International Journal of Educational Research 115 (2022) 102039

Contents lists available at ScienceDirect

International Journal of Educational Research

journal homepage: www.elsevier.com/locate/ijedures

Association between prospective elementary school teachers' year of study and their type of conception of intelligence

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ARTICLE INFO

Keywords:
Conceptions
Pre-service teachers
Intelligence
Developmental factors
Person-centered approach

ABSTRACT

Even though it has been recognized that prospective teachers' conceptions of intelligence and its development shape their teaching decisions, and, thereby, students' engagement and achievement, to date no research has examined these conceptions from a person-centered perspective taking into account year of training. This quantitative, questionnaire-based, cross-sectional research ($N = 904$) aimed to characterize differences in pre-service elementary school teachers' conceptions of intelligence in relation to where they were in their teacher education program. Cluster analysis revealed three distinct profiles: those giving predominant importance to innateness and inter-individual variability (*fixist*); those associating the development of intelligence with the accumulation of knowledge (*cumulative*); and those considering the development of intelligence as dependent on interactions with the environment (*socio-constructivist*). Although the same driving dimensions were present at the different stages of the training, adoption of the associated views fluctuated across the three years of training, in tandem with the process of construction of a professional identity and increasing field experience, with the cumulative perspective more likely in the first year, and the fixist profile more likely in the final year.

1. Introduction

The cost of early school dropout is deep, impacting economic sustainability, social stability, and the wealth and health of individuals throughout their lives (Beswick et al., 2019; OECD, 2016). Knowing these adverse consequences, a growing number of researchers have been looking at the school factors that influence students' cognitive engagement and achievement in school (Deci & Ryan, 2016; Deunk et al., 2018; Vedder-Weis & Fortus, 2011). Teachers' practices have been pinpointed as a key factor in that regard. The numerous meta-analyses and large body of research conducted on evidence-based classroom practices bear witness to this (Borgmeier et al., 2016; Stevens et al., 2018; Swanson et al., 2017). Although these evidence-based practices are learned in initial training (Dejemeppe, 2018), they are not implemented by all teachers (Charalambous et al., 2019; Ko et al., 2014). Several real and perceived barriers to the adoption of these practices have been pinpointed, such as a lack of necessary class time, a strong level of comfort with traditional methods, and lack of proper materials (Aragón et al., 2018). However, the structural barriers commonly cited by teachers represent only one type of barrier to change. The most influential factor is unquestionably teachers' beliefs about education (Issaieva & Crahay, 2014; Pajares, 1992; Safrudiannur & Rott, 2020; Voss & Kunter, 2019). Beliefs, shaped by teachers' personal and

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https://doi.org/10.1016/j.ijer.2022.102039
Received 18 March 2021; Received in revised form 26 June 2022; Accepted 30 June 2022
Available online 10 July 2022

professional experiences and their experience with formal knowledge, operate as a prism through which the teacher selects, interprets and evaluates all information of a professional nature (Buehl & Beck, 2015; Goldin et al., 2016; Voss & Kunter, 2019; Vause, 2010). Beliefs are organized in systems, with more centrally held beliefs (or core beliefs) being stronger and thereby, more decisive in teachers' pedagogical decisions than peripheral, less centrally held beliefs (Beswick et al., 2019; Green, 1971; Pajares, 1992; Safrudiannur & Rott, 2020).

In particular, teachers' beliefs about intelligence and its development have been outlined as having a strong impact on teachers' teaching decisions, judgments and practices (Aragón et al., 2018; Rattan et al., 2012; Rissanen et al., 2018). Two types of decisions are traditionally identified: teachers' planned decisions (made in advance) and in-the-moment decisions (made during the enacted lesson in response to how students respond to the teacher's initial prompt) (Eggleston, 2018; Remillard, 2018). Both concern the lesson content, the teaching style, the students' motivation of the students, the incentives or disincentives to apply, the resources to use, and so forth. Those decisions are visible through the teacher's behavior or practice, which, in turn, influences students' motivation and achievement.

For instance, studies with in-service teachers have identified positive associations between holding an incremental view of intelligence and effective teaching practices, that is, practices that maximize the probability that students will be actively engaged in the learning process, engagement being one of the most well-established predictors of achievement (Harbour et al., 2015), for example, considering error as a lever for learning, providing constructive feedback, increasing student motivation, emphasizing effort instead of ability, and creating an environment of cooperation instead of competition, and a negative association between beliefs and effective practices for those who share a more fixist view of intellectual capacities (Aragón et al., 2018; Rattan et al., 2012; Rissanen et al., 2018). The latter emphasize performance goals, interpret success and failures as lack of ability, and consider it fruitless to make large investments of time and resources, as only the smartest students will understand complex topics.

Other studies have documented an indirect impact of teachers' beliefs about intelligence on students' learning behaviors, through teacher expectations (Archambault et al., 2012; Rissanen et al., 2018). In this case, beliefs act as a self-fulfilling prophecy that greatly interferes with students' self-perceptions and, hence with their engagement. Teachers who believe that fixed factors such as intellectual capabilities are determinants of achievement drastically reduce learning opportunities for low achievers. These low achievers develop helpless attributes in the face of difficulty resulting in their disengagement and a decline in performance, results that confirm teachers' expectations (Rosenthal & Jacobson, 1968; Tiekstra & Minnaert, 2017).

Schmidt et al. (2015)'s findings, based on PISA data, revealed that underachievement is in large part related to the opportunities to learn that the teacher gives to their students. Still other studies have looked at the links between conceptions of intelligence, as core beliefs, and other educational beliefs. For example, Goffin et al. (2013), as well as Marcoux and Crahay (2008), highlighted a causal relationship between pre-service teachers' innate conception of intelligence and their belief in the benefits of grade repetition. Taken together, these studies underscore the counterproductivity of teaching effective practices in pre-service education without a substantive focus on the educational beliefs of future teachers, especially their implicit theories regarding intelligence and its development.

If the critical influence of teachers' beliefs about intelligence on students' achievement is no longer in doubt, it remains to be seen whether the majority of teachers hold conceptions of intelligence that are positively related to instructional quality and student learning outcomes. In order to be able to provide the necessary remedial measures, it is preferable to investigate this question with pre-service teachers, as a matter of priority.

In this respect, there are several shortcomings to the work that has been done so far. First, current work has relied mainly on the dichotomous approach to intelligence developed by Dweck et al. (1995), which contrasts an innate view with a constructivist-interactionist view. However, this dichotomy has proved to be incomplete to account for the complexity of the concept of intelligence (Curtiss, 2017; Issaieva & Crahay, 2014).

Second, of the scientific literature on teacher beliefs that has looked at the population of prospective teachers, most has focused on the final year of training. Looking at the different years of training would be informative. A better knowledge of students' beliefs at their entry in the teacher education program would make it possible to work on the beliefs from the very beginning, and thus possibly to have more control over them. Further, uncovering teacher candidates' beliefs at the different stages of their educational program will make it possible to better understand the influence of the current program – both the theoretical and the practical parts – on their educational beliefs and, thereby, to make the program more effective in changing counterproductive beliefs (Yang et al., 2020). The adoption of a cross-sectional design is all the more relevant as we know, on the one hand, that teaching experiences have a significant impact on teacher candidates' beliefs (Boraita & Crahay, 2013; Goffin et al., 2013; Jonsson et al., 2012) and, on the other hand, that teacher education programs are characterized by distinct stages of professional development (Bernal Gonzalez et al., 2018).

Third, most of this research has tended to favor a variable-centered approach, that is, one that describes the associations between variables found to a similar degree in all individuals (Issaieva & Crahay, 2014). Yet, teachers' beliefs are inherently highly individual (Voss & Kunter, 2019). So, taking into account inter-individual differences in pre-service teachers' views of intelligence, that is, adopting a person-centered approach, is a critical issue not only for educational theorists but also for teacher educators. At the conceptual level, a person-centered approach reflects teacher candidates' diversity in a more fine-grained way, while at the practical level, it allows for designing tailor-made and, hence, more effective, training programs aimed at developing desirable beliefs in terms of instructional practices and students' learning outcomes.

These drawbacks prompted us to investigate, in this contribution, pre-service elementary school teachers' views about intelligence and its development, from two complementary perspectives. The first seeks to identify distinct subgroups of teacher candidates with specific combinations of conceptions of intelligence. The second explores how these distinct subgroups are present over the different years of the teacher education program.

Table 1
Dimensions of the concept of intelligence emerging from factorial analyses conducted among French in-service teachers (Issaieva & Crahay, 2014).

