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The PSECEC study: Protocol for a randomized controlled study of professional development in science for early childhood education and care staff

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ABSTRACT

Science in Early childhood has received increasing attention in recent years. Early childhood education and care staff have crucial roles in the development of science practices as they can: provide learning environments in which children have an extensive range of opportunities to observe, explore, and discover the nature of materials and objects; assist children to become aware of their intellectual power; observe children, listen to their conversations, and challenge their questions while they engage in scientific exploration. This study aims to examine the effects of a professional development program (PSECEC) offered to early childhood education and care staff with regards to improve staff self-efficacy for science approaches, engagement with science, and attitudes toward science to enhance their possibilities to provide all children in municipality day nursery and/or kindergarten centres enhanced educative and playful experiences with science. The study is a prospective, sequential, 1:1 cluster randomized controlled wait-list trial where we will randomize 122 day nursery and/or kindergarten centres employing a total of 1456 early childhood education and care staff to either PSECEC intervention or education and care as usual (wait-list). The PSECEC intervention consists of online learning session, workshops and supportive visits organised in a nine-month long professional development program. PSECEC is provided first to the intervention group and then to the control group. The participants are assessed at baseline, midway and at the end of the intervention. The primary outcome is science self-efficacy measured by the Self-Efficacy for Science Approach (SESA) scale. Secondary outcomes include attitudes toward science, engagement with science in the work context subscale, and science approach behaviours. The trial is expected to contribute knowledge about the effect of professional development in science for early childhood education and care staff with regard to staff science self-efficacy, attitudes toward science and engagement with science in the work context.

Trial registration: The study was registered on September 29, 2022, at Clinicaltrials.gov registration number STB Trial 9012102.

List of abbreviations

ASS	Attitudes toward Science Scale
ECAU	education and care as usual
ECEC	early childhood education and care
EMEPDS	expectancy-value motivation for engaging in professional development in science
ES-life	Engagement with science in the non-work context
ES	work Engagement with Science in the work context
PSECEC	professional development in science for early childhood education and care staff
PSS	Practicing Science Scale
RCT	randomized controlled trial
SCPI	Science Capital for Professionals Inventory
SESA	Self-Efficacy for Science Approach scale

Background

Science in Early childhood has received increasing attention in recent years. This is not surprising considering findings that early

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childhood experiences can serve as a major influence on academic interests. Feelings of enjoyment and interest in science are likely to lead to a positive commitment toward science that is enduring (Osborne, Simon & Collins, 2003).

In 2018, the Danish Ministry of Children and Education, introduced a revised national pedagogical curriculum for early childhood education and care (children aged 0–6 years) (Ministry of Children & Education, 2020). According to the National curriculum, early Childhood Education and Care (ECEC) in Denmark is intended to promote children's well-being, learning, development and formation through safe and pedagogical learning environments, where play is essential and where the child perspective is the point of departure. The pedagogical curriculum covers six curriculum themes, one of which is nature, outdoor life and natural phenomena. The term natural phenomena cover science both as content and as context. The science approach emphasizes an investigative approach, which opens up for active involvement of nature and natural phenomena. The science approach focuses on children's emerging awareness of the laws of nature and their innate numeracy, intuitive sense of size and early mathematical awareness. Furthermore, children are to learn about different technological tools in relation to nature, outdoor life and natural phenomena (Ministry of Children & Education, 2020).

ECEC staff have crucial roles in the development of science practices as they can: provide learning environments in which children have an extensive range of opportunities to observe, explore, and discover the nature of materials and objects; assist children to become aware of their intellectual power; observe children, listen to their conversations, and challenge their questions while they engage in scientific exploration.

International studies suggests that science is a context, which ECEC staff find difficult to implement in a play-orientated practice (Sheridan, Williams, Sandberg & Vuorinen, 2011). This is also the case in a Danish context. (EVA, 2015). Working with science, the ECEC staff's role is to facilitate children's' science practice through manipulating materials, using all their senses, and discussing their ideas rather than simply transmitting the information to children. However, science is often introduced through activities where the staff presents a natural phenomenon to the children and children's interaction with the science content is more or less absent. There thus appears to be a common practical understanding in the field that science is detached from other parts of the curriculum, and that science is more time consuming in preparation compared to other activities. ECEC staff are therefore often avoiding science activities.

