



Early childhood educator's implementation readiness and intervention fidelity: Findings from a person-centered study

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ABSTRACT

Research has indicated that early educators' intervention fidelity is a significant predictor of children's responsiveness to classroom interventions. To improve understanding of predictors of intervention fidelity in early childhood settings, this study adopted a person-centered approach to identify profiles of "implementation readiness" in 1,192 Danish educators, and to examine relations with implementation fidelity. Multilevel latent profile analyses including setting-level characteristics as well as characteristics particular to the individual educator, showed reliable profiles of general and intervention-specific implementation readiness, which were associated with proportion of fulltime educators, employees with a teaching-related pre-service education, and investment in professional development. Higher and more positive implementation readiness predicted implementation dosage and adherence to early childhood interventions.

The number of randomized control trials (RCTs) of effective practices and interventions in early childhood education (ECE) settings, in particular of language and literacy interventions, has rapidly increased across the world (Walker et al., 2020). Although some interventions successfully facilitate young children's early skill development (Chambers, Cheung, & Slavin, 2016), there is increasing debate of the effectiveness of early childhood intervention programs, including those targeting language and literacy skills (Foundation for Child Development, 2020). Substantial research on the effects of early language and literacy interventions finds that achieving practically significant impacts on children's skills is difficult and varies substantially across studies. For instance, a meta-analysis by Chambers et al. (2016) showed average short-term impacts of the magnitude of 0.15 for literacy and 0.08 for language, albeit with individual study effect sizes ranging from -0.30 to 0.52.

One source of variation in intervention effectiveness is the fidelity with which an intervention is implemented (see Durlak & DuPre, 2008 for a review). Intervention fidelity reflects the extent to which an intervention is implemented as intended, and it is regarded as a multidimensional construct that includes aspects such as dosage, adher-

ence, and quality, among others (Durlak & DuPre, 2008; Hsueh, Halle, & Maier, 2020). Implementation fidelity, on the other hand, is used for more outwards aspect of the implementation, for instance, the extent to which implementation infrastructure such as provision of professional development and technical assistance is provided as intended (Biel et al., 2020; Hsueh et al., 2020). In this paper, we use the term intervention fidelity to capture both dosage and adherence to intervention. In the case of early language and literacy interventions, educators play a central role in executing an oftentimes complex intervention as intended. For example, a study of the intervention fidelity of MyTeachingPartner, a coaching intervention for educators, showed substantial variability in educators' implementation of core components of the intervention. This study further showed that in classrooms in which educators carried out a high dosage of activities which were of high quality, children gained significantly more than in classrooms with lower dosage and quality of the intervention (Hamre et al., 2010).

In this study, we explored early educators' implementation readiness as a potential contributor to intervention fidelity in two large-scale RCT studies of language and literacy interventions, implemented as part of

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the ECE program in Denmark; these interventions served to test, at scale, two classroom-based language and literacy curricula for preschool-age children (Bleses et al., 2018a; Author, 2018a; Bleses et al., 2018b). Early educators' fidelity of these interventions was carefully evaluated for dosage and adherence and was a significant predictor of child outcomes (Bleses et al., 2018a; Bleses et al., 2018b). In the present study, we examined profiles of early educators' general and intervention-specific implementation readiness and their associations with structural educator and childcare center characteristics. We then considered whether these profiles were associated with intervention fidelity.

1. What is implementation readiness?

Implementation readiness is best conceived as a multidimensional concept that includes one's willingness, mindfulness, and skills to enable change across multiple layers and levels of an organization and is linked to intervention implementation, that is, higher implementation readiness is associated with higher intervention fidelity (Damschroeder et al., 2009). Implementation readiness is multi-layered as it includes numerous types of readiness, and multi-leveled as it includes on-the-ground employees responsible for direct implementation of interventions as well as higher-level employees and stakeholders who are more distally connected to the intervention. These multiple layers are often conceptualized as the inner and outer context of implementation (Damschroeder et al., 2009), and implementation readiness is influenced by the inner as well as the outer context in which the organization resides (Damschroeder et al., 2009; Holt & Vardaman, 2013).

Many theories of and frameworks for understanding implementation highlight readiness at the level of the individual. Although individual-focused constructs vary slightly across these theories, we rely primarily on the work of Damschroeder et al. (2009), who synthesized conceptualizations across implementation theories to create the Consolidated Framework for Implementation Research. In the case of ECE settings, the individuals most directly responsible for implementation are usually the educators. In light of this, their implementation readiness—and the readiness of those around them—is key to understanding the fidelity with which an intervention will be implemented and lead to changes in educators' behaviors. For example, if educators are not motivated to change their book-reading routines in the classroom, they will likely show very low intervention fidelity to an early literacy and language intervention centered on shared book-reading activities.

Even at the individual level, implementation readiness is multifaceted to include both general readiness and intervention-specific readiness. The former focuses generally on individuals' abilities and interests to change beliefs and behavior. For example, individuals who are more open to new ideas and practices may be more likely to implement significant changes in their behavior resulting in higher intervention fidelity. One of the most common aspects of individuals' general implementation readiness is their own self-efficacy, or the belief that they can perform specific actions within a context (Damschroeder et al., 2009). Educators with high self-efficacy may therefore be more likely to add an additional intervention into their classroom practices. As a complement to general readiness, experts also describe the importance of intervention-specific readiness, which concerns one's knowledge of the intervention being implemented and beliefs about its utility, feasibility, and importance (Damschroeder et al., 2009). For example, educators who do not believe that an intervention will be beneficial, for them or for the children in their care, may be less likely to implement the full set of practices an intervention specifies causing lower intervention fidelity.

However, according to Damschroeder and colleagues, the inner setting also includes aspects of the work contexts in which the intervention will be implemented (Damschroeder et al., 2009). In the case of ECE settings, the structural characteristics of the childcare centers, including leadership, cultural climate (e.g., the collaborative climate) and the learning climate of the center may influence the educator's implementation readiness and, therefore, also intervention fidelity. For example,

educators in a center where other employees are open to change may be more likely to incorporate new strategies into their own classroom practices.

Few school-based studies have explored educators' intervention readiness (Wanless & Domitrovich, 2015) and even fewer have examined this in the context of ECE settings. However, a recent study by Zucker and co-authors suggested that the individual-level factors, such as a lack of skills and knowledge, which are related to the general implementation readiness of the educators, were the greatest barrier for implementing the language and literacy intervention *Developing talkers* with high fidelity (Zucker, Jacobos, & Cabell, 2021). Additionally, difficulties to change habits emerged as a significant barrier for some educators (Zucker et al., 2021). In this study, we build on this work by examining early educators' general and intervention-specific readiness to identify key readiness profiles that predict implementation fidelity in the ECE context.

2. Implementation in large-scale language and literacy interventions

In this paper, we examine educators' implementation readiness based on data collected during two large-scale RCTs evaluating the effects of two classroom-based small group interventions involving around 10,000 Danish 3- to 6-year-old children. Both interventions, *Structured Preschool Efforts in Language and Literacy* (SPELL; Bleses et al., 2018b) and *Language Education Activities for Preschoolers* (LEAP; Bleses et al., 2018a), were designed to improve children's language and literacy skills, given their predictive relations to future reading achievement (National Early Literacy Panel, 2008). The interventions were adapted from *Read It Again-PreK*, an empirically supported English-language preschool supplemental curriculum, developed by Justice and colleagues and tested for efficacy in the U.S. (Justice et al., 2010). In twice-weekly lessons conducted over a 20-week period, educators followed semi-scripted lessons to explicitly target growth in key language and literacy skills (vocabulary, narrative skills, rhyme and print awareness) corresponding to 23 learning objectives. The lessons featured common classroom routines, such as book reading, singing, play activities and storytelling, within which the educators explicitly targeted objectives using suggested language that can be embedded in each activity. Each lesson involved a soft scripted sequence of step-by-step instruction featuring a before, during, and after reading activity as well as suggested language that educators could use to support children's learning during each activity. For instance, in SPELL the lesson plan for each lesson included a specific book and the specific learning goal for that lesson (e.g., for vocabulary, one objective is to understand and use new words representing time concepts such as “before”, “after” and “then”) and a of step-by-step instruction featuring a before, during, and after reading activity (for a description of the full sequence and scope and two lesson plans in LEAP, see Bleses et al., 2018b). Moreover, accompanying each lesson was a ‘Learners’ Ladder,’ which presented specific scaffolding strategies that educators could use to adapt a given lesson for children who found it too difficult or too easy relative to the average student.

