for each factor, an *F* test and its corresponding *p* value were estimated using the Satterthwaite's method; (3) the highest order significant interaction was followed up with pairwise post hoc tests applying the Scheffe method to adjust *p* values for multiple comparisons.

Finally, to answer the last research question (i.e., "Do belief profiles reveal different changes in average content knowledge after the WBT?"), a second linear mixed-effect model was conducted. The steps taken were as follows: (1) fixed effects included an interaction between belief profile (i.e., eclectic profile, socio-cultural profile, person-environment profile) and time (i.e., pre-test and post-test), and knowledge type was included as a main effect in order to control for the fact that there were six different knowledge sections. Again, participant was introduced as a random intercept and time as a random slope. Steps 2 and 3 were identical to the previous model.

All linear mixed-effect models were conducted in R version 4.1.1 (2021-08-10) (R Core Team, 2021) using the Imer function of the lme4 package version 1.1-27.1 (Bates et al., 2015) and the lmerTest package version 3.1-3. The emmeans R package version 1.7.0 (Lenth, 2021) was used for post-hoc pairwise comparisons.

Results

What Distinct Latent Belief Profiles Emerge after Measuring Attribution Levels of Learning Theories Related to Writing (Behaviorist, Constructivist, Psycholinguistic, Maturation, Socio-cultural Theory, and Nativist Theories) before the WBT?

One to five latent profile models were assessed. Table 1 shows their fit indices and likelihood ratio tests. The BLRT was considered uninformative as its value was significant for each model analyzed (i.e., there were always significant differences between *k*-1 and *k* class models). The ALMR likelihood ratio test revealed that the three-profile model significantly improved the data fit compared to the two - profile solution ($p < .01$). Non-significant differences were found between the three and four-profile solutions and between the four and five-profile solutions. Although the AIC, BIC, and sBIC comparative fit indices successively decreased with increasing latent classes, some of the profiles in four and five-profile solutions had a very small sample size, with some profiles accounting for less than 7% of the population in the four-profile model and 5% in the five-profile.

After examining the item-profile plots, the three-profile solution was deemed optimal given the ALMR likelihood ratio test, satisfactory entropy, sample sizes within profiles, and meaningful and interpretable belief-related profiles. The average posterior classification probabilities were high for eclectic profile (.934, $n = 129$), socio-cultural profile (.896, $n = 85$), and person-environment profile (.871, $n = 105$), indicating small classification uncertainty and that the profiles were distinguishable from one another. Generally speaking, participants classified within the eclectic profile had similar scores in all theories, except for the nativist theory, where they showed low scores. Compared to the other profiles, the eclectic profile showed lower scores in all theories except for the behaviorist theory; in this regard, the socio-cultural profile was primarily characterized by low scores in the behaviorist theory. Finally, the person-environment profile showed higher scores on psycholinguistic and behaviorist theories compared to the other profiles. Boxplots of each belief profile are presented in Figure 1.

Participants who did not complete all the questionnaires according to the schedule's requirements were excluded from this study to guarantee research quality. Consequently, 158 PTs completed the full program intervention. The eclectic profile was made up of 70 users, followed by 47 users in the socio-cultural profile, and 41 users in the person-environment profile. When analyzing the dropout rate, significant differences were found between belief profiles ($p = .032$). Regarding the initial sample, the person-environment profile lost 39.8% of users, followed by the eclectic profile with a dropout rate of 36.6%, and finally the socio-cultural profile with 23.6% dropout rate.

Last, Pearson's chi-square test (χ^2) was used to determine whether or not the belief profiles differed in previous informal training and experience with children with writing learning disabilities. Results revealed that the three belief profiles who completed the WBT did not differ significantly in previous informal training, $\chi^2(14, 319) = 15.77$, $p = .32$, or experience, $\chi^2(4, 319) = 4.42$, $p = .35$.

Do Belief Profiles Reveal Different Changes in Attribution Levels in each Learning Theory after the WBT?