Dimensions of the concept of intelligence	Conceptions associated to each dimension
Origin	Intelligence as fixed and hereditary (fixed conception) vs. intellectual abilities as the same for everyone at birth, differences created by the environment (malleable conception)
Development: role of knowledge	Knowledge as a source of development (behaviorist conception) vs. no emphasis on knowledge
Development: role of interactions	Interactions with the physical environment and the socio-cultural context as a source of development (interactionist conception) vs. no importance given to interactions
Nature: understanding and cognitive speed	Intelligence as associated with the ability to understand and, in particular, with cognitive speed vs. intelligence as not related to comprehension and cognitive speed
Form	Intelligence as having multiple forms (individuals are endowed with qualities that differ according to domains) vs. a monolithic conception of intelligence

2. Conceptual clarifications of belief and intelligence

There is a sharp lack of consistency in the terminology used in the literature to designate what teachers regard as true (Beswick, 2012; Issaieva & Crahay, 2014; Voss et al., 2013; Yang et al., 2020). Terms such as beliefs, conceptions, preconceptions, representations, personal theories, dispositions, knowledge, are used in parallel, without clear-cut definitions. Among those constructs, two have been widely acknowledgd to significantly shape teachers' actions in the classroom, that is, beliefs and professional knowledge (Beswick, 2012; Beswick & Chick, 2019; Berry et al., 2016; Francis, 2015). These two constructs differ in terms of validation. Unlike knowledge, which presupposes agreement between individuals and evidence to justify its validity, beliefs are not subject to any validation (Beswick & Chick, 2019; Gess-Newsome, 2015; Vause, 2010), but constitute "a reservoir of values and preconceived ideas on which teachers rely to act in situations and to justify their actions" (Vause, 2010, p. 14, free translation). In the present contribution, we focused more specifically on beliefs and, like researchers who have documented the literature on this topic (Beswick & Chick, 2019; Issaieva & Crahay, 2014; Liljedahl et al., 2019), we have used the terms "belief" and "conception" interchangeably.

Dweck's account of implicit theories of intelligence (1995) was the first to emerge in the literature. According to her account, individuals endorse one of two different "self-theories" about the plasticity of everyone's intelligence. Some hold an entity conception of intelligence, whereas others espouse an incremental perspective. People with an entity view believe that intelligence is a stable, unchangeable and hereditary aptitude. In contrast, people who hold an incremental view consider intellectual capacities as malleable, dynamic and having the potential to develop through interactions with the environment. Other theories about intelligence have focused on more than just the cognitive aspect of intelligence, positing the existence of various forms of intelligence, such as Gardner's (1997) theory of multiple intelligences. However, both types of approach have proved incomplete in accounting for the meanings that individuals attribute to the concept of intelligence (Issaieva & Crahay, 2014). In light of that, several authors have undertaken to account for the plurality of the concept of intelligence and the complexity of the factors that contribute to its development (Curtiss, 2017; Issaieva & Crahay, 2014; Pishghadam et al., 2015). In particular, based on previous work, Issaieva and Crahay (2014) proposed a four-dimensional theoretical model that considers intelligence as a multi-level construct: (1) the origin of intelligence, (2) developmental factors, (3) the nature of intelligence, and (4) forms of intelligence. In this framework, beliefs or conceptions about intelligence are conceptualized as inferences that the individual makes with respect to the four dimensions of the construct.

The first dimension is the origin of intelligence, based on Dweck et al. (1995) implicit theories of intelligence. As stated above, intelligence is viewed as innate or malleable as far as its origin. The second dimension deals with the development of intellectual capacities and the factors that promote it. Four conceptions can be identified: (1) intellectual development as the result of the accumulation of knowledge (behaviorist perspective); (2) intellectual development as a function of the person's active interactions with their physical and social environment (socio-constructivist perspective); (3) intellectual development as rooted in the cultural environment and nurtured by the teacher's mediation (historico-cultural perspective); and (4) intellectual development as the product of a set of motivational factors of social and personal origin. The third dimension is based on Carroll's (1993) hierarchical model, which considers the nature of intelligence as multidimensional. According to this model, intelligence would be perceived as a set made up of a general component that is broken down into specific but interrelated cognitive abilities (e.g., memory, understanding, cognitive speed). The fourth dimension is based on Gardner's (1997) theory, according to which there are multiple forms of intelligence, the predominance of which varies from one individual to another.

This four-dimensional theoretical model was empirically validated with 207 experienced French in-service teachers (Issaieva & Crahay, 2014). Exploratory and confirmatory factorial analyses confirmed that teachers did not conceptualize intelligence as a general entity, but rather as a multi-level construct, of which the origin of intelligence (Dweck) and the multiplicity of forms of intelligence (Gardner) are only two facets. More precisely, factorial analyses revealed that the structure of in-service teachers' conceptions of intelligence consisted of five dimensions (Table 1). They split the second dimension into two.

3. Position of (future) teachers with regard to intelligence and its development

As mentioned earlier, very few studies that have looked at pre- and in-service teachers' implicit conceptions of intelligence have adopted a plural conceptualization of intelligence. However, this is necessary to capture the concept completely (Issaieva & Crahay, 2014). Even fewer have done so from a person-centered perspective. To our knowledge, the following are the only two studies

embracing the two perspectives that have been conducted to date.

The first study was carried out by Issaieva and Crahay (2014), following their factorial analyses. These authors used a quantitative methodology to examine the way in which experienced French in-service teachers ($n = 172$) combined the five dimensions of intelligence, described above. Three profiles were evident. Teachers with a *cumulative profile* (32%) subscribed to the belief that the development of intelligence depends on the accumulation of knowledge. Teachers holding that view did not seem to take the four other dimensions of intelligence into account. Teachers with a *fixist profile* (32.5%) adhered to the belief that intelligence is predetermined, comes in different forms and is associated with the learner's understanding. In other words, they viewed intelligence only through the prism of cognitive abilities, giving predominant importance to innateness and inter-individual variability. Quite logically, they paid little attention to the factors concerning the development of intelligence. A *socio-constructivist profile* (35.5% of teachers) was characterized by a strong adherence to the idea that intelligence can develop and that this development depends on interactions with the physical, social and cultural environment.

The second study was conducted by [Authors] with six future elementary school teachers in their final year of training, in French-speaking Belgium and was based on Issaieva and Crahay's (2014) model of intelligence (Hanin, Colognesi, Cambier, Bury, & Van Nieuwenhoven, 2020). This qualitative research highlighted that the core dimension(s) that defined each profile were the same as those found by Issaieva and Crahay (2014). More precisely, in our work, the two student-teachers with a *cumulative profile* defined intelligence by the amount of knowledge stored in memory; those with a *fixist profile* organized their discourse around inter-individual variability; and those with a *socio-constructivist profile* placed interactions with family, teachers and friends at the center of intellectual development. There was one difference between the two studies: the dimension "comprehension and cognitive speed" did not appear in the discourse of the Belgian prospective teachers, but was salient for the experienced French teachers holding a fixist profile.

In addition to reinforcing these central dimensions, the qualitative approach made possible to broaden the definition of each profile with secondary characteristics (Hanin, Colognesi, Cambier, Bury, & Van Nieuwenhoven, 2020). However, these must be interpreted with caution, given the non-generalizability of the results. A first observation was that while prospective teachers with both fixist and socio-constructivist views recognized the part played by the family and school environment in the development of intelligence, for those with a socio-constructivist perspective, it was only one developmental factor among others that resulted from chance, presented as not very reversible. Second, while both the socio-constructivist and the cumulative profiles considered the malleability of intelligence in terms of interactions with the environment, the former added respect for the rhythm of each learner and, the latter, the importance of work and effort. Third, while general knowledge defined intelligence in the eyes of the students with a cumulative profile, it was more a matter of active self-construction for their peers holding a socio-constructivist view. Finally, while the three profiles recognized a multiplicity of forms of intelligence, they interpreted this dimension differently. More precisely, inter-individual variability explained the differences in intelligence between individuals for those with a fixist profile and was seen as a richness that has the potential to be improved by those with the other two profiles.

4. Beliefs and professional identity

Teachers' lay theories about teaching and learning and being a teacher (conceptions about intelligence is one of them) developed from their classroom experience as pupils, in conjunction with social representations of elementary education teachers, determined their choice of and expectations from the profession, that is, shaped their professional identity (Androusou & Tsafos, 2018; Lutovac & Flores, 2021). Furthermore, pre-service teachers' professional identity is of vital concern, as it is the basis of meaning making and decision making (Bullough, 1997).

Teacher education plays an important role in the (trans)formation of the professional identity of pre-service teachers (Dassa & Derose, 2017; Lutovac & Flores, 2021). The cognitive transition from student to teacher is fueled by coursework, internships and students' interactions with their professors, field trainers and peers (Dassa & Derose, 2017). On this point, fieldwork seem to have a more substantial impact on pre-service teachers: in the field, they are viewed as the teacher by the students and their colleagues, and that impacts how they identify themselves. However, as mentioned by Cañabate et al. (2019), an important part of the teacher's professional identity regarding dealing with actual demands of the profession is the reflective practitioner and adaptive expert. These roles offer opportunities for student teachers to engage actively and meaningfully in problem identification, evaluation and resolution by using the theoretical content taught as a framework for the intelligibility of their practice. A qualitative study conducted with Belgian pre-service elementary teachers (Authors, submitted) documented the process of construction of this identity. During the first year, the student identity is predominant: the emphasis is on the validation of credits. In the second year, coursework, the first field experiences and students' beliefs clash and shake up their identity references. The tension between their teacher identity and their student identity is palpable. In the final year, the student teacher's identity is defined and affirmed through the accumulation of theoretical and practical contributions. Our findings were consistent with those of Dassa and Derose (2017), who observed that it is only when the field experiences are intertwined with the coursework that the process of professional identity development really begins.