Prior studies revealed that both SPELL and LEAP resulted in significant gains for children with respect to language and literacy outcomes, with effect sizes that according to new benchmarks by Kraft (2020) can be characterized as medium to large, depending on the specific variation of the interventions (Bleses et al., 2018a; Bleses et al., 2018b). As indicated above, these studies also suggested that intervention dosage, indexed as number of lessons a given child received, predicted language and literacy gains. There was significant variability among children in lesson exposure, both due to teachers not offering lessons, or children not participating in the offered lessons, for example, due to absence that particular day. For instance, the 10% of children experiencing the lowest intervention dosage participated in an average of nine lessons, whereas the 10% of children experiencing the highest intervention dosage

participated in an average of 36 lessons (Bleses et al., 2018a; Bleses et al., 2018b).

In addition to examining children's lesson exposure, we also examined educators' intervention adherence, which concerned the degree to which educators implemented the primary components of each lesson plan, whether they used the prescribed lesson materials (e.g., a storybook or song) and the extent to which they addressed the sequence and scope of the intervention. The 10% of educators who exhibited the lowest level of dosage implemented only 31% of lesson components, whereas those who exhibited the highest level of dosage implemented 100% of lesson components. Taken together, the evidence from these SPELL and LEAP RCTs indicates that educators' implementation fidelity may serve an important role in moderating intervention effects on children's language and literacy outcomes. Therefore, in this paper we explored educators' implementation readiness for its potential impact on intervention fidelity in classroom-based interventions.

3. The specific implementation context of the SPELL and LEAP interventions

Given that the SPELL and LEAP interventions were conducted in Denmark, it is useful to highlight some characteristics of the Danish ECE system. From a structural perspective, the Danish ECE system is a universal, heavily subsidized, and highly regulated public system in which all municipalities are obliged to ensure availability of ECE programs, commonly referred to as 'childcare' (Gupta & Simonsen, 2010). The majority of children are enrolled in center-based care (63%), and most centers serve children across the entire age range from 0 to 5 years (Ministry for Children and Social affairs, 2018a). For childcare centers serving children of three to five years of age, the setting for the SPELL and LEAP interventions, the educator-child ratio is relatively low, with one educator to about six children (Statistics Denmark, 2022 <https://www.dst.dk/da/Statistik/emner/borgere/husstande-familier-og-boern/boernepasning>). It is not mandatory to have a bachelor's (BA) degree to work in a childcare setting, but the majority of educators (60%) have a 3.5-year pedagogical BA degree (Ministry of Children and Social Affairs, 2018b) of which more than a third (36%) takes place in internships. After the first year, the students start a specialization into three different kinds of teachers (ECE settings, school settings or special education). Educators generally have a strong sense of professional self-efficacy, which is shaped by the university colleges offering the BA degree and a strong union which is highly involved in and endorse the BA.

A specific structural feature of the Danish ECE system is that childcare center leaders are also educators, most of them with some additional training such as a diploma or master's degree in education (Krejsler, 2012). Additionally, there is a relatively flat organizational structure in Danish ECE settings with low hierarchy in decision structures and organizations. This structure results in an organizational work culture resulting in a high degree of collaboration between leaders and employees (Krejsler, 2012). The majority of employees appear satisfied with the current collaborative practice (Jensen, Jager, Hulpia, Marques, & Cardona, 2019).

From a content perspective, a cornerstone of educational practice in Danish ECE settings is child-centered/child-initiated play with a holistic approach to pedagogy, the right to a childhood as a period of life in itself and not as preparation for adult life, and children's rights and influence on everyday life (Kragh-Müller, 2017). As a consequence, there has been a great deal of resistance towards educator-initiated and educator-led structured approaches to instruction, including adherence to an early learning curriculum. However, the implementation of a government-endorsed broad learning curriculum, which was strengthened in 2018, has resulted in an increased focus on integrating support for learning as well as wellbeing in Danish childcare programs. Nevertheless, the implementation of curriculum-based interventions has been uncommon

in Denmark childcare programs, and Danish early educators have very limited experience with such practices, and some are quite reluctant to use educator-led practices in their classrooms.

4. The current study

In the present study, we seek to determine the extent to which there are reliable subgroups (profiles) of early educators with respect to their implementation readiness, both in terms of general readiness (e.g., personal and organizational openness and willingness to change) and intervention-specific readiness (e.g., perceived difficulty of implementing the particular interventions). Given the preceding overview of the Danish ECE content, featuring a strong tradition of child-centered holistic instruction, we theorized that there would be specific profiles of educators reflecting varying degrees of both general and intervention-specific readiness to use a more structured, educator-led language and literacy curriculum.

To address these goals, we used latent profile analysis (LPA) as a means to identify profiles of educators with respect to implementation readiness. LPA is a person-centered analytical technique allowing for empirical examination of reliable clusters in data by modelling the probability of relationships among individuals on the basis of a set of (continuous) manifested variables, here called profile variables (Muthén & Muthén, 2000). In recent years, researchers have increasingly used LPA to study the complex interaction patterns among educational and organizational variables to identify various subgroups of students, educators, or other employees (e.g., Ferguson, Moore, E, & Hull, 2020; Morin, Morizot, Boudrias, & Madore, 2011; Williford, Maier, Downer, Pianta, & Howes, 2013). The use of person-centered approaches represents a viable and more informative alternative to variable-centered approaches, which apply a single profile to all individuals in the sample (e.g., the mean level of readiness among educators).

Using person-centered methods, the present study was conducted to first identify early educator profiles in terms of implementation readiness. Implementation readiness was conceptualized to include both general implementation readiness, concerning the educators' perception of the organizational context of implementation and their own ability and willingness to change, as well as intervention-specific readiness, representing the educators' perception of the specific interventions' feasibility at hand. Upon identifying reliable profiles, predictors of profile membership were explored to include characteristics of educators, such as age and experience, as well as characteristics of childcare centers, such as turnover rate and financial investment in professional development. Finally, profile membership of general and intervention-specific implementation readiness was examined as potential predictors of educators' intervention fidelity, conceptualized as intervention dosage and adherence. In total, three research questions were addressed. First, to what extent can reliable implementation readiness profiles be identified for SPELL and LEAP educators in terms of general and intervention-specific implementation readiness? Second, to what extent do educator and childcare center characteristics predict educators' profile membership? Third, to what extent do educators' implementation readiness profiles predict intervention fidelity, both dosage and adherence?

5. Method

5.1. Participants

The present study used data from the SPELL and LEAP interventions (Bleses et al., 2018a; Bleses et al., 2018b). Table 1 shows an overview of samples used for the present study. A first sample was used to form educator profiles of implementation readiness (see 'Educator profiles of implementation readiness' in Table 1). This concerned data from both

Table 1
Overview of samples used in analyses.