Table 2 shows the means, standard deviations, and score gain for the six learning theories by beliefs profiles. A linear mixed effect model predicting change in attribution levels by the learning theory and beliefs profiles while controlling for the random intercepts by participant and time revealed a significant learning theory-belief profile-time interaction as the highest order effect ($p < .000$) (see Table 3). This indicates that the Trazo WBT produced different effects on belief profiles depending on learning theory and time. To break down this interaction, pairwise post hoc contrasts between belief profiles across the learning theories at both measurement moments were run (see Appendix B). Broadly speaking, main effect analyses demonstrated significant differences between eclectic profile and the other belief profiles (i.e., the socio-cultural profile and person-environment profile) for behaviourist, maduration, nativist, and socio-cultural theories at pretest moment. More specifically, the eclectic profile showed significantly lower scores for maturation, nativist, and socio-cultural learning theories than the remaining profiles. With regard to the behaviourist learning theory, differences between belief profiles at pretest reveal significant lower punctuations of the socio-cultural profile compared to the eclectic profile ($p < .00$) and the person-environment profile ($p < .00$). There were also significant differences at pretest ($p < .00$) and posttest ($p < .01$) between the eclectic profile and the socio-cultural profile for constructivist learning theory, meaning that the eclectic profile showed significantly lower scores for constructivist items at both measurement moments when compared to the socio-cultural profile. Lastly, regarding the main effects within belief profiles across learning theories and time, only significant differences were

Table 1. Fit Statistics for the Latent Profile Analysis on Pre-service Teachers' Beliefs

	LL	BIC	sBIC	AIC	Entropy	ALMR *p*-value	BLRT *p*-value
Two Profiles	-6412.421	12934.380	12874.116	12862.842	.775	.000	.000
Three Profiles[1]	-6365.453	12880.801	12798.335	12782.906	.777	.002	.000
Four Profiles	-6339.705	12869.661	12764.992	12745.410	.790	.563	.000
Five Profiles	-6319.660	12869.927	12743.055	12719.319	.787	.271	.000

Note. [1]Model chosen as best class solution; LL = Log-likelihood; n = total number of observations; BIC = Bayesian information criterion; sBIC = sample-ajusted BIC; AIC = Akaike information criterion.

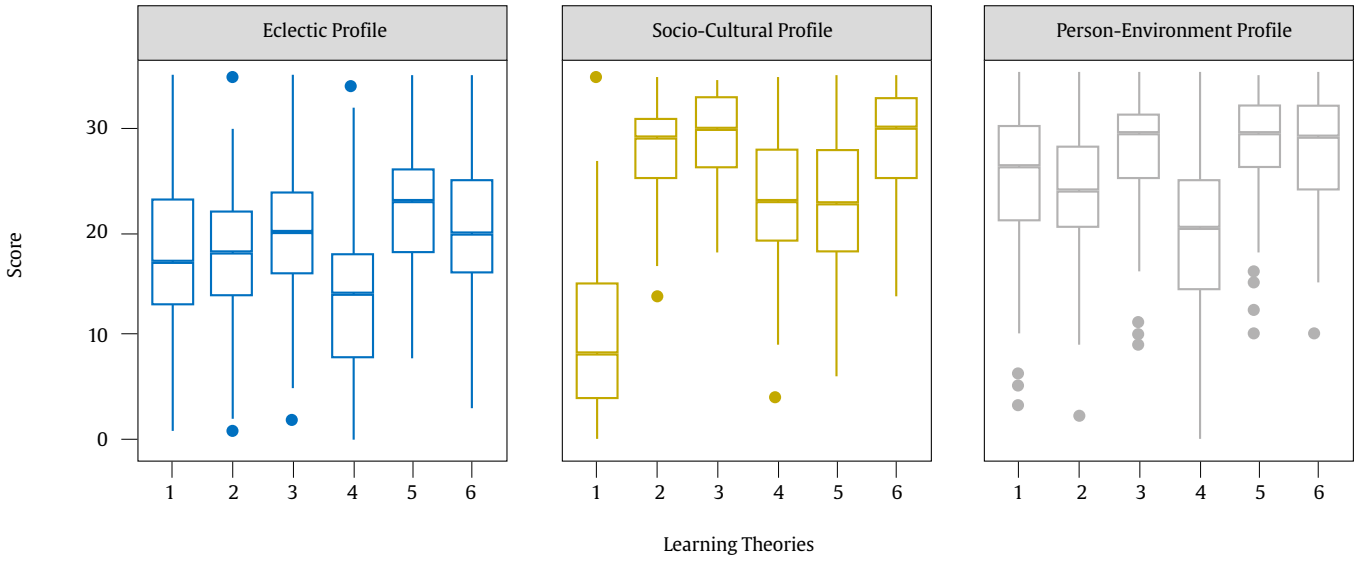

Figure 1. Boxplots of Each Belief Profiles.