With regard to the transformational power of preservice training, research has indicated that the core of pre-service teachers' lay theories remains very strong (Cañabate et al., 2019; Lutovac & Flores, 2021). The efforts invested to replace their conceptions, that is, to scaffold the creation of a different professional identity, do not really succeed (Androusou & Tsafos, 2018).

5. Research questions

As evidenced by the scarcity of studies on the subject, this research is original in that it takes up a new area of research in order to

advance knowledge both theoretically and practically. More precisely, the current study continues the two studies just described by adopting the multi-faceted conceptualization of intelligence and a quantitative person-centered perspective, while seeking to expand their findings on several levels. First, as teacher beliefs have been clearly portrayed as socially and culturally shaped mental constructs (Felbrich et al., 2012; Safrudiannur & Rott, 2020; Yang et al., 2020) and as dependent on age and experience (Jonsson et al., 2012; Safrudiannur & Rott, 2020), we wanted to test the validity of the typological configurations observed among French experienced primary school teachers with a sample of Belgian teacher candidates. Better identifying and understanding the educational beliefs of prospective teachers is all the more important as current teacher education programs are struggling to change student teachers' inappropriate beliefs, that is, those that are negatively associated with desirable instructional practices and students' learning outcomes (Beswick, 2012; Boraita & Crahay, 2013; Voss et al., 2013). Second, we wanted to establish and generalize our qualitative findings through a large-scale quantitative investigation allowing grasping of shared elements (Creswell, 2014). In this respect, while this contribution aims to validate the qualitative typology with a larger sample, it also intends to extend it to all years of the teacher education program. This quantitative investigation also intends to confirm a discrepancy observed between the study conducted with experienced French teachers and the study conducted with Belgian teacher candidates (Hanin, Colognesi, Cambier, Bury, & Van Nieuwenhoven, 2020) regarding the nature of intelligence. More precisely, while in the former, teachers with a fixist profile took a stand relative to the dimension "understanding and cognitive speed" (Issaieva & Crahay, 2013), in the latter, prospective teachers, regardless of their profile, did not mention it in their discourse (Hanin, Colognesi, Cambier, Bury, & Van Nieuwenhoven, 2020).

The research reported here adopted a person-centered perspective to examine future primary school teachers' conceptions about intelligence and its development, and how these conceptions differed for prospective teachers at different points in their teacher education program.

The research was guided by the following research questions:

(1) What meaningful distinct subgroups of pre-service elementary school teachers with specific combinations of conceptions of intelligence can be identified? More precisely, how do the pre-service teachers, at each stage of their teacher education program, combine the five dimensions that emerged from Issaieva and Crahay's factorial analysis (i.e., origin of intelligence, role of knowledge, role of interactions, understanding and cognitive speed, forms of intelligence) into a personal position?
(2) How are these distinct subgroups present over the course of the teacher education program?

Addressing these issues is critical not only for educational theorists, but also for teacher educators, allowing for designing tailor-made and, hence, more effective, training programs aimed at developing desirable beliefs in terms of instructional practices and students' learning outcomes.

6. Method

6.1. Educational context

In French-speaking Belgium, future primary school teachers are trained at pedagogical schools, and their educational program is spread over three years, at the end of which the student can move directly into teaching. This program alternates between theoretical courses and teaching experiences. Future teachers have a minimum of 700 h of practical training (CFB, 2000): one week of participant observation in the first year, four weeks of taking charge of the classroom in the second year and 10 weeks of taking charge in the third year, when the trainee usually takes charge of the class independently. Pedagogical schools provide support for students before, during and after their internships, in particular by integrating internships with practical work, practice analysis seminars and/or professional training workshops, and by using a formative evaluation system.

The training is organized around six axes: (1) disciplinary training that may include aspects of the didactics of the discipline or as applied to the discipline, (2) training in and through communication, (3) training in and through practice, (4) training in didactics and pedagogy, (5) training in human and social sciences, and (6) training in and through research in education and didactics (Ministry of the Wallonia-Brussels Federation, 2019). The connection between these axes is based primarily on training in and through practice, thanks to the implementation of professional situations. The learning of the contents is built progressively through interaction between the theoretical training situations and the professional situations (Ministry of the Wallonia-Brussels Federation, 2019).

The table in Appendix A details the courses for each year of the program. Four observations can be made. First, the first year is focused on learning the different disciplines to be taught from the point of view of content. From the second year onwards, the disciplines are approached from the perspective of didactics. We can also note a decrease in the number of credits allocated to these disciplines in the final year (for the benefit of practical training). Second, as the student progresses in the training, the theoretical courses become more specific, more targeted. For example, in the first year there is a general pedagogy course. This is replaced in the second year by a course on learning evaluation and a course on group management techniques. In the last year, this area is addressed in the following two courses: "Study of the Main Pedagogical Trends" and "Differentiation of Learning, Notion of Orthopedagogy and Detection of Learning Difficulties". Another example concerns the multicultural dimension. In the first year, it takes the form of a general course entitled: "Philosophy, Citizenship and History of Religions". In the second year, its approach is more specific, more targeted ("Theoretical and Practical Approach to Cultural Diversity and Gender" and "Opening the School to the Outside World"). Third, the construction of a professional teaching identity begins in the first year and reaches its peak in the last year with the final work dissertation and the course on "Development of the Professional". Finally, the internships become more and more important as the training progresses.

Table 2
Distribution of student teachers by year of study and pedagogical school attended.

	PS 1	PS 2	PS 3	PS 4	PS 5	PS 6	Total
First year	96	55	145	55	-	31	382
Second year	41	39	102	15	-	89	286
Third year	25	17	61	33	65	35	236
Total	162	111	308	103	65	155	904

Note. PS= pedagogical school.

Table 3
Description of the intelligence scale.

Scale name	Number of items	Cronbach's α			Sample item
		First year (n = 382)	Second year (n = 286)	Third year (n = 236)	
Origin of intelligence	4	.70	.64	.74	At birth, except in cases of severe disability, all children have the same intellectual potential.
Role of knowledge	5	.68	.70	.71	It is not by accumulating more and more knowledge that one develops one's intelligence.
Role of interactions	4	.64	.74	.72	By discussing your ideas with others, you develop your intelligence.
Understanding and cognitive speed	3	.74	.75	.75	An intelligent student is one who quickly understands.
Form of intelligence	3	.79	.80	.82	Students who are more proficient in social relations are often less proficient in mathematics and science.

6.2. Sample and procedure

A total of 904 pre-service teachers (first year = 382; second year = 286; third year = 236) consented to participate in this study (Table 2). They came from six pedagogical schools located in the six French-speaking geographical areas.

The questionnaire used to assess conceptions of intelligence and its development was completed in paper format by the students during a class session, under the supervision of their instructor (5–8 min). This happened at the same time of the school year (January) for all participants. It was accompanied by a brief description of the research context, instructions for completion and a guarantee of the confidentiality of the data collected.

6.3. Measures

Data were collected using the French intelligence-related scale developed by Issaieva and Crahay (2014) which has shown satisfactory psychometric properties (χ^2= 257.8; RMSEA = 0.06 and CFI = 0.92). This scale captures teachers' conceptions of intelligence and its development through the five dimensions outlined previously: (1) the origin of intelligence, (2) the role of knowledge ("development" dimension), (3) the role of interactions ("development" dimension), (4) the nature of intelligence (understanding and cognitive speed), and (5) the forms of intelligence. Respondents gave their opinion on the 19 statements using a four-point Likert-type scale ranging from totally disagree (1) to totally agree (4). It should be noted that prior to large-scale use, the questionnaire was submitted to 15 novice teachers in order to check for understandability and clarity. Only the negatively phrased items (one per dimension) raised a few comments about the fact that they require more concentration to be processed. Given their importance in countering possible biases such as the halo effect (Langevin et al., 2011), the original questionnaire was retained as is (Table 3).

The beliefs data from the 904 pre-service elementary teachers were submitted to cluster analysis, as described by Hair et al. (1998). Cluster analysis is a technique that seeks to discern structure in a set of data by grouping respondents according to the similarity of their responses. In this study, the technique was employed to identify distinct subgroups of future elementary school teachers in each year of teacher education program who were similar in terms of their conceptions of intelligence.