Analyses	Sample	Treatment condition	Time of measurement	N educators
Educator profiles of implementation readiness				
Profiles of general implementation readiness	Educators who completed the general implementation readiness questionnaire	Treatment and control	Baseline	1,058
Profile of intervention-specific implementation readiness	Educators who completed the intervention-specific implementation readiness questionnaire	Treatment	Baseline	536
Using profiles as predictors for implementation dosage and adherence				
General implementation readiness as predictor	Educators with general implementation readiness profiles and implementation dosage and adherence data	Treatment	Baseline During intervention ¹	Dosage: 737 Adherence: 605
Intervention-specific implementation readiness as predictor	Educators with intervention-specific implementation readiness profiles and implementation dosage and adherence data	Treatment	Baseline During intervention ¹	Dosage: 474 Adherence: 377

Note. The samples ‘Profiles of general implementation readiness’ and ‘Profile of intervention-specific implementation readiness’ overlap and together form the 1,192 teachers included in total in the educator profiles of implementation readiness. ¹Implementation readiness data was collected at baseline, data on implementation dosage and adherence was collected during the intervention.

treatment and control groups of implementation readiness questionnaires, which were completed by educators *before* the interventions took place. This altogether included 1,192 educators in 280 childcare centers who completed a questionnaire on general implementation questionnaire ($n = 1,058$). As only treatment educators completed the questionnaire on intervention-specific implementation readiness ($n = 536$), the response rate of educators providing data on both questionnaires was approximately 34%. This overlapping sample was found to have a biased representation in terms of educator education and reported sick leave, assumedly due to self-selection bias. Therefore, the two questionnaires were used separately to identify profiles of general and intervention-specific implementation readiness. A second sample was used when the profiles were explored as predictors for implementation dosage and adherence (see ‘Using profiles as predictors for implementation dosage and adherence’ in Table 1). The size of the second sample was lower than the first sample, due to the precondition that educators with profile membership of general implementation readiness required *also* data on implementation dosage ($n = 737$) or adherence ($n = 605$), and that educators with profile membership of intervention-specific implementation readiness *also* required data on implementation dosage ($n = 474$) or adherence ($n = 377$).

Of the 1,192 early educators included in the profiles of implementation readiness in total, 16% have 0-5 years of experience, 25% have 6-10 years of experience, 19% has 11-15 years of experience, 10% have 16-20 years of experience and 30% have more than 20 years). Moreover, 80% had a BA or advanced degree. Information from Statistics Denmark provided information about the children in the educators’ classrooms; the children (52% boys) were between 3 and 6 years of age and were, on average 54 months ($SD = 11$ months). About 10% of the children had a migrant background, as either an immigrant or recent descendant. Regarding parental background, 18% of mothers had graduated from primary school, 36% from high school or vocational school, 29% with a BA degree, and 17% with advanced degrees. For fathers, 20% had graduated from primary school, 46% from high school or vocational school, 19% with a BA degree, and 16% with advanced degrees. Median family income per year (personal income of parents combined) was 608,038 Danish crowns. Because SPELL and LEAP samples differed on child variables (significant differences for parent’s education, income and immigrant status), educator variables (significant differences for age and experience), and childcare variables (significant differences for all variables included in Table 6), type of intervention was controlled for in the further analyses right.

5.2. Procedure

Prospective childcare centers across the nation of Denmark were recruited to participate in the SPELL or LEAP RCTs via an invitation to study participation provided to all Danish municipalities. From 20 municipalities that volunteered to participate, 14 municipalities were selected on the basis of geographic and socioeconomic characteristics. From these 14 municipalities, a total of 300 childcare centers provided participants (children, educators, childcare center leaders), 154 and 144 centers for the SPELL and LEAP interventions, respectively.

After recruitment, stratified random sampling was used at the childcare center level based on strata of family structure (single parenthood or not), parental education and income, and use of social services using data from Statistics Denmark. Each center was randomly assigned to one of four intervention conditions, including a control condition (business-as-usual) as well as planned variations of the intervention under evaluation but for the current purpose all treatment groups were combined (for more information about the different treatment conditions in SPELL and LEAP, see Bleses et al., 2018a; Bleses et al., 2018b). Overall, the RCTs provided data of 1,192 educators, which were combined for the present study.

Within the childcare centers, all children and educators participated in the intervention. Educators delivered their assigned intervention to children in small groups with up to six children per group with one exception for one treatment group in the LEAP study where the intervention was tested in a large group setting. Both interventions were designed to support educators in stimulating children’s language and literacy skills in 20 weeks’ time for 30 minutes twice per week, for instance, in activities focused on storytelling or reading. Before the interventions took off, educators were requested to complete two researcher-developed questionnaires on perceived general implementation readiness and intervention-specific implementation readiness.

After each intervention lesson, it was mandatory that educators in both interventions administered implementation notes on an online platform (in SPELL via an iPad) which included questions pertaining to intervention implementation, more specifically dosage as well as adherence to the intervention (see Measures). Moreover, three times during the intervention (after lesson 6, 20, and 36), the educators tracked individual children’s progress towards the objectives of the interventions.

We did not collect data of the instructional practice of the business-as-usual practice in the control groups during the intervention. However, a study of the process quality of the classrooms participating

in the SPELL study based on the Classroom Assessment Scoring System Pre-K (CLASS PreK, Pianta, La Paro, & Hamre, 2008) before the intervention began, indicates that educators in Danish ECE programs targeting children at 3- to five years of age show medium to high levels of Emotional Support and Classroom Organization, whereas scores for Instructional Support were in the low range (Slot, Bleses, Justice, Markussen-Brown, & Højen, 2018). Furthermore, the study shows that holding a BA in ECE was related to higher observed process quality in Emotional Support and Classroom Organization but not to Instructional Support. Other studies indicate that the SPELL/LEAP treatment groups would differ substantially from the business-as-usual practice as business-as-usual practice would be formed around child-centered/child-initiated play with a holistic approach to pedagogy with little presence of structured small-group activities.

5.3. Measures

Measures of relevance to the proposed study are of two types. First, educators completed questionnaires designed to capture their implementation readiness across two dimensions: General implementation readiness and intervention-specific readiness. Second, educators also provided ongoing information about their implementation fidelity. In addition, data concerning educator background characteristics were captured using demographic questionnaires at baseline, including gender, age (5 categories ranging from under 25 years to 55 years and up), teaching experience, and educational credentials. Likewise, structural childcare center characteristics were self-reported by the leaders of the childcare centers at baseline. These included, for instance, financial resources invested in the professional development of the childcare centers' employees (in the past year per fulltime educator), turnover rate (per employee in the past year), number of days that employees were on sick leave (ranging from 5 or less or more than 17 days), years of leader's experience in childcare centers and years of leader's experience as a center leader (both ranging from less than 5 or more than 20 years of experience), proportion of fulltime educators in the childcare center (per employee) and proportion of employees with teaching-related education (per employee).

Measures of implementation readiness. Two questionnaires, a general implementation questionnaire and an intervention-specific questionnaire, were administered at baseline, prior to any educator training or curriculum implementation. Items on both questionnaires adhered to a 5-point Likert-type scale ranging from 1 (*Not at all*) to 5 (*To a high degree*).

Items from the implementation readiness questionnaires served as profile variables to identify educator profiles. Raw questionnaire items were used, since latent profile models with constructs as profile variables resulted in no model identification (e.g., not enough information to estimate model parameters) or low levels of entropy. Therefore, to retain variability and discriminate value for identifying the educator profiles, raw questionnaire items were selected. First and foremost, items were selected that were most representative of the questionnaire constructs. If that still resulted in low variability, items were added or selected on the basis of entropy levels and reliability following methodological literature (Mäkikangas et al., 2018; Wurpts, 2014). Beneath, we describe the overall development of each questionnaire, the general constructs that were captured and the individual items that were chosen and used in the analyses.

General implementation readiness questionnaire. The general implementation questionnaire measures the extent to which educators perceived personal and organizational preconditions for intervention implementation. The questionnaire was developed based on analyses of extent questionnaires related to organizational change and the implementation of health interventions (Edwards, Jumper-Thurman, Plested, Oetting, & Swanson, 2000; Emmons, Weiner, Fernandez, & Tu, 2012; Fixsen, Naoom, Blase, Friedman, & Wallace, 2005; Lehman, Greener, & Simpson, 2002; Weiner, 2009; Weiner, Amick, & Lee, 2008) and items

drawn from the Organizational Readiness for Change Social Agency Employees measure (ORC; Lehman et al., 2002) and the Evidence-Based Practice Attitude Scale (EBPAS; Aarons, 2004). In total, 39 items addressed two constructs: Competency to change and Openness to change and work climate. Competency to change (24 items, $\alpha = .90$) consisted of the employees' knowledge of children's language development. Openness to change and work climate (15 items, $\alpha = .74$) was related to the employees' willingness to change, their openness to new ways of work and their current work and learning climate.