Table 2. Means and Standard Deviations before and after the Web-based Training by Participants Who Completed the Web-based Training and by Belief Profiles

	Initial sample *n* = 319		Participants who complete WBT *n* = 158					Eclectic Profile *n* =70					Socio-Cultural Profile *n* = 47					Person-Enviroment Profile *n* = 41			
	Pretest		Pretest		Posttest		Gain	Pretest		Posttest		Gain	Pretest		Posttest		Gain	Pretest		Posttest	
Learning Theories	*M*	*SD*	*M*	*SD*	*M*	*SD*	*MD*	*M*	*SD*	*M*	*SD*	*M*	*M*	*SD*	*M*	*SD*	*MD*	*M*	*SD*	*M*	*SD*
Psycholinguistic	23.80	6.36	23.84	5.99	24.91	6.16	1.07	22.24	5.39	22.94	6.34	0.70	22.34	6.43	25.19	5.34	2.85	28.31	3.94	27.95	5.54
Behaviorist	17.20	9.58	16.01	9.38	19.24	8.46	3.23	17.00	6.98	19.71	7.73	2.71	6.36	5.05	14.70	7.82	8.34	25.39	5.51	23.63	7.95
Maturation	24.40	6.98	23.79	7.18	25.83	6.44	2.04	18.28	5.75	22.15	6.33	3.87	29.25	4.16	29.51	4.47	0.26	26.95	5.22	27.90	5.19
Nativist	17.05	8.04	16.12	8.27	19.06	7.73	2.94	10.80	6.15	14.97	6.92	4.17	21.74	7.10	23.38	6.10	1.64	18.78	7.19	21.09	7.34
Socio-cultural	24.49	7.35	23.89	7.67	25.81	6.45	1.92	18.14	6.47	22.20	6.32	4.06	28.72	5.10	29.10	5.15	0.32	28.19	4.98	28.21	4.75
Constructivist	22.02	7.13	21.60	7.33	23.48	7.15	1.88	16.30	5.75	19.22	6.84	2.92	28.31	4.03	28.02	5.18	-0.29	22.97	5.58	25.53	5.37

Note. M = mean; *SD* = standard deviation; MD = differences in means between pretest-posttest scores; WBT = web-based training.

found for the socio-cultural profile at tge behaviorist theory (p < .05), meaning that their level of attribution for this theory was significantly higher after the WBT.

Do Belief Profiles Reveal Different Changes in Average Content Knowledge after the WBT?

Table 4 shows means, standard deviations, and score gain of participants who completed the full WBT for the six-knowledge type. A linear mixed effect model predicting change in knowledge type by beliefs profiles after the WBT was conducted. The mixed-effects model yields a positive and significant effect of time (p < .000), meaning that the overall difference in content knowledge was significant prior and after the WBT. Last, it was also found a significant effect of the belief profile (p = .02), meaning that there were significant differences between the three beliefs profiles in the overall content knowledge. It should be noted that the interaction of the belief profile x time did not reveal significant differences (p = .91), meaning that the overall difference between the profiles did not increase after the WBT (see Table 5).

Discussion

The main goal of this study was to evaluate the efficacy of web-based instruction for writing by employing a quasi-experimental design and a person-centered approach. Overall, the findings

Table 3. Type III Analysis of Variance Table with Satterthwaite's Method of the Fixed Effects of Belief Profile, Time, and Learning Theory

	Sum Sq	Mean Sq	*df*	Den *df*	*F* value	Pr(> *F*)
Learning Theory	19584.1	3916.8	5	1550.00	134.47	< 2.2e-16 ***
Belief Profile	4959.9	2479.9	2	155.00	85.14	< 2.2e-16***
Time	1056.9	1056.9	1	155.01	36.28	1.19E-08***
LearningTheory:Belief Profile	16560.4	1656.0	10	1550.00	56.85	< 2.2e-16***
LearningTheory:Time	226.2	45.2	5	1550.00	1.55	0.170424
BeliefProfile:Time	283.9	141.9	2	155.01	4.87	0.008863**
LearningTheory:Belief .Profile:Time	1553.8	155.4	10	1550.00	5.33	8.90E-08***

*p < .05, **p < .01, ***p < .001.