7. Results

There were very little missing questionnaire data, due to the fact that after students completed the questionnaire, one of the team's researchers checked that students had not left particular items blank. When this occurred (<1% of cases), she returned the scale to the student to complete those item(s).

Summary statistics for each variable under research are available in Appendix B. Factorial analyses (Appendixs C–E) validated Issaieva and Crahay's (2014) five-dimensional structure.

Table 4
Cluster centroids (mean values) and MANOVA results for the first year of training.

Cluster patterns	Cluster 1: fixist	Cluster 2: socio-constructivist	Cluster 3: cumulative	*F*(2)	η^2
n (%)	107 (28.0)	120 (31.4)	155 (40.6)		
Knowledge	-.59a	-.57a	.47b	69.19***	.27
Interactions	.08b	.46c	-.78a	78.72***	.29
Form	.55b	.34b	-.24a	25.42***	.12
Origin	-1.06a	.87c	.00b	208.39***	.53

Note. The letters indicate post hoc comparison groupings for each variable based on the Bonferroni test; cluster centroids with different letters (reading across the row) differ significantly.
**$p < .01$; ***$p < .001$.

Table 5
Cluster centroids (mean values) and MANOVA results for the second year of training.

Cluster patterns	Cluster 1: fixist	Cluster 2: socio-constructivist	Cluster 3: cumulative	*F*(2)	η^2
n (%)	116 (40.6)	77 (26.9)	93 (32.5)		
Knowledge	-.08b	-.69a	.63c	55.85***	.29
Interactions	-.12a	1.27b	-.35a	110.21***	.29
Form	.37c	-.28b	-.73a	43.95***	.24
Origin	-.61a	.65b	.41b	79.41***	.36

Note. The letters indicate post hoc comparison groupings for each variable based on the Bonferroni test; cluster centroids with different letters (reading across the row) differ significantly.
**$p < .01$; ***$p < .001$.

Table 6
Cluster centroids (mean values) and MANOVA results for the third year of training.

Cluster patterns	Cluster 1: fixist	Cluster 2: socio-constructivist	Cluster 3: cumulative	*F*(2)	η^2
n (%)	102 (43.2)	67 (28.4)	67 (28.4)		
Knowledge	.01b	-.35a	1.20c	72.82***	.39
Interactions	.06b	.64c	-.62a	39.00***	.25
Form	.68c	-.80b	-.49a	96.65***	.45
Origin	-.32a	.71b	-.32a	30.58***	.21

Note. The letters indicate post hoc comparison groupings for each variable based on the Bonferroni test; cluster centroids with different letters (reading across the row) differ significantly.
**$p < .01$; ***$p < .001$.

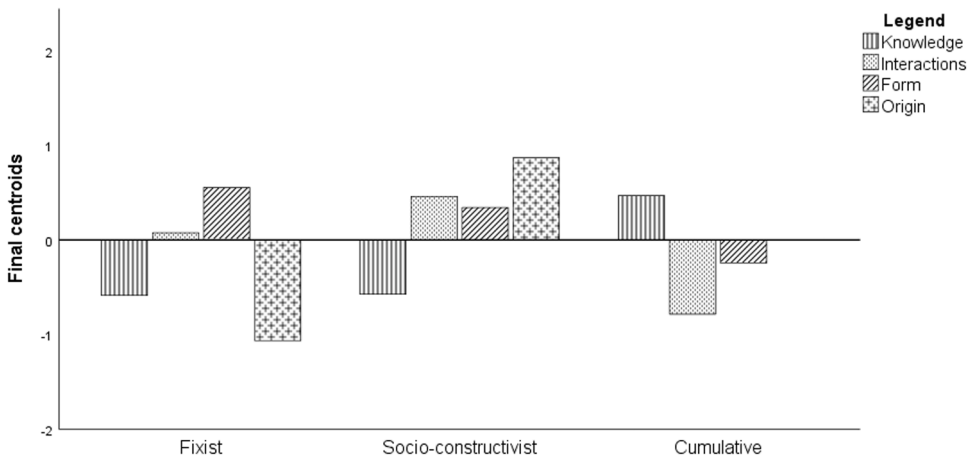

Fig. 1. Standardized means of cluster variables for each profile for the first year of training ($n = 382$).

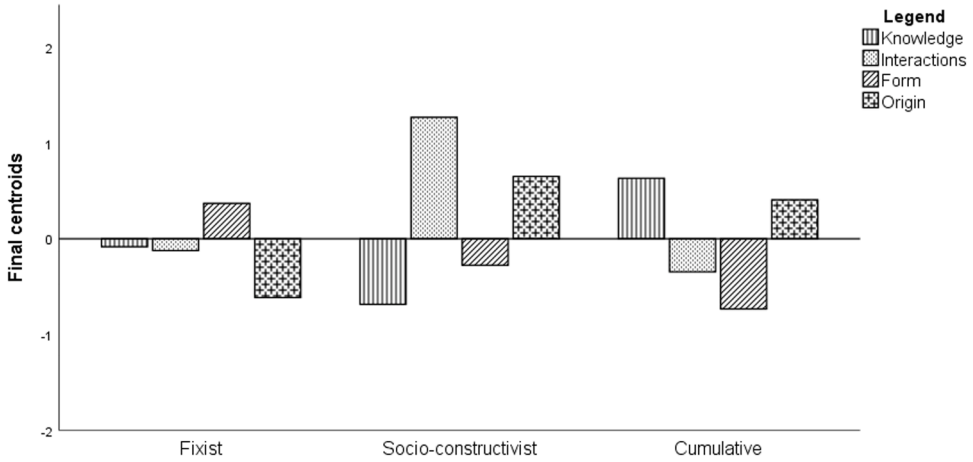

Fig. 2. Standardized means of cluster variables for each profile for the second year of training ($n = 286$).

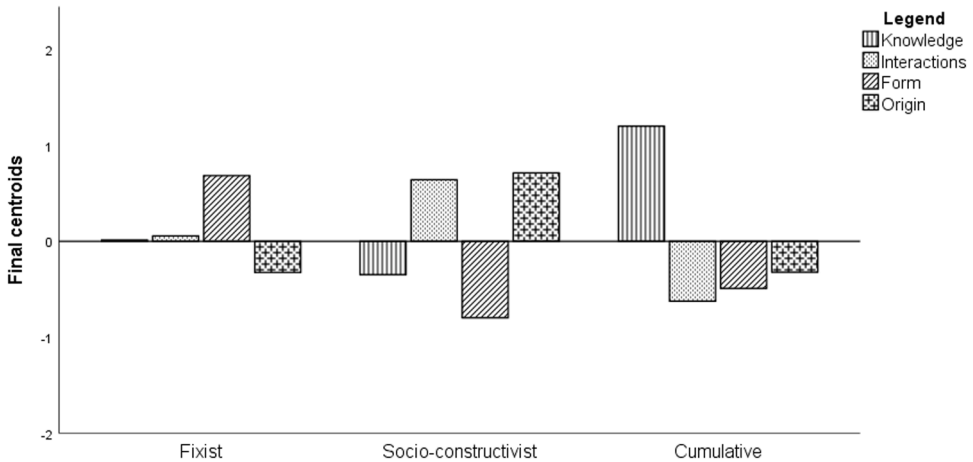

Fig. 3. Standardized means of cluster variables for each profile for the third year of training ($n = 236$).

7.1. Cluster analysis

Variables were standardized through Z-transformations before starting the cluster analysis. The procedure described hereafter was conducted separately for each year of the teacher education program. Hierarchical cluster analysis using Ward's linkage method and squared Euclidean distances as the measure of similarity was used to identify the number of clusters and to fix cluster centers (Aldenderfer & Blashfield, 1984). Further, Hair et al. (1998) underlined the importance of examining a range of possible cluster solutions in order to determine a final solution that best fits with theoretical categories or other reliable evidence. Several variations of the clustering procedure were thus considered. On examination of both the dendrogram and Issaieva and Crahay's (2014) typological configuration, it was determined that, for each year of the program, three clusters fit the data best. The three-cluster solutions were interpretable and had a good distribution of cases across clusters. Next, a K-means cluster procedure with a three-cluster solution was run to construct the final solution (Bergman, 1998). Specifically, the three clusters revealed by Ward's analysis were used as the initial cluster centers. The K-means procedure revealed more discriminating profiles and a better distribution of cases across clusters when the dimension "understanding and cognitive speed" was not taken into account in the analysis. This finding supported our previous qualitative analyses (Hanin, Colognesi, Cambier, Bury, & Van Nieuwenhoven, 2020) and, thereby, led to the exclusion of this dimension in the construction of the final clusters. The final cluster centroids for the three clusters characterizing each year of teacher education program are displayed in Tables 4–6 and illustrated in Figs. 1–3. Centroids reflect students' means for each of the intelligence dimensions in each cluster. It is worth mentioning that, as scales were standardized, a positive centroid indicates a higher score than the overall sample mean and a negative centroid reflects a lower score than the average score of the sample. The reliability of this solution was also examined through a MANOVA, as described below.