Previous research on ECEC staff's beliefs, perceptions, and attitudes in terms of science reveals that ECEC staff are uncomfortable in science and do not provide a desirable amount of science activities (Erden & Sönmez, 2011).

Barenthien, Oppermann, Steffensky and Anders (2019) highlights that pre-school teachers seldom offer science activities to the children, and that the amount of offered science activities increases even through short-term professional development (PD) courses. Not only do ECEC offer more science activities; the quality of these activities and the pedagogical content knowledge of the ECEC staff also raises through PD (Gropen, Kook, Hoisington & Clark-Chiarelli, 2017).

The effect of participation in a PD program on pre-school science is not limited to single participants. Vujičić and Čamber Tambolaš (2017) argues that PD courses are the offset of a cultural change in pre-school settings. Furthermore, the ECEC staff not participating in the PD program also raises the amount of science activities if the staff attaining the PD courses discuss these courses in their teams at work (Barenthien et al., 2019). The effects for ECEC staff of participating in PD has shown to include a higher self-efficacy and enthusiasm towards science as well as a deeper science content knowledge (Barenthien, Oppermann, Anders & Steffensky, 2020).

The positive effect of PD courses shall though be seen in the light of the structure of these courses. Even if short term courses have an effect, a review study shows that there are indicators of increased effect if the PD includes modelling, demonstration from the PD teachers, and feedback to the participants both during workshops and practical trials (Snell, Forston, Stanton-Chapman & Walker, 2013).

This trial aims to assess the effectiveness of a nine-month-long professional development program to improve early childhood educators' and carers' self-efficacy for science approaches, engagement with science, and attitudes toward science in ECEC to ultimately provide all children in municipality day nursery and/or kindergarten centres enhanced educative and playful experiences with science.

Methods and design

The study is a prospective, clustered, sequential, 1:1 randomized controlled wait-list trial with two study arms: intervention (PSECEC) and education and care as usual (ECAU). Day nursery and/or kindergarten centres are randomized to receive either PSECEC or ECAU. Participants will receive oral and written information on the project. Ethical approval has been obtained from the internal review board at UCL. The protocol conforms to the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) guidelines (Fig. 1). The final reports of the trial will be written following the Consolidated Standards of Reporting Trials (CONSORT) statement.

Participants

Participants are early childhood education and care (ECEC) staff. To be eligible, participants must be employed in a day nursery and/or kindergarten centre in Odense municipality at the time of randomization.

Inclusion and exclusion criteria

Adults employed in one of four pedagogical positions: pedagogues [pædagoger], assistants [pædagogiske assistenter], assistant teachers [pædagogmedhjælpere], and daily leaders [daglig leder] in a day nursery and/or kindergarten centre in the municipality of Odense at the start of the intervention, are included in the study.

Employees are excluded if they fulfil one or more of the following criteria: 1) Employed in other positions in a day nursery and/or kindergarten centre than the four mentioned for inclusion (c.f. above), 2) "at home child carers" [dagpleje] in Odense municipality, or 3) Not able to fill out questionnaires in Danish

Intervention and comparison

Theory of change

The PSECEC intervention has the overall aim to impact positively on how children encounter and engage in science activities in the ECEC context. The logic model (Fig. 2) for the project implies that in order to reach such an impact it is essential that ECEC staff gain a more positive attitude towards science and become more self-efficacious in relation to working with science in an ECEC context and establishing science learning environments for the children (Fig. 2).

The input for reaching the intended outcome consist of a mandatory

	Study period				
	Enrollment	Allocation	Post-allocation		
Timepoint	-t	-t	t_0+t_1	t_2	t_3
Enrollment:					
All ECEC staff	X				
Information	X				
Allocation		X			
Interventions:					
PSECEC			←	—	→
Control			←	—	→
Assessments:					
Baseline			X		
Midway				X	
Follow-up					X

Fig. 1. Schedule of enrolment, intervention, and assessments.