Table 4. Means and Standard Deviations before and after the Web-based Training by Participants Who Completed the Web-based Training and by Belief Profiles

	Participants who complete WBT $n = 158$					Eclectic Profile $n = 70$					Socio-Cultural Profile $n = 47$					Person-Environment Profile $n = 41$				
	Pretest		Posttest		Gain	Pretest		Posttest		Gain	Pretest		Posttest		Gain	Pretest		Posttest		Gain
Knowledge type	*M*	*SD*	*M*	*SD*	*MD*	*M*	*SD*	*M*	*SD*	*MD*	*M*	*SD*	*M*	*SD*	*MD*	*M*	*SD*	*M*	*SD*	*MD*
General writing knowledge	4.91	1.38	7.61	1.13	2.70	5.22	1.93	7.83	1.78	2.61	4.93	1.36	7.39	1.52	2.46	5.06	1.57	7.47	1.63	2.41
Handwriting knowledge	5.09	1.68	7.61	1.67	2.52	6.17	2.02	8.35	1.51	2.18	5.01	1.51	7.39	1.59	2.38	5.73	1.89	8.07	1.67	2.34
Spelling knowledge	5.71	1.90	7.99	1.62	2.28	6.79	2.16	9.05	1.38	2.26	6.35	1.79	8.85	0.94	2.50	6.87	2.11	8.93	1.06	2.06
Writing composition knowledge	5.48	1.94	8.55	1.37	3.07	5.70	1.96	8.77	1.33	3.17	4.91	1.60	8.26	1.25	3.35	5.75	2.17	8.52	1.51	2.77
Writing in pen and keyboard modes	6.68	2.04	8.96	1.18	2.28	4.88	1.60	7.68	1.09	2.80	5.03	1.15	7.55	1.13	2.52	4.81	1.22	7.56	1.23	2.75
RtI framework	5.00	2.03	7.96	1.88	2.96	5.39	2.01	8.26	1.92	2.87	4.59	1.78	7.51	1.78	2.92	4.79	2.23	7.98	1.88	3.19

Note. *M* = mean; *SD* = standard deviation; WBT = web-based training.

Table 5. Type III Analysis of Variance Table with Satterthwaite's Method on the Mixed Effect Model for Belief Profile, Time, and Knowledge

	Sum Sq	Mean Sq	Num DF	Den DF	*F* value	Pr(> *F*)
Belief Profile	14.17	7.08	2	155	3.89	0.02236*
Time	1539.72	1539.72	1	155	846.73	< 2e-16***
Knowledge	532.15	106.43	5	1575	58.52	< 2e-16***
Belief Profile: Time	0.33	0.17	2	155	0.09	0.9122

*$p < .05$, **$p < .01$, ***$p < .001$.

support the existence of three belief profiles which differed from each other in the degree of attribution of the different learning theories, but remarkably all of them experienced significant differences in content knowledge acquisition after the WBT provided. In this regard, the findings may support previous results of web-based designs for improving content knowledge (Stricklin & Tingle, 2016) and changing beliefs (Ferrara, 2017; Jiménez & O'Shanahan, 2016; Jiménez et al., 2021; Luo et al., 2017; Zhang et al., 2016).

What Distinct Latent Belief Profiles Emerge after Measuring Attribution Levels of Learning Theories Related to Writing (Behaviorist, Constructivist, Psycholinguistic, Maturation, Socio-cultural Theory, and Nativist Theories) before the WBT?