Nine single items were selected from the two constructs to be part of the profile variables. The construct *competency to change* provided the items: (1) Educator knowledge (I have sufficient knowledge of effective methods and/or interventions to strengthen children's linguistic development), (2) develop own practice (I seek knowledge to further develop my own educational practice), and (3) develop practice in childcare (I take initiative to further develop the educational practice in the childcare center). The construct *openness to change and work climate* provided the items: (4) High individual readiness to change (I like to try new methods in my educational practice), and (5) leader supports learning climate (My leader supports the employees' proposal for the further development of the educational practices), (6) leader engaged in practice (My leader engages in the daily educational practice), (7) high social climate in childcare (We have a good social community among employees), (8) close collaborative culture (We work professionally closely together), and (9) high collective commitment (We use each other as co-operation partners).

Intervention-specific readiness questionnaire. The intervention-specific questionnaire assessed the educators' perception of the intervention's feasibility, that is, the extent to which the interventions' procedures, goals and effects were found usable and valid by the educators. The questionnaire was based on literature on the social acceptability of interventions (Finn & Sladeczek, 2001; Foster & Mash, 1999; 1977; Kazdin, 1977,1980; Lindo & Elleman, 2010; Schwartz & Baer, 1991; Witt & Martens, 1983; Wolf, 1978) and items from the Treatment Evaluation Inventory (TIE; Kelley, Heffer, Gresham, & Elliott, 1989) and the Intervention Rating Profile (IRP; Witt & Martens, 1983). In total, 25 items were used to capture (1) ease of dissemination ($\alpha = .80$), (2) social validity ($\alpha = .87$), and (3) cost ($\alpha = .72$). First, ease of dissemination (9 items) covered the difficulty of the intervention and its coherence with the existing educational practices, and the perception of intervention material and learning objects. The second theme, social validity (12 items), was inspired by items of the TIE and IRP, on social acceptability of the intervention's procedure (structure, core components and materials), goals (ultimate goal of children's language learning and the instrumental learning objectives of the interventions), and perception of the intervention's effectiveness. The third theme, cost (4 items), concerned the educators' perception of the resources used in relation of the intervention's effects.

Eleven single items were selected from the three constructs to be part of the profile variables. The construct *ease of dissemination* provided the items: (1) Goal match (There is coherence between the goals of SPELL/LEAP and your own current educational goals), (2) feasibility goals (It is possible to work with explicit goals in activities), (3) feasibility duration (It is feasible to work with the same small group of children over a period of 20 weeks), and (4) practice match (There is coherence between my existing educational practices and the structures and methods of SPELL/LEAP). The construct *social validity* provided the items: (5) Intervention goals (The overall goal of supporting children's language development is important), (6) positive effects on language skills (The intervention will improve the children's language skills), (7) positive long-term effects (The intervention will have a lasting effect on children's language skills), (8) individual child effects (The intervention will be beneficial for individual child), and (9) usability for educational practice (The intervention will be useful for your own educational practice). The construct *costs* provided the items: (10) Uptake (Educators will use the program, because it requires limited training) and

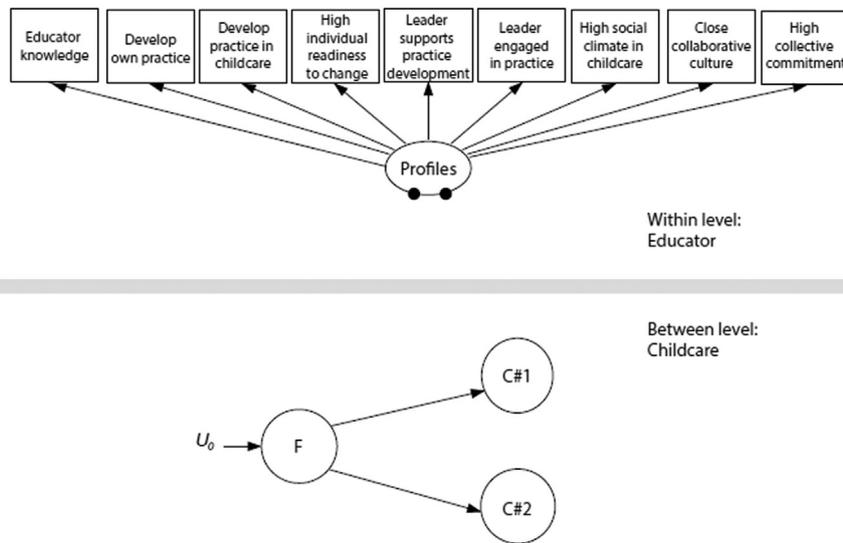


Fig. 1. Two-level MLPA with continuous latent class indicators.

(11) resource usability (The resource use of the program is realistic in practice).

Measures of intervention fidelity. Intervention fidelity was operationalized as implementation dosage and adherence. Implementation dosage captures the number of lessons the child has participated in during the intervention with a maximum of 40 lessons. In the implementation notes, educators recorded children's attendance to lessons (i.e., implementation dosage). Educators also recorded the extent to which the intervention elements were implemented, that is, use of intervention material and activities and using the sequence and scope in lesson activities. Based on research indicating that educators may not always implement core elements as intended (Bleses et al., 2018a, Bleses et al., 2018b), implementation adherence was based on the question asking the educators how many intervention elements they had implemented and if they implemented those in the right order. Response categories were: (1) implemented all elements in the right order together with accompanying materials, (2) implemented all elements but in different order, (3) implemented some elements and did not use accompanying materials, (4) implemented some elements but changed the order, and (5) implemented some elements and did not use the accompanying materials. A binary outcome variable was created which covered if the educator used all intervention elements (whether or not in the right order) based on response category 1 and 2. Next, this binary variable was aggregated on the group level to index implementation adherence as proportion of intervention elements used in groups of children.

5.4. Analytic approach

To form educator profiles, two multilevel LPAs (MLPAs; general and intervention-specific implementation readiness) with continuous latent profile variables were conducted in Mplus (Version 8). Two separate MLPAs were modelled due to low levels of entropy whenever items from the general and intervention-specific questionnaire were combined into one model. Single questionnaire items were used for the MLPA profile variables instead of using composite scores. As described above, this allowed us to make full use of item variance, rather than losing the information that is contained in a composite score and compromising classification probability. This also made it possible to focus on items that were contributing more or less to the profiles.

In the first step of the analysis, 1-5 profile solutions were examined with single-level LPAs (SLPA) (Henry & Muthén, 2010; Mäkikangas et al., 2018). The model parameters were generated using means of full information maximum likelihood (FIML) estimation with standard errors that are robust to nonnormality (MLR in Mplus; Muthén

& Muthén, 1998-2017). This MLR estimator is recommended when estimating multilevel mixture models, given its robustness to the nesting of observations. Following Mäkikangas et al. (2018), the SLPAs were first estimated with unequal variances across profile variables and profiles. Since the models would not converge, more parsimonious model estimations were conducted by constraining the variances across profiles, but not across profile variables. Covariances were fixed to zero as the default. To avoid the local maximum issue of clustering and profile analyses techniques, 500 random starts were used and doubled to replicate final model findings (Asparouhov & Muthén, 2008; Morin et al., 2011).

Similar procedures were followed in the second step of the analyses, wherein the nested structure of the samples was accounted for in MLPAs by including the childcare center clusters in the analyses. See Figure 1 for a visual representation of the MLPA models.