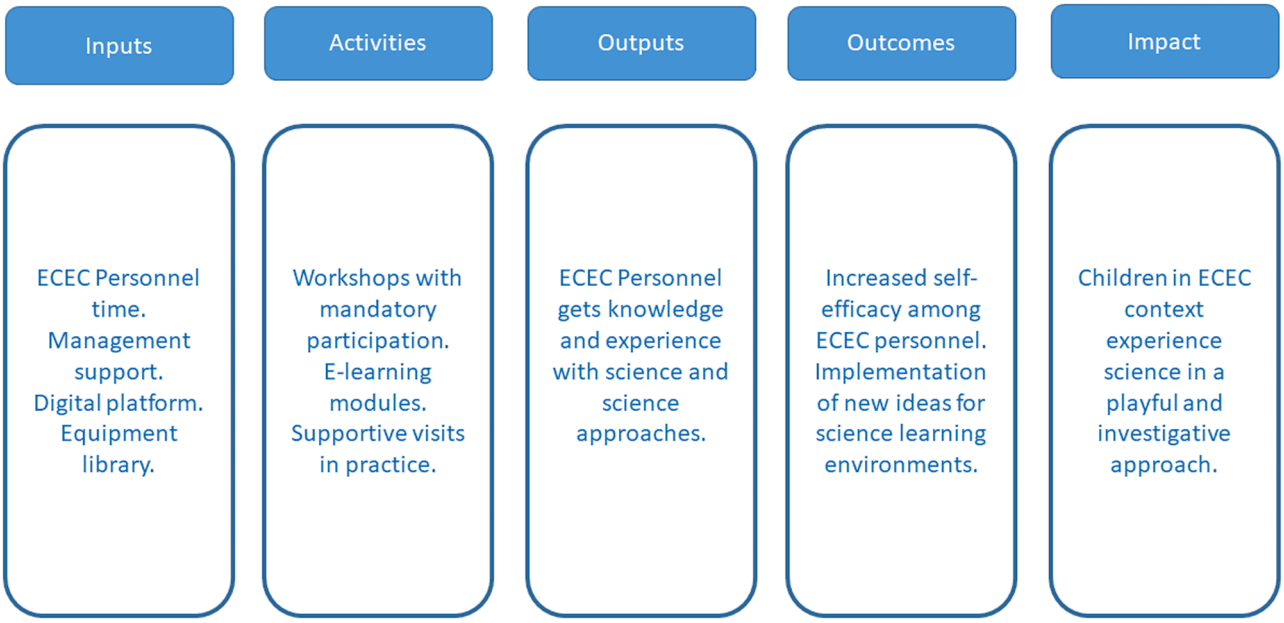


Fig. 2. The logic model for Theory of change in the PSECEC intervention.

PD for all ECEC personnel in the municipality. The PD intervention (see 2.2.3 for an outline of the PD intervention) is supported by local management. Additional input is a digital platform providing learning support through workshop materials and e-learning modules, practical experiences from the staff (see 2.2.2 for an outline of the development of this input). Alongside these inputs, the municipality builds an equipment library in each institutional area ($n = 17$) with a broad spectrum of science and technology equipment aimed at the ECEC context. The ECEC personnel can borrow materials like robots, digital microscopes, large-scale marble runs etc. for a limited time span. The inputs support the activities in the PD in that all digital materials become available in the digital platform. These materials are used in the workshops and underpin the supportive visits between the workshops. The digital platform also opens the possibility for ECEC staff to report and distribute their experiences from practice to other staff via a discovery room. In all, this supports the underlying assumption, that the output of ECEC (i.e. having more knowledge and experience with science and science approaches leads) to the outcome of increased self-efficacy towards science approaches in the pedagogical work with the children in the ECEC context.

Developing the intervention

The content and structure of the PD program is developed during a 10-month pilot phase as co-creation between a core team of professional developers and ECEC staff from the field of practice. The pilot phase is ongoing. The core team consists of eight teachers and researchers, from a university college early childhood care and education bachelor degree programme, specialized in early childhood science and mathematics teaching, general pedagogics, child perspectives, as well as adult training in the field. The team is further strengthened by participation of 18 ECEC practitioners, who are freed up from their daily work for 25 h to participate in the development of the intervention. This composition of the development team was chosen to ensure a good fit of content and framing of the intervention to the field of practice and to ensure participant involvement as the first part of a cultural change (Vujičić & Čamber Tambolaš, 2017).