First, latent belief profiles that can be identified among PTs were examined. With this person-oriented approach, it was wanted to examine what kinds of groups of PTs with different belief profiles emerge from measuring implicit theories of learning to write. Three groups were identified: the eclectic profile, the socio-cultural profile, and the person-environment profile. These groups differed from each other in the degree of attribution of the different learning theories. The creation of these profiles is congruent with the extended idea that beliefs are held in clusters rather than isolated, which means that incompatible or inconsistent beliefs might co-exist (Eichler & Erens, 2015; Green, 1971). For example, a person might argue that sometimes the learning process is the result of changes through instruction and correction (i.e., belief corresponding to behaviorist theory), but other times it is the result of active knowledge construction by the child (i.e., belief corresponding to constructivist theory).

The "eclectic profile" (44.30%) was the biggest group of the three. PTs belonging to this group have the lowest scores in almost all learning theories explored in this study (e.g., psycholinguistic, maturation, nativist, socio-cultural, and constructivist). In other words, PTs in this profile tend to agree less with all learning theories than the remaining profiles. Besides, this flat profile represents a group of PTs who might understand the teaching of writing from different disciplinary perspectives because they hold beliefs about all learning theories applied to the writing field.

The "socio-cultural profile" (29.74%) was characterized by the lowest score on the behaviorist theory. This group represents an interesting and theoretically meaningful profile and, somehow, opposite to the other belief profiles. PTs of this profile tend to agree less with statements directed related to the role of direct and immediate feedback in learning (e.g., "I consider that the immediate correction of errors is very helpful in learning to writing"). The behaviorist theory holds that learners undergo some kind of conditioning, and the learning process results from changes in behavior through instruction or correction (Çakıroğlu, 2019). Moreover, PTs with this profile have the highest attribution levels of socio-cultural and constructivist theories. These two theories came from a socio theory of learning (Tracey & Mandel, 2012). The socio-cultural theory advocates that learning has emerged due to effective interaction and social communication in the environment (Vygotsky, 1979). The constructivist theory emphasizes the active construction of knowledge by integrating new knowledge based on children's activities. Both theories emphasize the role of the environment in the construction of knowledge and the fact that the 'inference process' made up by the child is the reason for the knowledge construction. Consequently, this profile group agrees to a higher degree with statements about individuals' active construction of knowledge by respecting their natural process and providing 'free spaces' (e.g., "It seems to me that it is important to give children different spaces where they can write what they feel, independent of spelling mistakes, handwriting, etc."). In a previous study, correlation analyses revealed that behaviorist and constructivist theories represent different theoretical approaches (r = -.459, $p < .001$) (Seoane et al., 2020), which makes it especially interesting to appreciate this theoretical contrast within this profile. Also, this profile also showed the highest attribution levels of maturation and nativist theories.

The former holds that instruction should start when children are developmentally ready (Morrow, 2012). In this profile, PTs coincide to a high degree with statements that emphasize the idea that children need to mature and develop their psychomotor system skills before they can begin the formal process of writing. In the latter, language is claimed to be a biologically-based phenomenon, and humans are regarded as having a natural competence to learn the language. This has been defined as the 'language acquisition device' by Chomsky (1957). Therefore, in this profile, PTs also coincide to a high degree with statements that emphasize that writing development depends on children's natural ability (e.g., "I consider that there are children who precociously discover writing by themselves").

The "person-environment profile" (25.94%) was the smallest group of the three. PTs in this group have higher scores on the psycholinguistic and behaviorist theories compared to the other profiles. The psycholinguistic theory presumes that written language builds on the foundation of oral language. Therefore, PTs in this profile have the highest attribution levels in statements focused on the importance of oral language, syntax, and graphemic language aspects for writing acquisition. Finally, and as opposed to the socio-cultural profile, PTs in the person-environment profile have the highest attribution levels of the behaviorist theory, showing a tendency to statements about the role of direct and immediate feedback in learning. On the contrary, both groups (i.e., the person-environment profile and the socio-cultural profile) showed equally high attribution levels for socio-cultural theory. Moreover, PTs in this group also showed a flatter profile compared to those in the socio-cultural profile. The person-environment profile seems to self-attribute all the learning theories, meaning that they understand writing activity from a broad perspective. The main difference from the eclectic profile is that the person-environment profile has higher attribution levels in all learning theories.

Do Belief Profiles Reveal Different Changes in Attribution Levels in each Learning Theory after the WBT?