7.2. Validation of the cluster solution

A one-way MANOVA was computed, with cluster membership as the between-subjects factor and the four cluster variables as dependent variables. The overall MANOVA was significant for the three years: first year: Pillai's trace = 1.07; $F(8, 752) = 108.58$, $p < .001$, $\eta^2 = .54$; second year: Pillai's trace = 1.12; $F(8, 560) = 88.38$, $p < .001$, $\eta^2 = .56$; third year: Pillai's trace = 1.10; $F(8, 462) = 70.82$, $p < .001$, $\eta^2 = .55$. Given the significance of the overall tests, the univariate main effects were considered each time. As shown in Tables 4–6, the univariate tests for each cluster variable were all significant, and cluster membership explained between 12% and 53% of the variance in the four variables used to create the clusters. Results suggested that the composition of each cluster was significantly different from that of the others.

Further, a cross-validation procedure was set up to assess the replication of the three-cluster solution (Breckenridge, 2000; Tibshirani &Walther, 2005). To do so, the data set related to each year of training was randomly divided into two samples (first year: $n_1 = 198$, $n_2 = 183$; second year: $n_1 = 146$, $n_2 = 139$; third year: $n_1 = 130$, $n_2 = 106$;]). K-means clusters—specifying a three-cluster solution—were performed separately on samples 1 and 2 using the cluster centroid derived from the global sample. According to Cohen's (1960) recommendation, the agreement between the cluster solutions for the whole sample and for the two subsamples was substantial (average κ for the first year = .74; average κ for the second year = .72; average κ for the third year = .79).

8. Description of the clusters

The three-cluster solution, with the clusters' validity confirmed by both theoretical and statistical criteria, revealed meaningful profiles of conceptions of intelligence highlighting specific patterns of variables for each year of the program.

8.1. First year students

(1) Fixist ($n = 107$; 28.0%): the first cluster was named the *fixist profile*, due to a substantial, low centroid for origin. Students in this profile considered intelligence to be immutable and hereditary. Accordingly, they seemed not concerned with the factors contributing to the development of intelligence, as evidenced by a low centroid for "knowledge" and a quasi-neutral positioning on interactions. In addition to a strong emphasis on innateness, the presence of a relatively high centroid for "form" indicated a strong interest in inter-individual variability.
(2) Socio-constructivist ($n = 120$; 31.4%): the second cluster was labeled the *socio-constructivist profile*, due to having high positive centroids for origin and interactions and a low centroid for knowledge. A typical student from this cluster would thus consider intelligence as a faculty that can be developed, and would associate this development not with the accumulation of knowledge, but essentially with the person's interactions with their environment. Secondarily, this profile was also characterized by a slightly above-average centroid for form, indicative of a conception of intelligence as having multiple forms.
(3) Cumulative ($n = 155$; 40.6%): the third cluster included the highest centroid for knowledge and, hence, was entitled the *cumulative profile*. Compared to the socio-constructivist profile, these students saw the development of intelligence essentially through the prism of knowledge accumulation. The low centroid for interactions indicated that for them, the relationships between the person and their environment do not contribute to the development of intelligence.

8.2. Second year students

(1) Fixist ($n = 116$; 40.6%): the first cluster included a low centroid for origin and, hence, was labeled the *fixist profile*. Further, in contrast to both the socio-constructivist and the cumulative profiles, this cluster exhibited a positive centroid for form. In short, students in this profile gave prominence to innateness and inter-individual variability.
(2) Socio-constructivist ($n = 77$; 26.9%): the second cluster was named the *socio-constructivist profile* due to a substantial, high centroid for interactions. This profile was also characterized by a high centroid for origin and a low centroid for knowledge. In other words, students in this cluster adhered to a developmental conception of intelligence. For them, this development was the result of the individual's interactions with their environment and not of the accumulation of knowledge.
(3) Cumulative ($n = 93$; 32.5%): the final cluster was termed the *cumulative profile* due to its high centroid for knowledge. Students in this profile also differed from the average student in terms of origin (with a positive centroid) and form (with a negative centroid). A typical student from this cluster would thus hold a monolithic view of intelligence and consider its development as the result of the accumulation of knowledge.

8.3. Final-year students

(1) Fixist ($n = 102$; 43.2%): the second cluster was labelled the *fixist profile* due to a low centroid for origin. In contrast to the other two profiles, these students were also characterized by a relatively high centroid for form. According to these students, intellectual capacities can manifest themselves in multiple forms and are fixed from birth.
(2) Socio-constructivist ($n = 67$; 28.4%): the final cluster had high centroids for both interactions and origin and, hence, was labeled the *socio-constructivist profile*. This cluster also showed a substantial, low centroid on form. A typical student from this cluster would thus view intelligence as monolithic and consider its development as occurring essentially through the person's interactions with their environment.

(3) Cumulative ($n = 67$; 28.4%): the first cluster was entitled the *cumulative profile* due to a substantial, high centroid for knowledge. This cluster also showed negative centroids for both interactions and form. Students in this cluster considered intelligence to be a general capacity that develops primarily through the accumulation of knowledge. In their view, interactions with the social and physical environment did not contribute to this development.

9. Discussion

This study investigated future elementary school teachers' beliefs about intelligence and its development from two complementary perspectives. The first seeks to document how pre-service teachers at each stage of their teacher education program combine the four dimensions of intelligence into a personal position. The second perspective questions whether these personal positions tend to differ over the course of the training program.

9.1. Prospective elementary school teachers' conceptions about intelligence

- Characteristics of first-year students

Teacher candidates do not begin their educational program empty of all ideas about the teaching–learning process. In line with previous work (Haser & Dogan, 2012; Liljedahl et al., 2019; Vidović & Domović, 2019; Voss & Kunter, 2019), our results indicate that they enter it with already well-established conceptions about intelligence and its development. In the current study, three clusters of first-year students displayed distinctive differences in terms of their views about intelligence. One profile was characterized by a strong adherence to the idea that intelligence refers to personal traits that are not easily modifiable and that result in great inter-individual variability. We find here a combination of Dweck et al. (1995) view that for some individuals intelligence is a fixed aptitude and Gardner' s (1997) theory of multiple intelligences. A second profile, accounting for a third of our sample, was characterized by deep engagement with the issue of the origin of intelligence and a central position for the role in intellectual development of the person's interactions with their physical, social and cultural environment. Those with this profile endorsed both a socio-constructivist (Doise & Mugny, 1981) and a historico-cultural perspective (Vygotsky, 1978). A third profile, also one third of the sample, was characterized by the belief that the development of intelligence is linked to the accumulation of knowledge, thus indicating a behaviorist stance (Issaieva & Crahay, 2014). Students with this profile were neutral as to the origin of intelligence.

- Characteristics of second-year students

With respect to second-year teacher candidates, while the driving dimensions of each profile remained unchanged, our findings revealed several differences with freshmen profiles. First, while second-year students with a fixist profile gave a firm place to innateness and inter-individual variability, they espoused an innate conception of intelligence that was less marked than that of their first-year peers. Consistently, they positioned themselves in a relatively neutral way with respect to intellectual development factors. Second, while second-year students holding a socio-constructivist view also defended a malleable conception of intelligence and stressed the importance of interactions in the development of intelligence, their position on this second dimension was much more marked than that of first-year students with this profile. Further, our analysis revealed that while first-year students with a socio-constructivist view tended to view intelligence as having multiple forms, second-year students tended to adhere to a monolithic conception of intellectual abilities. Third, like their first-year peers, second-year students with a cumulative profile clearly adhered to the assumption that the development of intelligence is based on the accumulation of knowledge. However, they differed from the former by taking a positive stance on the origin of intelligence – recognizing its malleability – by displaying a stronger position in favor of a monolithic conception of intelligence, and by less firmly rejecting the role of interactions in the development of intelligence. One possible explanation for these differences is the influence of teacher education program on future teachers' beliefs. This assumption is deepened below. Further, differences were also observed between the first two years of the teacher education program regarding the distribution of students within the three profiles. While the proportion of students with a socio-constructivist profile was roughly the same, there seemed to be a shift from the cumulative profile to the fixist profile.

- Characteristics of final-year students

Regarding final-year students, our findings indicate more marked differences from students in previous years. First, those holding a fixist view of intelligence displayed a significantly lower positioning on the innate conception of intelligence. This change was strengthened by a neutral position on intellectual development factors. These findings are consistent with those from our qualitative study, which showed that final-year students integrated both ends of the continuum (fixed versus growth) in their conception of the origin of intelligence (Hanin, Colognesi, Cambier, Bury, & Van Nieuwenhoven, 2020). Thus, contrary to the thesis defended by Dweck et al. (1995), it would appear that the malleability and stability of intelligence are not perceived by these future teachers as mutually exclusive characteristics. However, although final-year students holding a fixist perspective seemed to be less inclined to view intellectual abilities as fixed and hereditary, they were firmly convinced of the inter-individual variability of intelligence.