The pilot phase consists of iterations of workshops and joint fieldwork to produce the PD program making up the total intervention with online learning sessions, workshops with physical participation as well as supportive visits from the PD teachers (Fig. 3). In the pilot phase, the core team and the practitioners meet in a total of eight three-hour development workshops.

At the end of the development phase the content and form of the PD is tested by the developmental team in the respective institutions of the practitioners in the team, and subsequently finalized for implementation for all ECEC staff in the municipality (PSECEC intervention). The set-up is inspired by the model of teacher professional growth (Clark & Hollingsworth, 2002), and also addresses findings from PD programmes specifically aimed at ECEC staff (e.g., Barenthien et al., 2019, 2020; Vujičić & Čamber Tambolaš, 2017).

The development workshops are each focused on 1) how to practice science, 2) how to support the language around science and technology, 3) playful approaches, and 4) scientific content. Within the *how to practice science* focus area, the development team work with practices that are present when doing science in ECEC (Haug, 2021). Scientific

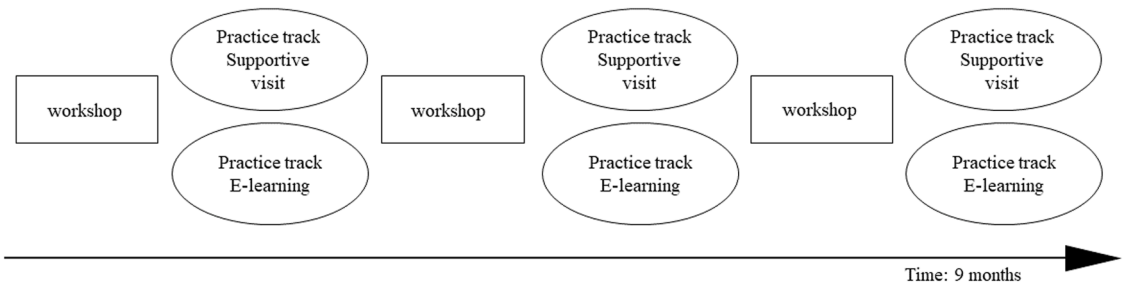


Fig. 3. A structural overview of the PSECEC intervention.

practices are introduced to clarify the more general concept of enquiry. The purpose is to contribute to a common understanding of what scientific practices are and how ECEC-staff can establish scientific environments in ECEC that supports the children in doing scientific practices. The science practice cards developed by Ahrenkiel, Petersen and Jørgensen (2023) for use within the Danish ECEC covers eleven science practices within three domains: four enquiry practices, four practices with (body) language and three practices with early mathematical awareness. The cards are used to examine ECEC environments for science practices and further development of practices.

The second focus area *how to support the language around science and technology*, is an area of particular attention within the participating municipality. Although children acquire language by interacting with each other, adult involvement scaffolding the child's learning is also a source for language learning. We utilize Markussen-Brown et al.'s (2020) 12 language strategies to work with ways ECEC staff can support children's language development. An example is the *advanced and nuanced language* strategy, which is used when naming objects or using and describing words the children do not know, such as naming a pipette or ladybugs, or describing friction. Another example of a language strategy is *asking open questions* where ECEC-staff ask questions like, 'How can you figure out why the water disappears?' which afford the children to give in-depth answers.

In the third focus area of *playful approaches* is closely linked to the national ECEC curriculum, where ECEC-staff should promote children's wellbeing, learning, development and formation through safe and pedagogical learning environments, where play is essential and where child perspectives are the point of departure. (Ministry of Children & Education, 2020). Hence, a given scientific environment in ECEC should include a playful approach. Here we draw on moods of play and play practices, with four play moods: devotion, intensity, tension and euphoria (Karoff, 2013; Skovbjerg, 2021). Play mood is created when we engage with the world, e.g., science and technology, during play practices. Play practices are further unfolded into play qualities (Skovbjerg and Jørgensen (2022), which can be used to focus on children's actions in playing with science and technology.

For the fourth and last focus area of *scientific content* a preliminary taxonomy of children's, encounters with natural phenomena in ECEC is developed, inspired by Lindhardt, Andersen & Pedersen, 2013). In this, there are continuing discussions on if and how content specific science content is connected to the three other focus areas (i.e., practice, language and play), and as such the PD program needs to address these three areas in order to provide relevant science content for the workshops. This could be e.g., friction where the children can practice and play with the playground slope, and ECEC staff can use terms like friction, inclination etc. in talking with the children about the science content.