Regarding the effects on PTs' beliefs, the most interesting finding was that the Trazo WBT produced different effects on belief profiles depending on the learning theory and the time. A possible explanation for these differences relies on the profile scores on each learning theory prior to the WBT. This fact might shed light on why significant differences between profiles were mainly found at the pretest moment: (1) the eclectic profile showed significantly lower scores for maturation, nativist, and socio-cultural learning theories than the remaining profiles; and (2) the socio-cultural profile compared to the eclectic profile and the person-environment profile showed significant lower scores at the behaviourist learning theory. None of these significant differences remained significant at posttest, which suggest that WBT may reinforce changes in prior PTs' conceptions. Nonetheless, it should be mentioned that the eclectic profile showed significantly lower scores for constructivist items at both measurement moments when compared to the socio-cultural profile. This specific result might support that participants' prior belief profile influences such changes, and that some beliefs might remain stable after the WBT. Again, this could be caused by significant differences at pretest. In line with this thought, looking at main effects within belief profiles, significant differences were only found for the socio-cultural profile in the behaviorist theory. After the WBT, the socio-cultural profile attributes significantly higher statements about the role of direct and immediate feedback in learning. It should be noted that Trazo WBT relied on a broad perspective of writing research that shows that teaching writing requires knowledge of different learning theories. After the WBT, the socio-cultural profile understood that feedback facilitates learning, and some mistakes are likely to persist without feedback and direct instruction.

Do Belief Profiles Reveal Different Changes in Average Content Knowledge after the WBT?

With regard to the effects on PTs' knowledge, the three belief profiles showed an improvement in the content knowledge for teaching writing. The absence of significant interaction between belief profiles per time in content knowledge outcome suggests that prior belief profiles might not influence knowledge gain. In other words, knowledge gain is not constrained by the belief profile.

Influential research established that beliefs are associated with knowledge acquisition by filtering the interpretation of new information (Pajares, 1992). The challenging relationship between knowledge and beliefs has been addressed based on the differences between both elements. The former has been characterized by their subjective and affective character and are based on personal experiences (Pajares, 1992; Richardson, 1996); the latter has been characterized by its objective nature, which explains why they are widely accepted and do not depend on the individual itself (Rodrigo et al., 1993). Beyond the definition of both concepts, their joint approach is interesting since it is the nature of their relationship that explains teaching practices (Pajares, 1992). To our knowledge, this is the first time that belief profiles have been considered a prerequisite when measuring the effects of a WBT on PTs' belief and knowledge changes for writing instruction.

Within the context of WBT effects, previous research conducted with in-service teachers has found changes in knowledge and beliefs after a WBT (Jiménez et al., 2021). In the area of reading, knowledge acquisition about teaching early reading components was associated with a greater attribution of the psycho-linguistic theory after WBT (Jiménez & O'Shanahan, 2016). The educational implication of both variables is well-known: teachers will require content knowledge to understand the subject they teach, and their teaching practices will be mediated by their own implicit theories (Jiménez et al., 2021). Establishing this relationship's nature can be foolhardy for PTs, as they are still exploring and developing their own beliefs through academic experiences (Baum & King, 2006), while also gaining content knowledge. Therefore, both should be considered equally for their professional development. In fact, the results of this work suggest that in the stage of teacher education, beliefs about how to teach writing are malleable, and the acquisition of knowledge about the content of writing is plausible through web-based training.

The findings presented above highlight the importance of providing PTs with evidence-based content knowledge before starting in-service training. According to some theoretical models, knowledge and beliefs go hand in hand in educational practice, and both can be modified by practice (Blömeke et al., 2015; Santagata & Yeh, 2016). For this reason, it is relevant to provide evidence-based knowledge to future teachers and make them aware of their teaching beliefs. Besides, it should be noted that in students' writing development all learning theories have their application at some point (Seoane et al., 2020). For example, explicit and systematic instruction is typical for the behaviourist approach, and the lack of agreement with this theory might not be expected according to some empirical evidence that posits that explicit and systematic instruction can especially benefit students' writing performance (Koster et al., 2015). Exploring teacher candidates' beliefs profiles beforehand can be a good opportunity to emphasize the educational application of those learning theories, and WBT may be a suitable tool for achieving this purpose.