Two MLPAs were estimated (for general and intervention-specific implementation readiness) with continuous latent profile variables and a random intercept on the childcare center level (see Muthén & Muthén, 1998-2017; Vermunt, 2003). The filled dots of the latent variable 'Profiles' represent the random intercepts of the profiles, which can be found in the between level part of the model as C#1 and C#2 (see the between level in the lower part of Fig. 1). These random intercepts were combined in one factor (F) to avoid heavy computation. In this way, only one dimension of integration is used, which fits the data equally well since the random intercepts are often highly correlated (Henry & Muthén, 2010). By default, the first factor loading (C#1) was set to one for estimation. Means and variances were freely estimated across profile variables and profiles on the between level and covariances were fixed to zero as the default. Model fit was evaluated on the basis of relative measures of BIC and ABIC, absolute and relative levels of entropy (≥ 0.80) and the Lo-Mendell-Rubin likelihood ratio test (LMR, $p < .05$). Entropy levels per profile variable were also requested in the model syntax to evaluate each profile variable's contribution to the classification accuracy of educators in latent profiles.

The MLPA profile memberships per educator were examined to explore what predicted profile membership and what was predicted by profile membership. To examine what predicted profile membership, multilevel multinomial logistic regression was run with profile membership as nominal variable and educator characteristics (e.g., age) and childcare center characteristics (e.g., turnover rate) as covariates, at the first and second level respectively. Type of intervention (SPELL or LEAP) was likewise used as covariate on the first level to control for confounding effects. Profile membership was based on profile probability, given that the classification accuracy was very high for both MLPAs (entropy = .995 and .859 for general and intervention-specific imple-

Table 2
Descriptive statistics of profile variables of general implementation readiness.

#	Variable	1	2	3	4	5	6	7	8	9
1	Educator knowledge	1								
2	Develop own practice	.26	1							
3	Develop practice in childcare	.26	.61	1						
4	High individual readiness to change	.13	.46	.39	1					
5	Leader supports practice development	.22	.27	.23	.19	1				
6	Leader engaged in practice	.18	.21	.16	.12	.62	1			
7	High social climate in childcare	.14	.16	.17	.14	.28	.21	1		
8	Close collaborative culture	.17	.19	.20	.11	.32	.30	.67	1	
9	High collective commitment	.14	.18	.19	.17	.32	.23	.57	.67	1
	N	1058	1056	1054	1051	1034	1044	1052	1051	1052
	Mean	3.46	3.77	3.74	3.81	3.98	3.74	3.99	3.81	3.99
	SD	0.62	0.56	0.55	0.48	0.63	0.95	0.64	0.65	0.63
	Range	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5
	ICC	.03	.02	.01	.08	.25	.24	.25	.25	.17
	Cronbach's alpha	.77	.74	.75	.76	.74	.75	.74	.73	.74

Table 3
Descriptive statistics of profile variables of intervention-specific implementation readiness.

		1	2	3	4	5	6	7	8	9	10	11
1	Match with own educational goals	1										
2	Feasibility of intervention goals	.24	1									
3	Feasibility of intervention duration	.24	.30	1								
4	Match with educational practice	.40	.19	.27	1							
5	Importance of intervention goals	.15	.29	.19	.06	1						
6	Positive effect on language skills	.23	.26	.31	.18	.25	1					
7	Positive long-term effects	.21	.21	.30	.21	.21	.75	1				
8	Individual child effects	.25	.26	.28	.15	.23	.70	.63	1			
9	Applicability to educational practice	.22	.23	.34	.23	.19	.55	.54	.61	1		
10	Probability of uptake	.20	.23	.32	.25	.21	.43	.40	.42	.51	1	
11	Usability of resources	.20	.25	.39	.31	.16	.34	.36	.33	.39	.51	1
	N	536	516	527	534	536	536	494	525	525	489	525
	Mean	3.77	3.58	3.26	3.17	4.62	3.77	3.55	3.82	3.76	3.20	2.47
	SD	0.51	0.44	0.75	0.59	0.30	0.51	0.55	0.60	0.71	0.69	0.83
	Range	1-5	2-5	1-5	1-5	3-5	1-5	1-5	2-5	1-5	1-5	1-5
	ICC	.09	.05	.21	.16	.06	.09	.05	.18	.21	.09	.31
	Cronbach's alpha	.78	.78	.76	.78	.78	.78	.76	.75	.75	.77	.76

mentation readiness, respectively). Analyses of what predicted profile membership were done after the identification of the profiles in the LPAs (also called enumeration process) to avoid misspecification of covariate effects and subsequently to avoid finding an abundant number of profile extractions (Nylund-Gibson & Masyn, 2016). To examine the predictive power of educators' profile membership, multilevel regressions were run with implementation dosage at the child level nested in groups, educator and childcare centers and implementation adherence at the group level nested within educators and childcare centers. In the regressions with intervention-specific implementation readiness profiles as predictor, type of intervention was included as covariate because effects were found on profile membership. Standardized regression coefficients were obtained by standardizing implementation fidelity variables before analysis to serve as indicators of effect sizes.

6. Results

6.1. Preliminary analyses

Tables 2 and 3, respectively, provide descriptive data and correlations for the profile variables representing general implementation readiness and intervention-specific implementation readiness. Generally, these data show small to moderate correlational relations amongst the main implementation variables. With regard to mean scores, high values were shown for profile variables of general implementation readiness overall (see Table 2), with average scores ranging from 3.46 (educator knowledge) to 3.99 (high social climate in childcare, high collective commitment) on a 5-point scale. High ICCs for profile variables inquiring about general implementation readiness on the childcare level (.17-

.25) indicated that responses conformed substantively from one childcare center to another. For the intervention-specific profile variables (see Table 3), mean scores were also overall high (> 3.0 on a 5-point scale), except for usability of resources ($M = 2.47$), which also showed a higher standard deviation relative to the other profile variables. Overall, these preliminary results suggest that educators' implementation readiness was relatively high, although the standard deviations showed significant variability among educators.

6.2. Profiles of general and intervention-specific implementation readiness

The first research question concerned the extent to which reliable profiles of readiness would exist among these early educators when implementing one of the two early language and literacy interventions in their classrooms. We first examined profiles of general implementation readiness, and Table 4 presents model fit measures for single- and multilevel LPAs. For the SLPA, model fit values indicated that a 3-profile solution fit the data better than a 2-profile solution, and model results with 3- and 4-profile solutions were not identified during parameter estimation. Thus, the 3-profile solution performed best in terms of lowest model fit values of BIC and ABIC, and highest entropy value. The LMR test was significant for both the 2- and 3-profile solutions, indicating that model fit was significantly better than solutions with one less profile. Subsequently, a 3-profile solution was used to build the MLPA.

Fig. 2 shows a visual representation of the three profiles, and Table 5 provides the three profiles' means and standard deviations. Generally, the three profiles correspond to patterns of high, average, and low general implementation readiness, with the greatest differentiation among profiles occurring for childcare center contextual characteristics (leader

Table 4
Model fit measures of profiles of general and intervention specific implementation profiles.

Model	#Profiles	Log	#Parameters	BIC	ABIC	Entropy	LMR p
General implementation readiness							
SLPA	1	11174	18	22475	22417	1	NA
SLPA	2	10500	28	21196	21107	.747	<.001
SLPA	3	10076	38	20417	20297	.995	.018
SLPA	4	8162	48	NA	NA	NA	NA
SLPA	5	8059	58	NA	NA	NA	NA
MLPA	3	10028	40	20335	20208	.995	NA
Intervention-specific implementation readiness							
SLPA	1	6509	22	13156	13086	1	NA
SLPA	2	5963	34	12141	12033	.852	<.001
SLPA	3	5805	46	11900	11753	.865	.067
SLPA	4	4928	58	NA	NA	NA	NA
SLPA	5	4848	70	NA	NA	NA	NA
MLPA	2	5787	48	11875	11723	.859	NA

Note. N =1,058, unstandardized, random starts = 1000. SLPA: single-level Latent Profile Analysis, MLPA: multilevel Latent Profile Analysis.