The PSECEC intervention

The PSECEC intervention consists of a nine months long professional development program with an interchange between three e-learning modules and three workshop. Furthermore, each ECEC assigned a specific support person, who makes supportive visits between the workshops.

The PSECEC intervention balances effort and time in a blended learning setting, with three physical three-hour workshops and three online learning sessions. Between each workshop, there is a supportive visit in practice to facilitate implementation of content from the workshops.

Fig. 3 shows the structure of the PSECEC intervention. The same structure is repeated for the control group in the second run.

Each workshop is 3 h with approximately 100 participants. The e-learning modules are completed individually by ECEC staff. Between workshops, each ECEC will receive a two-hour supervisory visit to support professional development. The daily leader of the ECEC sets the theme for each supervisory visit to enhance development as much as possible. In that way the supportive visit is flexible and tailored to each ECEC needs. Theoretically, the intervention builds on experience from in-service teacher training indicate that teachers use e-learning modules on domain specific content of science on their own while e-learning modules on pedagogics and didactics often is used in groups (Madsen, Buus, Petersen & Staadsen-Boesen, 2020). It is a hypothesis that the same is due to ECEC-staff, but literature is not well established in this field.

The detailed content of the PSECEC intervention will be described in later publications as the pilot phase is not yet completed.

Participants are allowed to receive any other professional development offered to all ECEC staff in the municipality during the trial (i.e., ECAU). If a participant decides to change employment to outside of Odense Municipality or to a position within Odense Municipality with an occupational title not included in the trial, the intervention will be discontinued.

Education and care as usual

Participants in both the intervention and control group are allowed to receive any professional development offered during the trail. The ECAU offer different kinds of professional development through conferences about science and technology, collaboration with learning consultants in relation to technology and ECEC-staffs participation in other development project in relation to science and technology. It is up to the individual ECEC which, if any ECAU they participate in. Hence, the professional development is decentralised in the municipality as a range of offer.

Procedures and randomization

We will recruit 1456 ECEC staff employed in the 122 day nursery and/or kindergarten centres in Odense Municipality,[1] who will be participating in the mandatory profession training program PSECEC. The randomization will allocate approximately 61 centres to the first run of PSECEC and approximately 61 to ECAU continuing on to the second run of PSECEC. The flow chart is presented in Fig. 4.

The day nursery and/or kindergarten centres are organized in geographical areas, which covers four to 10 centres. Centres in geographical areas with seven or more centres will be allocated equally to PSECEC (the first run) and ECAU (the second run and control group during the first run) within each area. Centres in each of the four smallest geographical areas will be allocated as a group to either PSECEC or ECAU. The latter will give a slight, and at this point unknown, difference in the number allocated to the two groups. Allocation to the two groups is blinded to the allocator conducting the randomization.

Randomization to the intervention or waiting-list control condition is done at the day nursery and/or kindergarten centre level in a ratio of 1:1 to either PSECEC or waiting-list. Randomization is performed by an independent researcher (EEE), who has no practical involvement in the trial, using anonymized lists of geographical area IDs and day nursery and/or kindergarten centre IDs. Randomization lists are stored in a secured, logged drive. Allocation is performed in the following way: Within each geographical area the day nursery and/or kindergarten centres are randomized to either intervention or wait-list. Each day nursery and/or kindergarten centres is given a unique ID and allocation will be conducted using a random number generator (random.org). For each geographical area, a list of 0 s and 1 s (matching the number of day nursery and/or kindergarten centres in the geographical area) is generated to determine whether the day nursery and/or kindergarten centre is allocated to intervention or the waiting-list group. 0 indicates wait-list and 1 indicates intervention. For practical reasons the four

[1] As of April 2022, 1456 ECEC staff were employed, so this is the number we took departure in for the protocol. New staff numbers will be obtained prior to baseline measurements.