Although PTs' belief and content knowledge were assessed, it was not measured how PTs use this WBT experience to inform their practices, as they have not yet been employed as in-service teachers. Thus, one main limitation of this study is that it is unknown if the

changes in beliefs and gain in knowledge will directly impact future classroom practice, and even more interesting if there would be differences in classroom practice based on their prior belief profiles. A further step in the research will be to provide evidence on the instructional practices of PTs. In this way, it would be possible to respond precisely to the relationship between beliefs and knowledge in the educational context. For this, future research should consider the possibility of using longitudinal research designs or, failing that, taking advantage of the internship period that takes place during university training.

Another limitation of this study is the fact that we only collected pre-data about the different sources for learning used before the training and previous experience with students with learning disabilities in writing. More specific data about prior literacy courses (prior courses in reading or learning theories) might have helped to better understand the belief profiles. Future research on the field might include pre-data about literacy courses and the final grades obtained by PTs.

Lastly, a potential methodological limitation is the fact that we used a "hard classification" of the groups after the latent profile analysis (i.e., each participant belonged exclusively to one group) and, therefore, we did not account for class membership uncertainty. We based this decision on the fact that the average posterior classification probabilities of the three profiles was high (> 0.87), indicating a high probability that participants were correctly classified into the correct profile. However, future studies should consider implementing an approach that models the classification uncertainty and leads, therefore, to less biased results (see Bakk & Kuha, 2021, for a review). Despite these limitations, the present study provides a promising approach for studying PTs beliefs profiles, within a WBT context rather than isolated, and how these may impact PTs' achievement in knowledge content acquisition and changes in beliefs.

Conclusion

WBT may supply the lack of teacher education concerning writing instruction. The Trazo WBT achieves to face this challenge, improving content knowledge and changing beliefs about writing instruction. Consequently, the main educational implication of this work relies on the potential of the WBT as a tool to boost teachers' education for teaching writing. Second, the use of the latent profile analysis provides some promising educational implications to consider in preparation for teaching writing: (a) it provides evidence on the prior heterogeneity of PTs' beliefs about learning to write and (b) the use of profiles allows to provide more adaptable online learning environments, since knowing the belief profiles of PTs is an opportunity to emphasize the educational application of different learning theories.

Conflict of Interest

The authors of this article declare no conflict of interest.

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Appendix A

Trazo Web-based Training Syllabus Design

Week	Module	Contents	Resources
1	-	Initial questionnaires: (1) previous sources for learning, (2) previous experience with children with learning disabilities in writing, (3) beliefs survey.	
2	Module 1	Content knowledge	Video tutorial: What is the writing activity?
3	Module 1	Content knowledge	Video tutorial: Handwriting (part I)
4	Module 1	Content knowledge	Video tutorial: Handwriting (part II)
6	Module 1	Content knowledge	Video tutorial: Handwriting (part III)
7	Module 1	Content knowledge	Video tutorial: Spelling (part I)
8	Module 1	Content knowledge	Video tutorial: Spelling (part II)
9	Module 1	Content knowledge	Video tutorial: Spelling (part III)
10	Module 1	Content knowledge	Video tutorial: Writing composition (part I)
11	Module 1	Content knowledge	Video tutorial: Writing composition (part II)
12	Module 1	Content knowledge	Video tutorial: Writing by pen and keyboard mode
13	Module 1	Content knowledge	Video tutorial: Prevention and RtI Model: Learning Disabilities in writing (part I)
14	Module 1	Content knowledge	Video tutorial: Prevention and RtI Model: What is the RtI? (part II)
15	Module 2	Pedagogical knowledge for instruction	Instructional activities for teachers and students about how to teach within the RtI Tier 2
16	Module 3	Pedagogical knowledge for CBM assessment	Curriculum-based measurement: IPAE (Indicadores de Progreso de Aprendizaje en Escritura [Indicators of Basic Early Writing Skills]
17	Module 4	Experiences	Video recordings on how to implement good teaching practices about vocabulary, alphabetical knowledge, phonological awareness, handwriting, spelling, and text production
17	Module 5	Supplemental resources	Evidence-based articles to support writing instruction
18	-	Final questionnaire: (1) beliefs survey	

Note. RtI = Response to Intervention Model.