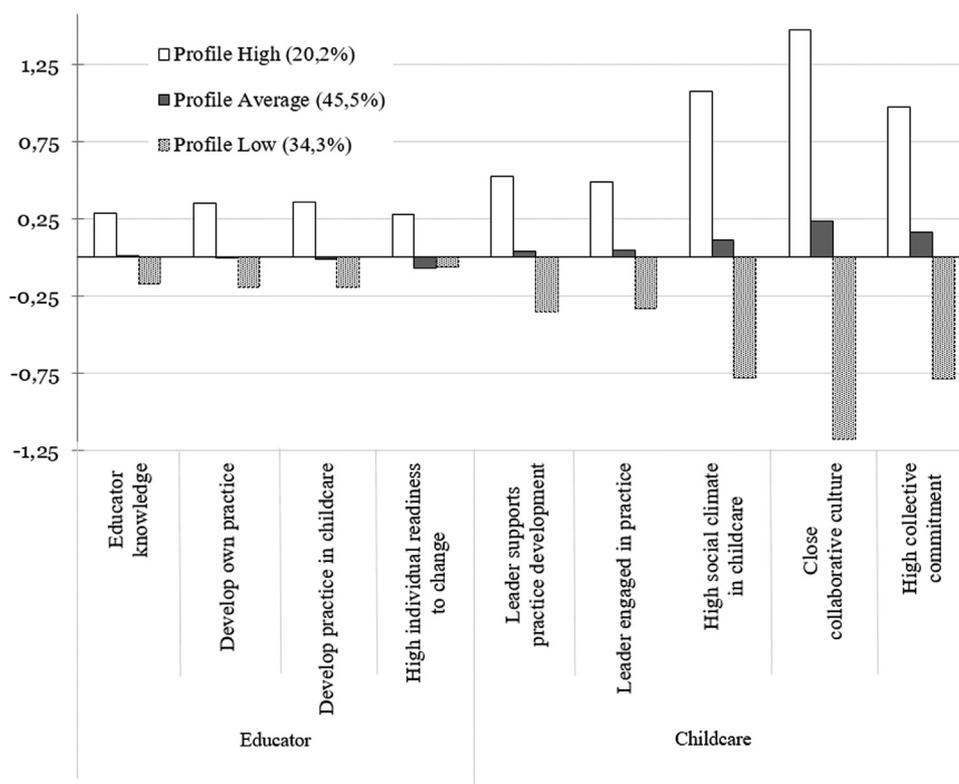


Fig. 2. Graphical representation of the 3-Profile solution for general implementation readiness. Note. Profile variables were standardized.

supports practice development, high social climate in childcare, close collaborative culture, and high collective commitment). The first profile comprising 20% ($n = 214$) of the educators represented a *High general implementation readiness profile* (High). This profile was characterized by relatively high educator openness to and competences for change, and high supportive organizational context of implementation with levels of leader support in practice development and engagement in practice in between the individual and the more collective factors. The second profile comprising 46% ($n = 481$) of the educators represented an *Average general implementation readiness profile* (Average). These educators demonstrated relatively lower means than the educators in the High profile and showed a similar yet more flat pattern with lower profile variable values on leader support/engagement and the organizational collective context. The third profile comprising 34% of the educators ($n = 363$) represented a *Low general implementation readiness profile* (Low). The educators in the Low profile especially displayed a low supportive childcare context of implementation compared to the High and

Average profile. Entropy values indicated a relatively high contribution to overall classification accuracy for variables that tapped into collaborative support ($entropy = .27-.99$) as compared to the variables that tapped into the ability and willingness to change ($entropy = .05-.09$).

We then turned to examining the extent to which educators exhibited reliable profiles with respect to intervention-specific implementation readiness, the SLPA model fit values indicated a 3-profile solution fit the data overall better than a 2-profile solution (see Table 4). Although the LMR test was borderline significant, a 3-profile solution was preferred given the other measures of model fit of BIC, ABIC and entropy level, which favored the 3-profile solution.

A visual representation of the final profile membership of intervention-specific implementation readiness is shown in Fig. 3, and Table 5 provides the three profiles' means and standard deviations. Overall, the three profiles correspond to patterns of positive, neutral, and negative intervention-specific implementation readiness, and differed mostly in relation to educators' evaluation of the intervention's

Table 5
Unstandardized means of profile variables adjusted for childcare level (standard deviations).

General implementation readiness	Profile types		
	Low	Average	High
N	363	481	214
Educator knowledge	3.33 (0.05)	3.46 (0.04)	3.68 (0.05)
Develop own practice	3.62 (0.04)	3.76 (0.03)	4.03 (0.06)
Develop practice in childcare	3.59 (0.04)	3.73 (0.03)	4.00 (0.05)
High individual readiness to change	3.77 (0.04) ^a	3.76 (0.03) ^a	4.00 (0.06)
Leader supports practice development	3.70 (0.05)	4.01 (0.04)	4.40 (0.06)
Leader engaged in practice	3.41 (0.07)	3.78 (0.05)	4.21 (0.07)
High social climate in childcare	3.36 (0.41)	4.08 (0.03)	4.85 (0.03)
Close collaborative culture	2.86 (0.02)	4.00 (0.00)	5.00 (0.00)
High collective commitment	3.36 (0.04)	4.12 (0.03)	4.76 (0.03)
Intervention-specific implementation readiness	Negative	Neutral	Positive
N	157	286	93
Match with own educational goals	3.44 (0.11) ^b	3.87 (0.05) ^b	4.03 (0.08)
Feasibility of intervention goals	3.26 (0.07)	3.64 (0.06)	3.93 (0.07)
Feasibility of intervention duration	2.76 (0.14)	3.38 (0.07)	3.73 (0.13)
Match with educational practice	2.86 (0.12) ^c	3.27 (0.06) ^c	3.37 (0.12)
Importance of intervention goals	4.36 (0.07)	4.67 (0.04)	4.88 (0.03)
Positive effect on language skills	3.01 (0.10)	3.83 (0.07)	4.63 (0.11)
Positive long-term effects	2.83 (0.09)	3.64 (0.08)	4.39 (0.11)
Individual child effects	2.97 (0.07)	3.93 (0.10)	4.86 (0.11)
Applicability to educational practice	2.96 (0.17)	3.90 (0.07)	4.64 (0.07)
Probability of uptake	2.63 (0.18)	3.28 (0.06)	3.93 (0.10)
Usability of resources	1.87 (0.16)	2.58 (0.08)	3.11 (0.14)

Note. Scores range from 1 (not at all) to 5 (to a high degree). ^{abc} Non-significant pairwise comparisons.

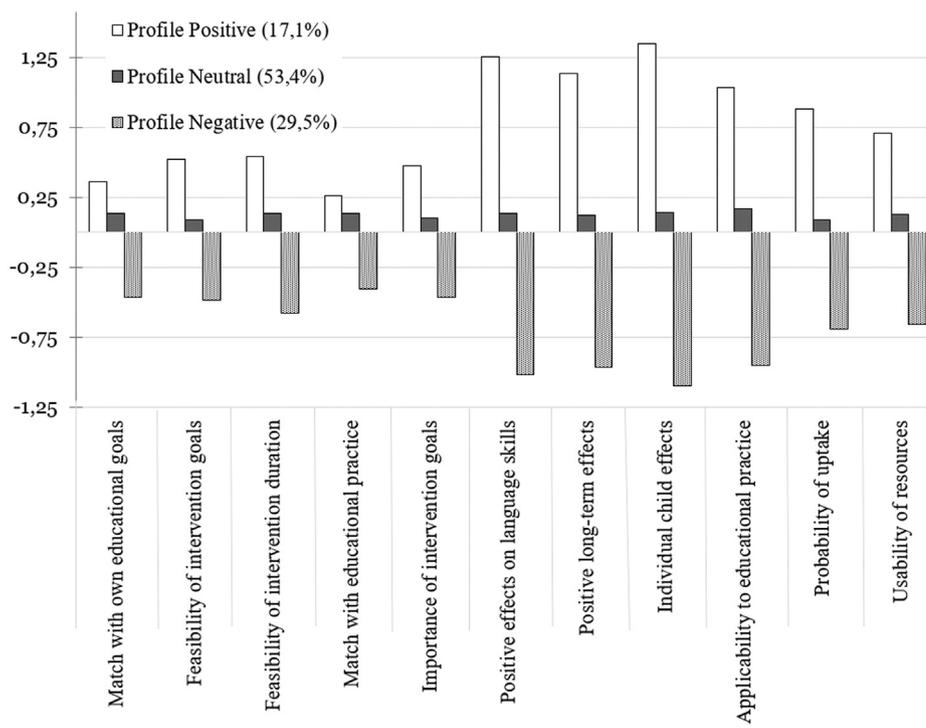


Fig. 3. Graphical representation of the 3-profile solution for intervention-specific implementation readiness.
Note. Indicators were standardized.