Second, regarding final-year students with a socio-constructivist profile, the most striking difference from their peers from previous years was a strong adherence to a monolithic conception of intelligence. This finding is contrary to those of our qualitative study (Hanin, Colognesi, Cambier, Bury, & Van Nieuwenhoven, 2020). Although it would be interesting to replicate the qualitative study

with a larger number of participants to substantiate our conclusions, this divergence highlights the richness using both qualitative and quantitative approaches. Based on the findings from both studies, it appears that while the majority of final-year teacher candidates defending a socio-constructivist view of intelligence conceived it as monolithic, some of them recognized a certain inter-individual variability. Our results also indicate that they rejected less strongly the idea of an association between intelligence and accumulation of knowledge. Again, our previous qualitative investigation sheds light on this observation (Hanin, Colognesi, Cambier, Bury, & Van Nieuwenhoven, 2020), highlighting that this connection depended on the idea that knowledge is actively constructed by the learner themself. Further, this research showed that they espoused the role of interactions in the development of intelligence less fervently than their second-year peers, but a little bit more than first-year students. Conversely, they expressed equally strong support for the idea that intelligence is a characteristic that can be developed.

With regard to final-year students with a cumulative profile, they showed a markedly more pronounced position than their peers in previous years favoring the role of knowledge accumulation in the development of intelligence. They also rejected more clearly than second-year students the role of interactions in this development, echoing the position of first-year students. Further, while, like their second-year peers, they positioned themselves weakly with regard to the origin of intelligence, they also embraced the opposing conception – that intelligence is innate. However, according to the qualitative analysis (Hanin, Colognesi, Cambier, Bury, & Van Nieuwenhoven, 2020), along with the idea that intelligence is innate, they also recognized the malleability of intelligence.

The above analysis highlights the presence of more assertive profiles in the final years of the teacher education program. This observation can be connected to the presence of a clearer professional identity among teacher candidates at this stage (Bernal Gonzalez et al., 2018). On this point, previous work (Henry, 2016; Macias Villegas et al., 2020; Meijer et al., 2011) has stressed that the discovery by teacher candidates of the reality of the profession in the second year of their training results in a reality shock that induces a major identity reconversion. This later stage is characterized by many tensions, particularly between the conceptions of the profession that the student had formed and conceptions as to the professional they wish to become (Bernal Gonzalez et al., 2018; Jorro, 2011). While in their final year, on the strength of their relatively long-term teaching experiences, teacher candidates are more aware of the various facets of the profession, enabling them to build a more stable professional identity. This hypothesis is supported by the greater closeness evident between the in-service teachers' profiles for conceptions of intelligence put forward by Issaieva and Crahay (2014) and those of the final-year teacher candidates in the current study.

As for the distribution of students in the three profiles, the trend observed in the second year was maintained in the final year: a similar proportion of students with a socio-constructivist profile and a gradual shift from the cumulative profile to the fixist profile. A significant number of teacher candidates were thus likely to be shifting from a conception of intelligence based on the accumulation of knowledge to one that gives central importance to innateness and inter-individual variability. This shift reflects, in our opinion, a widely shared belief within teaching staff that some students make no progress even though the teacher has tried everything (Van Praag et al., 2017). Closely associated with this is the idea that some students are more "manual" than "intellectual".

9.2. Relationships between the teacher education program and the differences in teacher candidates' beliefs by year of training

This contribution echoes previous studies that have stressed the potential of the teacher education program to bring about changes in pre-service teachers' educational beliefs (Boraita & Crahay, 2013; Goldin et al., 2016; Liljedahl et al., 2019).

With respect to the theoretical part of the program, studies conducted so far have highlighted that the learning content is filtered by the prospective teachers' existing beliefs (Haser & Dogan, 2012; Liljedahl, Oesterle, & Bernèche, 2012; Voss et al., 2013). More recent work has also pointed out that pre-service teachers' beliefs are permeable to the content taught (Hanin, Colognesi, Cambier, Bury, & Van Nieuwenhoven, 2020; Celik et al., 2018; Tatto, 2019; Wall, 2016). On this point, analysis of current teacher education program has revealed a pronounced global (socio-)constructivist approach to teaching and learning (Dejemeppe, 2018). Specifically, pedagogical schools report taking special care to encourage each student to reach their full potential and even to surpass themselves; to learn and to encourage teamwork; to learn to reproduce as well as to innovate; to become responsible citizens, social actors who are actively and critically involved in their work environment and in society; to develop a capacity for self-education; to build creativity, autonomy, flexibility and critical thinking in relation to their training and environment; and to encourage students to reflect on the ethics of their profession (Haute Ecole Léonard de Vinci, 2021; Haute Ecole Louvain en Hainaut, 2021).

We believe that this (socio)constructivist approach has contributed to the differences in prospective teachers' beliefs about intelligence, especially between the first two years of training, where most of the theoretical courses are concentrated (see Appendix A). A less strong positioning of fixist students as to the innate dimension of intelligence, a very strong interactionist stance among socio-constructivist students, and a greater openness to the malleability of intelligence among students with a cumulative profile would reflect the impact of a learning environment that promotes a socio-constructivist approach to teaching and learning. However, the differences in the three profiles by year of training in terms of the form of intelligence takes a different direction. On that point, our findings highlighted a less marked positioning of the teacher candidates with a fixist profile in the later years of training in favor of a conception of intelligence as multiple, a strengthening of the adherence to a monolithic view of intelligence for those with a cumulative profile, and a turnaround in the socio-constructivist profile, moving from a multiple conception to a single one. Three assumptions can clarify this conclusion. The first is related to the focus of the training program during the second year. Theories and concepts are introduced in the first year and further developed in the second year. Appendix A shows that several courses straddle the first 2 years of training. Their foundations are laid in the first year, while the more complex conceptualization work takes place in the second year. As mentioned in the context section, the courses in the second year are also more targeted. Moreover, it is also in the second year that the didactics of the disciplines are really addressed (Appendix A). As one can see, the second year is characterized by new and more complex content, thus placing a strong emphasis on the cognitive dimension of intelligence. The second hypothesis concerns the

presence of a strong identity as a student during the first years of training (Beckers, 2007; Boraita & Crahay, 2013; Ruohotie-Lyhty & Moate, 2016), that is, the encouragement of a logic of certification instead of a logic of professional development (Altet, 2013; Vacher, 2017). This certification, based essentially on the mastery and mobilization of knowledge, promotes a monolithic conception of intelligence. The third assumption concerns the evaluative practices promoted in initial training. These practices rely heavily on the classical view of intelligence, which recognizes only two types of intelligence, verbal and mathematical (Dejemeppe, 2018). Although the situation has become more critical with highly diverse classrooms, the classical conception of intelligence is still largely dominant in the culture we live in (Altan, 2012), in close association with the legitimization of the intellectual categorization of human beings (Jonsson & Beach, 2010), and drives every part of society, including the field of education.

Although our results do not allow us to quantify the influence of the theoretical content taught in teacher education programs on teacher candidates' existing beliefs, previous work has agreed that it is fairly marginal in comparison with the influence of their practical experiences (Hanin, Colognesi, Cambier, Bury, & Van Nieuwenhoven, 2020; Celik et al., 2018; Voss & Kunter, 2019; Wall, 2016). Research has indicated that prior to their first field experience, teacher candidates know little that is concrete about the pupils and how they learn (Henry, 2016; Tatto, 2019; Vacher, 2017). Empirical studies have converged in the same direction, revealing that first-year student teachers conceive teaching as simply the fact that the teacher teaches and the students learn. The accumulation of their experiences in real classrooms enables them to grasp the full complexity of the profession (Crasborn and Hennissen, 2014; Standal et al., 2014; Voss & Kunter, 2019). Pre- and in-service teachers claim it themselves: field experiences constitute the crucial element in teacher education programs (Hanin, Colognesi, Cambier, Bury, & Van Nieuwenhoven, 2020; Standal et al., 2014; Voss & Kunter, 2019). It is, therefore, not surprising to learn that this part of the training is the one that has the most decisive impact on students' existing beliefs (Hanin, Colognesi, Cambier, Bury, & Van Nieuwenhoven, 2020; Boraita & Crahay, 2013; Wall, 2016). However, what is far less often discussed in the literature is the positive or negative shading that these teaching experiences give to teaching beliefs. And yet, as reflected in final-year students' qualitative comments (Hanin, Colognesi, Cambier, Bury, & Van Nieuwenhoven, 2020), these will be very completely different experiences for the trainees, depending on whether the supervising teacher imposes their pedagogical choices and thus their conceptions of intelligence on the trainee, or give the trainee the opportunity to implement their own ideas so that they can judge for themselves their relevance, or strongly encourages the trainee to test out the practices learned about during the theoretical courses (i.e., a socio-constructivist approach).