Appendix B

Table B1. Main Effects between Belief Profiles across the Learning Theories at both Measurement Moments

Learning Theories	Belief Profiles	Time	Estimate	*SE*	*df*	*t* ratio
Psycholinguistic	1-2	1	-0.10	1.06	1372.99	-0.09
		2	-2.25	1.22	746.11	-1..85
	1-3	1	-6.07	1.11	1372.99	-5.49
		2	-5.01	1.27	746.11	-3.95
	2-3	1	-5.98	1.20	1372.99	-4.97
		2	-2.76	1.38	746.11	-2.00
Behaviorist	1-2	1	10.64	1.06	1372.99	10.03***
		2	5.01	1.22	746.11	4.12
	1-3	1	-8.39	1.11	1372.99	-7.59**
		2	-3.92	1.27	746.11	-3.09
	2-3	1	-19.03	1.20	1372.99	-15.84***
		2	-8.93	1.38	746.11	-6.48
Maturation	1-2	1	-10.97	1.06	1372.99	-10.35***
		2	-7.35	1.22	746.11	-6.04
	1-3	1	-8.67	1.11	1372.99	-7.84***
		2	-5.75	1.27	746.11	-4.53
	2-3	1	2.30	1.20	1372,.99	1.92
		2	1.61	1.38	746.11	1.17
Nativist	1-2	1	-10.94	1.06	1372.99	-10.32***
		2	-8.41	1.22	746.11	-6.91
	1-3	1	-7.98	1.11	1372.99	-7.22*
		2	-6.13	1.27	746.11	-4.83
	2-3	1	2.96	1.20	1372.99	2.47
		2	2.29	1.38	746.11	1.66
Socio-cultural	1-2	1	-10.58	1.06	1372.99	-9.98***
		2	-6.91	1.22	746.11	-5.68
	1-3	1	-10.05	1.11	1372.99	-9.09***
		2	-6.02	1.27	746.11	-4.74
	2-3	1	0.53	1.20	1372.99	0.44
		2	0.89	1.38	746.11	0.64
Constructivist	1-2	1	-12.02	1.06	1372.99	-11.33***
		2	-8.79	1.22	746.11	-7.23*
	1-3	1	-6.68	1.11	1372.99	-6.04
		2	-6.31	1.27	746.11	-4.97
	2-3	1	5.34	1.20	1372.99	4.45
		2	2.48	1.38	746.11	1.80

Note. Belief profiles: 1= eclectic profile; 2 = socio-cultural profile; 3 = person-environment profile; time, 1= pretest, 2 = posttest; *SE*= standard error; *df*= degrees of freedom.
$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Table B2. Main Effects within Belief Profiles across the Learning Theories at both Measurement Moments

Learning Theories	Belief Profiles	Time	Estimate	*SE*	*DF*	*t* ratio
Psycholinguistic	1	1-2	0.70	0.95	1315.58	0.72
	2	1-2	2.85	1.17	1315.58	2.43
	3	1-2	-0.36	1.25	1315.58	-0.29
Behaviorist	1	1-2	2.71	0.95	1315.58	2.82
	2	1-2	8.34	1.17	1315.58	7.11*
	3	1-2	-1.75	1.25	1315.58	-1.40
Maturation	1	1-2	3.87	0.95	1315.58	4.03
	2	1-2	0.25	1.17	1315.58	0.21
	3	1-2	0.95	1.25	1315.58	0.75
Nativist	1	1-2	4.17	0.95	1315.58	4.34
	2	1-2	1.63	1.17	1315.58	1.39
	3	1-2	2.31	1.25	1315.58	1.84
Socio-cultural	1	1-2	4.05	0.95	1315.58	4.22
	2	1-2	0.38	1.17	1315.58	0.32
	3	1-2	0.02	1.25	1315.58	0.01
Constructivist	1	1-2	2.92	0.95	1315.58	3.05
	2	1-2	-0.29	1.17	1315.58	-0.25
	3	1-2	2.56	1.25	1315.58	2.04

Note. Belief profiles: 1 = eclectic profile; 2 = socio-cultural profile; 3 = person-environment profile; time, 1 = pretest; 2 = posttest; *SE* = standard error; *df* = degrees of freedom.
$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.