effects (positive effects on language skills, positive long-term effects, individual child effects) and practicality (applicability to educational practice, probability of uptake, usability of resources). The profile comprising 17% ($n = 93$) of the educators represented a *Positive intervention-specific implementation readiness profile* (Positive). These educators in the Positive profile demonstrated a positive attitude towards the intervention’s feasibility, goals, and costs, yet especially displayed positive expectations towards the intervention’s effects. The profile comprising 53% ($n = 286$) of the educators represented the *Neutral intervention-*

specific implementation readiness profile (Neutral). The educators in the Neutral profile can be characterized by showing a steady and slightly positive attitude towards all the intervention’s aspects included in the profiles. Lastly, the profile comprising 30% ($n = 157$) of the educators represented the *Negative intervention-specific implementation readiness profile* (Negative). The educators in the Negative profile predominantly showed a negative attitude in relation to intervention’s effects (positive effects on language skills, positive long-term effects, individual child effects) and practicality (applicability to educational practice, probability

Table 6
Effects, standard errors and p-values of educator and childcare center level predictors of profile membership.

	General implementation readiness			Intervention-specific implementation readiness		
	B	SE	p	B	SE	p
<i>Educator level</i>						
Woman	0.522	0.423	.218	0.047	0.561	.934
Age	-0.267	0.168	.112	-0.087	0.275	.752
Experience	0.171	0.108	.113	0.024	0.198	.904
BA or advanced degree	-0.138	0.323	.670	1.078	0.591	.068
<i>Childcare center level</i>						
Educator-to-child ratio	-0.007	0.131	.957	-0.253	0.202	.210
Sick leave	-0.112	0.097	.249	0.039	0.141	.780
Leader's experience in childcares	-0.155	0.129	.229	-0.264	0.242	.276
Leader's experience as center leader	0.090	0.107	.402	0.173	0.191	.364
% Fulltime educators	6.034	2.146	.005	4.903	2.846	.085
% Educated employees	-3.959	1.847	.032	-6.078	2.463	.014
% Professional development	0.135	0.048	.005	0.014	0.089	.873
% Turnover	-2.965	2.759	.283	1.628	4.215	.692

Note. For general implementation readiness coefficients of profile High are presented and compared to profile Low, and for intervention-specific implementation readiness the coefficients of profile Positive are presented and compared to profile Negative. Experience: years of experience as early educator, BA or advanced degree: educator finished BA degree or higher, educator-to-child ratio: number of educators divided by the number of children at the childcare, sick leave: number of days that employees were on sick leave in the past year, leader's experience in institutions: years of leader's experience in childcare centers, leader's experience as center leader: years of leader's experience as a center leader, % fulltime educators: number of fulltime educators in the childcare center per employee, % educated employees: number of employees with teaching-related education per employee, % professional development: money spent on employees' professional development in the childcare in the past year per fulltime educator; % turnover: number of educators that left the childcare per employee in the past year.

of uptake, usability of resources). Entropy levels were higher for the profile variables focusing on the intervention effects and applicability (*entropy* = .32-.52) than profile variables focusing on the interventions' goals, feasibility, and costs (*entropy* = .07-.16).

6.3. Predictors of implementation readiness profiles

To examine predictors of educators' implementation readiness, the second research question in this study, general and intervention-specific profile memberships were regressed on educator and childcare center covariates. As shown in Table 6, we predicted profile membership for both general implementation readiness and intervention-specific readiness from four educator-level variables and eight center-level variables.

The results of these regression analyses showed that no educator-level predictors were significantly associated with profile membership. However, three center-level predictors were significantly associated with educators' general implementation readiness profiles: percentage of fulltime educators, educated employees, and amount of professional development. The estimates indicate that as the proportion of full-time educators and financial investment in professional development increases, educators are more likely to have a *High general implementation readiness profile*. Yet, as the proportion of educated employees increases in the childcare, educators are more likely to have a *Low profile of general implementation readiness*. This latter association was also found for the intervention-specific profiles, such that educators were more likely to have a negative intervention-specific profile when educated employees in the childcare center increases.

6.4. Predicting intervention fidelity from implementation readiness profiles

The final research question concerned the extent to which educators' general and intervention-specific implementation readiness profiles may be predictive of intervention fidelity. For these analyses, dosage and adherence of SPELL and LEAP served as the outcome measures. Multi-level regressions were conducted with the educator profiles as predictors of intervention dosage and adherence, and models were run separately for the general and intervention-specific implementation readiness profiles. The educator profiles and intervention dosage outcomes were en-

Table 7
General and intervention-specific educator profiles as predictor for implementation dosage and adherence.

	Dosage			Adherence		
	B	SE B	β	B	SE B	B
General Implementation Readiness Profiles (reference group: low)						
High	1.651	0.678	.164*	0.100	0.027	.389***
Average	1.006	0.505	.100*	0.036	0.022	.142
Intervention-Specific Implementation Readiness Profiles (reference group: negative)						
Positive	1.599	0.863	.163	0.151	0.037	.590***
Neutral	0.902	0.640	.092	0.089	0.029	.349**

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

tered as educator-level variables, whereas implementation adherence was entered as a group-level variable (see Data Analysis). Type of intervention (SPELL or LEAP) was entered as covariate in the intervention-specific regression, being a significantly predictor of profile membership of intervention-specific implementation readiness.

Table 7 presents results for these analyses and shows that there are some relations between general profile membership and intervention dosage and adherence. Note that the omitted profiles of Low and Negative are the reference groups. Intervention dosage was significantly higher for educators in the *High general implementation readiness profile* compared to educators in the *Low general implementation readiness profile* ($b = 1.651, SE = 0.678, \beta = .164, p > 0.05$), as was dosage for those in the *Average general implementation readiness profile* compared to the *Low general implementation readiness profile* ($b = 1.006, SE = 0.505, \beta = .100, p > 0.05$). The same pattern was found for intervention adherence, for which adherence was higher for educators in the *High general implementation readiness profile* compared to educators in the *Low general implementation readiness profile* ($b = 0.100, SE = 0.027, \beta = .389, p > 0.001$). There was no difference in adherence when comparing the *Average general implementation readiness profile* and *Low general implementation readiness profiles*.

With respect to intervention-specific intervention readiness, educator profiles were predictive of intervention adherence. Intervention adherence was higher for educators in the *Positive intervention-specific readiness profile* and *Neutral intervention-specific readiness profile* as com-

pared to educators in the *Negative intervention-specific readiness profile* (resp. $b = 0.151$, $SE = 0.037$, $p > 0.001$ and $\beta = .590$; $b = 0.089$, $SE = 0.029$, $\beta = .349$, $p > 0.01$, respectively). No significant increase in implementation dosage was found for educators in the *Positive intervention-specific readiness profile* as compared to the educators in the *Negative intervention-specific readiness profile*.