If the above empirical literature suggests a relationship between the differences in beliefs between the beginning and end of the teacher education program and an increase in the number of teaching experiences, the research carried out does not make it possible to distinguish what is related to the practical experience from what is related to other experiences during training. Our contribution lies in the fact that we have shown that experiences during initial training have a significant effect on the initial conceptions of teacher candidates.

9.3. *Practical implications*

This contribution informs us that more than 70% of teacher candidates in their final year of teacher education programs adhered to conceptions of intelligence that were negatively related to instructional quality and student learning outcomes. Previous work has indeed shown a close link between a conception of intelligence as a hereditary and not very malleable aptitude and teaching and assessment practices that are not conducive to learning, which, in turn, undermine learner motivation (Aragón et al., 2018; Hanin, Colognesi, Cambier, Bury, & Van Nieuwenhoven, 2020; Patterson et al., 2016; Rissanen et al., 2018). Further, the evolution of society's needs in terms of literacies and skills has made learning by simple rote memory and regurgitation of facts inadequate for effective participation in today's knowledge economy (Darling-Hammond, 2017; Okogbaa, 2017). On the contrary, societal developments now require citizens capable of analyzing and resolving complex situations, that is, mobilizing their knowledge in situations in a relevant, flexible and creative way. In such a context, the adoption of a conception of intelligence based essentially on the accumulation of knowledge is at odds with the needs of today's society.

Taken together, these findings underscore the importance of reducing fixist and cumulative views of intelligence among teacher candidates. In this regard, scholars agree on the key role played by teacher education programs in combating teacher beliefs that are educationally undesirable (Boraita & Crahay, 2013; Liljedahl et al., 2019; Goldin et al., 2016). Teacher education should cultivate beliefs about intelligence among prospective teachers that support learning for active integration into society, that is, beliefs that recognize the developmental nature of intelligence, the key role of interactions and the environment in this development, and the importance of the teacher's role as a facilitator of learning, that is a socio-constructivist perspective. If we look at the content of the theoretical courses in teacher education (see Appendix A) and the pedagogical approaches adopted, it is clear that they are in fact in line with this perspective (Dejemeppe, 2018). How is it, then, that they do not have a greater impact on students' beliefs? Two obstacles to changing student teachers' beliefs have been agreed upon by educational scholars. One is the lack of a link between the theoretical training, which advocates a socio-constructivist approach, and the reality that teacher candidates encounter in the practicum (Boraita & Crahay, 2013; Goodnough et al., 2016; Perez-Roux, 2016) and the other is the absence of real work during the training program addressing the initial conceptions of future teachers (Beswick & Chick, 2019; Boraita & Crahay, 2013; Liljedahl et al., 2019). With regard to the latter, researchers have pointed to the need for teacher training that helps teacher candidates: (1) to become aware of their beliefs, (2) to be led to question the internal coherence of their beliefs and their appropriateness in relation to the reality of teaching, and (3) to adapt and replace their beliefs (Beswick & Chick, 2019; Liljedahl et al., 2019). This is part of a global approach that aims to teach effective teaching practices without locking the student into a specific educational paradigm. At the beginning of their training, students could, for instance, be invited to draw up a profile of their conceptions of intelligence on the basis of the questionnaire, as a starting point for reflection on what intelligence is.

The same scholars also stressed that, for such a system to be effective, teacher educators need to be aware of the conceptions held by their students. On this point, our research makes a valuable contribution by documenting the evolution of the conceptions of intelligence among future primary school teachers throughout their training.

9.4. Future perspective and limitations

This research broadens the dimensions to be considered when examining the influence of prospective teachers' conceptions of intelligence on their future instructional decisions and hence on student learning and performance. Until now, this question has been approached mainly from a dichotomous perspective, which contrasts an innate view with a constructivist-interactionist view. The results of our typological analyses confirm that future teachers conceive intelligence as a multifaceted concept, combining its facets in various ways into a personal position (Issaieva & Crahay, 2014).

However, there are a number of limitations. First, the use of a self-report questionnaire to tap teachers' beliefs allows access only to the beliefs that are conscious. This is why many researchers recommend cross-referencing such data collection with discourse analysis and real-class observation that allow inferring of beliefs from what people say, intend and do (Curtiss, 2017; Francis, 2015; Safrudiannur & Rott, 2020). The results of the present research can be cross-referenced with the results from the qualitative study based on the same theoretical model and conducted with final-year students with the same characteristics as those who participated here (Hanin, Colognesi, Cambier, Bury, & Van Nieuwenhoven, 2020), in order to grasp the phenomenon under study in all its complexity. It would also be interesting to conduct a similar qualitative study with first- and second-year students.

Second, while the psychometric qualities of the questionnaire's subscales have been validated (internal coherence and exploratory factorial analyses), the cluster analysis rejected one of the dimensions of the initial structure from the questionnaire developed and used by Issaieva and Crahay (2014). In order to contribute to the advancement of theoretical knowledge on this point, it would be interesting to conduct a study with the aim of shedding light on this difference: did the removal of the "understanding and cognitive speed" dimension result from a cultural difference (French education system vs. Belgian educational system) between the two samples or from differences in professional experience (in-service vs. pre-service teachers)?

Third, it would be useful to deepen the description of profiles by adding personal characteristics such as gender and age, two criteria acknowledgd to have an influence on teachers' conceptions (Boraita & Crahay, 2013; Fiorilli et al., 2012). In the same vein, it would be informative to document how these profiles differ regarding prospective teachers' actual instructional practices. So far, this link has only been investigated through adopting a binary conceptualization of intelligence. In concrete terms, two options can be considered. The first would consist in collecting teachers' self-reports of their practices, with the advantages and biases that such a survey entails, and the second would consist in carrying out observational studies of the professional actions of teacher candidates when they are in classrooms. Gathering information on prospective teachers' internship experiences would not only shed light on the specific and reciprocal impact of beliefs on educational practices, but would also distinguish the impact of these experiences from that of their coursework. To put it another way, future studies should look in greater detail at the various experiences during pre-service training so that the impact of internships and academic courses on prospective teachers' beliefs can be more accurately documented.

Fourth, in order to better guide continuing education and thus more effectively support in-service teachers' professional development, it would be advisable to carry out a similar study among in-service elementary school teachers. In this respect, given that in-service teachers move through specific developmental stages (Lunenberg et al., 2014; Mukamurera, 2014; Nault, 1999; Sprott, 2019), it would be interesting to identify specific profiles for each of these stages. In the same vein, just as future elementary school teachers' views about intelligence would benefit teacher education programs and, hence, the teachers' eventual instructional and student learning outcomes (Boraita & Crahay, 2013), it would be insightful to conduct a comparable study among future secondary school teachers, especially since current practices in secondary education are described as less desirable at the educational level (e.g., structure of performance goals, prevalence of the transmissive approach, highly controlling and framing practices) (Topping, 2011; Younès & Gaime, 2012).

Finally, based on theories that postulate that teachers' beliefs are structured in systems (e.g., Beswick et al., 2019; Green, 1971; Pajares, 1992; Safrudiannur & Rott, 2020), it appears necessary to look at how beliefs about intelligence intertwine with the other beliefs of (future) teachers (e.g., about teaching and learning, about the role of the teacher and of the learner). More specifically, the aim would be, on the one hand, to be able to distinguish core beliefs and peripheral beliefs and, on the other hand, to characterize their mutual influences. This better understanding of the structure of prospective teachers' belief systems would make it possible to design more effective training interventions to combat inappropriate beliefs.

Declaration of Competing Interest

The authors declare that there is no conflict of interest.

Acknowledgments

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Appendix A

Appendix A

Appendix A

List of courses by year of training.

First year		Second year		Final year	
Oral and Written Mastery of the French Language	2	Oral and Written Mastery of the French Language	3		
Contribution of Information and Communication Technologies and Media in Teaching	2	Contribution of Information and Communication Technologies and Media in Teaching	2	Contribution of Information and Communication Technologies and Media in Teaching	1
Introduction to Research and Epistemology of Disciplines	2	Research and Epistemology of Disciplines	1	Introduction to Research and Epistemology of Disciplines (in support of their end-of-study work)	2
Developmental Psychology	6	Developmental Psychology	2	*Study of the Main Pedagogical Trends*	1
Psychology of Learning	3	Psychology of Learning	2	*Differentiation of Learning, Notion of Orthopedagogy and Detection of Learning Difficulties*	1
General Pedagogy	3	*Evaluation of Learning*	2	*Sociology and Politics of Education*	1
		Group Management Techniques and Oral Expression	2	*Introduction to Arts and Culture*	1
Philosophy, Citizenship and History of Religions	2	*Theoretical and Practical Approach to Cultural Diversity and Gender*	2	*Neutrality*	1
		Opening the School to the Outside World			
Religion and Didactics	2	Didactics of Religion	2	Didactics of Religion	1
Mathematics and Didactics	5	Didactics of Mathematics	5	Didactics of Mathematics	3
French and Didactics	5	Didactics of French	5	Didactics of French	3
Science, Geography, History Education and Didactics	6	Didactics of Sciences, Geography and History	6	Didactics of Sciences, Geography and history	3
Physical Education and Psychomotricity, Musical Education, Visual Arts Education and Didactics	6	Physical Education and Psychomotricity, Music Education, Visual Arts Education and Didactics	5	Physical education and psychomotricity, music education, Visual Arts Education and Didactics	3
Teacher Identity and Ethics	4			Teacher Identity and Ethics	2
				Development of the professional project	2
Interdisciplinarity Activities	2	Interdisciplinarity Activities	2	*Final work dissertation*	12
Professional training workshops	9	Professional training workshops	7	Professional training workshops	4
Internship	1	Internship	12	Internship	18

Note. (1) Courses that change from year to year are listed in italics. (2) The numbers indicate the number of credits associated with each course. The credit is the unit corresponding to the workload required of the student for one course, within a program of study. It takes into account not only the hours of lectures, but also practical work, seminars, laboratories, internships, personal work, research and field surveys, and so forth.