7. Discussion

Across the world, language and literacy interventions in ECE settings have been developed and evaluated using causal designs but the effectiveness of such interventions on child outcomes varies, in part as a function of the fidelity with which educators implement interventions (Foundation for Child Development, 2020). It is therefore critical to learn more about how educators' intervention fidelity can be improved. Many theories of and frameworks for understanding implementation highlight readiness at the level of the individual have been developed (Damschroeder et al., 2009) but little is known about how implementation readiness influences the implementation fidelity of early language and literacy interventions in ECE settings. In the current study, we explored how two aspects of implementation readiness – general implementation readiness and intervention-specific implementation readiness – predicted intervention fidelity of two large-scale language and literacy interventions, implemented in the universal ECE system in Denmark (Bleses et al., 2018a, Bleses et al., 2018b). By means of a multilevel profiling technique, we followed an educator-centered perspective by which educators' implementation readiness was approached as an interactive and contextual whole. The advantage of person/educator-centered perspectives on implementation readiness as opposed to variable-centered is that that variable-centered approaches ignores that “. . . persons move through instructional environments, not variables. . .” (Bråten & Olaussen, 2005). Moreover, a person-centered rather than a variable-centered approach might also be more in line with management and policy practices in which phenomena and people are described in a categorical fashion rather than in terms of isolated/detached variables (Morin et al., 2011). In other words, results from person-centered approaches potentially have a higher applicability and usability in actual practice than results from variable-centered outcomes.

The first main finding of the current study – pertaining to the first research question, that is, the extent to which reliable implementation readiness profile can be identified – we observed substantial variability in educators' general and intervention-specific readiness and based on this variation specific profiles of educator implementation readiness could be identified. Regarding general implementation readiness, educators could be divided into low, average and high performing implementation readiness profiles depending on personal and organizational preconditions for intervention implementation. In the *High general implementation readiness profile*, educators had a high professional self-efficacy, experienced high leader support and engagement and were working in a highly collaborative, committed and supportive work environment, whereas the opposite was the case for educators with a *Low general implementation readiness profile*. In addition to this, a positive, neutral and negative intervention-specific implementation readiness profile emerged concerning educators' perception of the workability and validity of the evidence-based language interventions at hand. Educators with a *Positive intervention-specific implementation readiness profile* had a positive attitude towards the feasibility and applicability of the intervention and held strong beliefs about the potential effects of the intervention; for those with the negative profile, the pattern was reversed.

The *Low general implementation readiness profile* was more prevalent than the *High general implementation readiness profile*; in fact, the *Low general implementation readiness profile* comprised more than one third of the educators who participated in the studies, whereas only 20% had a high profile. A similar pattern emerged for the intervention-specific profile

where the low profile comprised a third of the educators (vs. 17% with a positive intervention-specific profile). This finding corroborates the description of the Danish ECE culture as one, at least at the time of the implementation of these interventions, where only few educators have a positive attitude towards engaging in more educator-led interventions (Kragh-Müller, 2017). Interesting, ICCs for profile variables inquiring about leader support and collaborative factors on the childcare level (.25-.31) indicated that educators' responses were substantively similar within childcare centers, and more so than the individual factors. This finding indicates that at least in a Danish context collaborative factors play a significant role for implementation readiness and may be related to the flat organization structure where leaders are also educators and high satisfaction with the collaborative work environment dominates (Krejsler, 2012).

A second finding related to the second research question (the extent to which educator and childcare center characteristics predict educators' profile membership) was that only certain childcare-level characteristics predicted profile membership. The probability that an educator perceived a supportive organizational context for implementation (*High general implementation readiness profile*) was higher when the childcare center's investment in professional development and number of fulltime educators was higher. This highlights the role of the general learning climate at a center as a driver of individuals' implementation readiness (Hsueh et al., 2020). Moreover, the probability of an educator ending up in a low/negative profile was higher when the proportion of educated employees was higher. This finding may again be related to the Danish context, in this case to the high professional self-efficacy that many educators experience and a strong union which historically has played a central role in formulating the ECE culture with its holistic approach to pedagogy and a strong emphasis on child-centered/child-initiated play.

The last finding relating to the third research question (the extent to which the implementation readiness profiles predict fidelity) was that both types of profiles were predictive of intervention fidelity, either adherence or both adherence and dosage. Higher general implementation readiness and positive intervention-specific implementation readiness predicted higher intervention fidelity – both dosage and adherence – in line with concurrent implementation theories and frameworks (Damschroeder et al., 2009); Educators who had a high self-efficacy and a good collaborative environment and believed in the intervention's feasibility, applicability and effects implemented higher dosage of the intervention and with higher quality (adherence), although the intervention-specific implementation readiness profile predicted only adherence. These findings suggest that understanding implementation readiness can help us to appreciate how interventions will be implemented in new settings. Thus, a fruitful way to move forward may be to assess and enhance educators' general and intervention-specific implementation readiness before interventions start. Given that a third of educators have a low or negative implementation readiness profile suggest that there is a large potential for improving intervention fidelity by improving their implementation readiness before the intervention is carried out. The fact that there was a significant difference also between the low and the average implementation readiness profile, means that even increasing general implementation readiness to an average level is enough to promote intervention dosage, which in turn predicts child outcomes. A different strategy to magnify the impact of an intervention, would be if municipalities only chose to implement the intervention in those sites where educators' readiness profiles have the best match with a particular intervention (Damschroeder et al., 2009); Moullin, Dickson, Stadnick, Rabin, & Aarons, 2019). For instance, educators with a low self-reported self-efficacy may feel more confident implementing a more structured intervention leading to higher fidelity, compared to an intervention with more discretion in choices. The two different strategies may complement each other.

How implementation readiness can be increased is an empirical question that needs more attention moving forward. Our general readiness

findings suggest that cultivating a culture of openness to change, at both the individual- and group-level may improve implementation readiness and ultimately, intervention fidelity. This aligns with other school-based work that has found a culture of innovation to be predictive of intervention implementation and may reflect an increased absorptive capacity of the organization (Malloy et al., 2015), which enables greater uptake of new practices (Greenhalgh, Robert, Macfarlane, Bate, & Kyriakidou, 2004). Our findings also suggest that it is important that educators understand the usability and relevance of early language interventions they are being asked to implement. Implementation science has identified several drivers that can help engage educators in this, such as the use of intervention champions and change agents to disseminate this knowledge throughout programs (Greenhalgh et al., 2004; Rogers et al., 2004). Additionally, engaging educators in the design and decision-making process of choosing new interventions to implement can increase their buy-in (and thus, potentially lead to greater intervention fidelity, see Moullin et al., 2019).

Several limitations of this study warrant mention. First, combining data of two RCTs (SPELL and LEAP) could have biased the profiling and predictive power of the profiles, despite controlling for effects when predicting intervention fidelity. Yet, bigger sample sizes (of the two interventions together) also allowed better model representations (Wurpts, 2014). Secondly, as the current study was conducted within a universal ECE setting in Denmark, it is unclear to which extent the results are generalizable to other ECE settings. Thirdly, even though the development of measures of general and intervention-specific readiness were based on contemporary research that have identified important constructs of readiness and had satisfactory psychometric qualities, inclusions of other aspects of implementation readiness may have resulted in different results.

In conclusion, the current paper is a first step in measuring multi-dimensional aspects of implementation readiness among childcare educators. The identification of profiles highlights the importance of thinking about people, not variables when moving forward towards understanding the role of implementation readiness for implementing interventions with fidelity. These results were established based on two language and literacy interventions that were implemented at scale under routine practice, thereby increasing the value of the results. By both identifying predictors of implementation readiness and documenting its importance to actual intervention fidelity, this work begins to help us understand how to approach intervention implementation in ECE settings in the future.

Data availability

The data have been uploaded to a secured server hosted by Statistics Denmark and cannot be exported. Independent researchers can apply to Statistics Denmark for access (contact mvandersen@econ.au.dk).

CRediT authorship contribution statement

Dorthe Bleses: Conceptualization, Methodology, Writing – original draft, Project administration, Funding acquisition. **Marinka M. Willemsen:** Methodology, Data curation, Formal analysis, Writing – original draft. **Laura M. Justice:** Conceptualization, Writing – review & editing. **Pauline Slot:** Conceptualization, Writing – review & editing. **Anders Højen:** Conceptualization, Writing – review & editing.

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