Appendix B

Appendix B

Means, standard deviations, skewness, kurtosis, and correlation matrix for the assessed variables.

First year ($n = 381$)								
	M	SD	*S*	*K*	1	2	3	4
1.Knowledge	2.18	.40	.33	1.06	1	-.24**	-.05	-.003
2. Interactions	2.99	.41	.08	.10		1	-.003	.08
3.Form	1.93	.53	.34	.45			1	-.11*
4.Origin	2.96	.52	-.05	-.56				1
Second year ($n = 285$)								
1.Knowledge	2.24	.39	.16	.51	1	-.27**	-.06	-1.07
2. Interactions	3.12	.41	-.02	.45		1	-.07	.13*
3.Form	1.75	.51	.29	-.25			1	-.09
4.Origin	3.00	.48	-.12	-.23				1
Third year ($n = 236$)								
1.Knowledge	2.34	.41	.15	-.01	1	-.17**	-.12	-.02
2. Interactions	3.06	.39	-.16	1.47		1	-.09	.16*
3.Form	1.80	.52	.20	-.31			1	-.15*
4.Origin	2.96	.52	-.17	.07				1

*$p < .05$; **$p < .01$.

Appendix C

Appendix C
Most significant item saturation coefficients by factors for the first year of training.

Items	Factors 1	2	3	4	5
18. Les enfants intelligents n'ont pas besoin de recevoir de longues explications avant de comprendre.	0.76				
15. Quand on est moins intelligent, il faut du temps pour comprendre.	0.75				
1. Un élève intelligent est un élève qui comprend rapidement.	0.70				
9. En augmentant sa culture générale, on développe aussi son intelligence*.		-0.72			
5. Ce n'est pas en accumulant de plus en plus de connaissances qu'on développe son intelligence.		-0.71			
3. Plus on accumule de connaissances, plus on devient intelligent*.		-0.60			
2. Ce n'est pas en améliorant sa culture générale qu'on développe son intelligence.		-0.51			
13. Ce n'est pas parce qu'on lit beaucoup qu'on développe son intelligence.		-0.42			
11. Les élèves doués en mathématiques et en sciences sont souvent moins doués pour les relations sociales.			0.85		
7. Les élèves doués pour les relations sociales sont souvent moins doués en mathématiques et en sciences.			0.83		
19. Les élèves qui ont une intelligence plutôt littéraire éprouvent des difficultés dans les domaines scientifiques.			0.54		
4. A la naissance, hormis les cas de handicap sévère, tous les enfants ont le même potentiel intellectuel.				0.79	
16. Dès la naissance, certains sont plus intelligent que d'autres*.				0.73	
17. Nous naissons tous approximativement avec les mêmes capacités intellectuelles. C'est le milieu qui fait la différence.				0.54	
8. L'intelligence est fixée à la naissance*.				0.46	
12. L'intelligence se construit en interaction avec le milieu.					0.79
14. L'intelligence se développe principalement grâce aux stimulations du milieu.					0.72
10. En discutant ses idées avec autrui, on développe son intelligence.					0.46
6. Interagir avec des gens compétents aide à développer son intelligence.					0.42
% variance explained (51.3% for the entire factor structure)	13.8%	12.5%	9.8%	7.9%	7.3%

* Reverse-coded for data analysis.
Factor 1= understanding and cognitive speed; factor 2 = role of knowledge; factor 3 = forms of intelligence; factor 4 = origin of intelligence; factor 5 = role of interactions.

Appendix D

Appendix D
Most significant item saturation coefficients by factors for the **second year** of training.

Items	Factors 1	2	3	4	5
2. Ce n'est pas en améliorant sa culture générale qu'on développe son intelligence.	-0.73				
9. En augmentant sa culture générale, on développe aussi son intelligence*.	-0.68				
3. Plus on accumule de connaissances, plus on devient intelligent*.	-0.65				
5. Ce n'est pas en accumulant de plus en plus de connaissances qu'on développe son intelligence.	-0.59				
13. Ce n'est pas parce qu'on lit beaucoup qu'on développe son intelligence.	-0.44				
11. Les élèves doués en mathématiques et en sciences sont souvent moins doués pour les relations sociales.		0.84			
7. Les élèves doués pour les relations sociales sont souvent moins doués en mathématiques et en sciences.		0.83			
19. Les élèves qui ont une intelligence plutôt littéraire éprouvent des difficultés dans les domaines scientifiques.		0.65			
4. A la naissance, hormis les cas de handicap sévère, tous les enfants ont le même potentiel intellectuel.			0.75		
16. Dès la naissance, certains sont plus intelligent que d'autres*.			0.67		
8. L'intelligence est fixée à la naissance*.			0.55		
17. Nous naissons tous approximativement avec les mêmes capacités intellectuelles. C'est le milieu qui fait la différence.			0.45		
12. L'intelligence se construit en interaction avec le milieu.				0.70	
14. L'intelligence se développe principalement grâce aux stimulations du milieu.				0.67	
10. En discutant ses idées avec autrui, on développe son intelligence.				0.62	
6. Interagir avec des gens compétents aide à développer son intelligence.				0.61	
1. Un élève intelligent est un élève qui comprend rapidement.					0.78
15. Quand on est moins intelligent, il faut du temps pour comprendre.					0.73
18. Les enfants intelligents n'ont pas besoin de recevoir de longues explications avant de comprendre.					0.59
% variance explained (52.9% for the entire factor structure)	14.6%	13.5%	9.7%	7.9%	7.2%

* Items that were returned.
Factor 1 = role of knowledge; factor 2 = forms of intelligence; factor 3 = origin of intelligence; factor 4 = role of interactions; factor 5 = understanding and cognitive speed.

Appendix E

Appendix E

Most significant item saturation coefficients by factors for the **last year** of training.

Items	Factors 1	2	3	4	5
1. Un élève intelligent est un élève qui comprend rapidement.	0.78				
18. Les enfants intelligents n'ont pas besoin de recevoir de longues explications avant de comprendre.	0.67				
15. Quand on est moins intelligent, il faut du temps pour comprendre.	0.58				
10. En discutant ses idées avec autrui, on développe son intelligence.		0.71			
12. L'intelligence se construit en interaction avec le milieu.		0.68			
6. Interagir avec des gens compétents aide à développer son intelligence.		0.59			
14. L'intelligence se développe principalement grâce aux stimulations du milieu.		0.52			
5. Ce n'est pas en accumulant de plus en plus de connaissances qu'on développe son intelligence.			0.77		
3. Plus on accumule de connaissances, plus on devient intelligent*.			0.74		
2. Ce n'est pas en améliorant sa culture générale qu'on développe son intelligence.			0.50		
9. En augmentant sa culture générale, on développe aussi son intelligence*.			0.43		
13. Ce n'est pas parce qu'on lit beaucoup qu'on développe son intelligence.			0.42		
4. A la naissance, hormis les cas de handicap sévère, tous les enfants ont le même potentiel intellectuel.				0.82	
16. Dès la naissance, certains sont plus intelligent que d'autres*.				0.74	
17. Nous naissons tous approximativement avec les mêmes capacités intellectuelles. C'est le milieu qui fait la différence.				0.63	
8. L'intelligence est fixée à la naissance*.				0.42	
11. Les élèves doués en mathématiques et en sciences sont souvent moins doués pour les relations sociales.					0.92
7. Les élèves doués pour les relations sociales sont souvent moins doués en mathématiques et en sciences.					0.89
19. Les élèves qui ont une intelligence plutôt littéraire éprouvent des difficultés dans les domaines scientifiques.					0.56
% variance explained (55.3% for the entire factor structure)	15.7%	13.3%	9.3%	8.9%	8.1%

* Items that were returned.

Factor 1 = understanding and cognitive speed; factor 2 = role of interactions; factor 3 = role of knowledge; factor 4 = origin of intelligence; factor 5 = forms of intelligence.

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