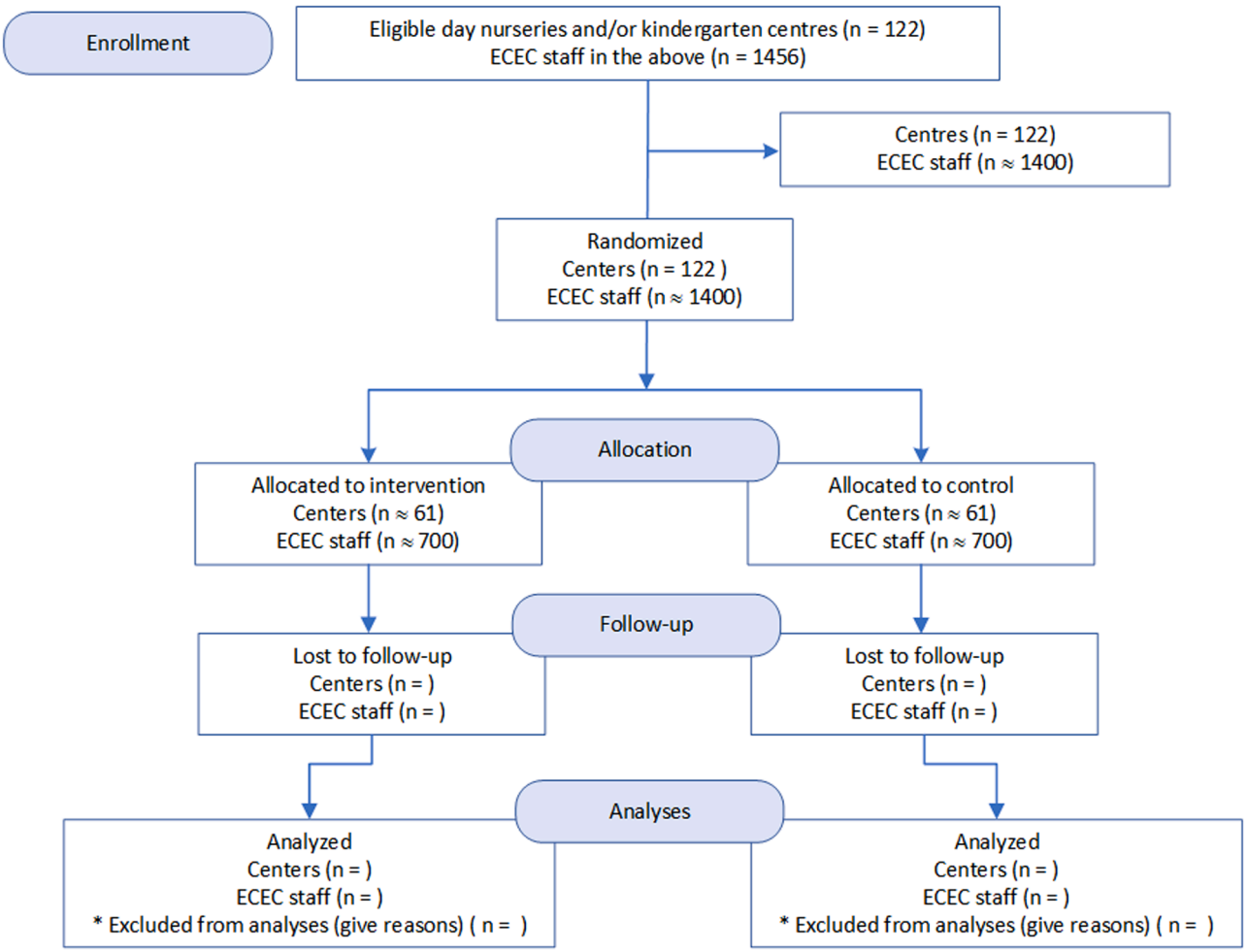


Fig. 4. Study flow chart.

smallest geographical areas will be randomized at the area level as they have few day nursery and/or kindergarten centres. A random list of numbers from 1 to 4 will be generated to determine whether the geographical areas is allocated to intervention or the waiting-list group. Even numbers indicate intervention and odd numbers indicate control. All number generations will be documented by a time stamp.

Participants will be informed via their daily leader whether they partake in the first or second run of the intervention, and that they will be asked to complete three questionnaires, one prior to the first run, one halfway through and one after the first run, and this whether they get the intervention in the first or second run. Baseline data will be collected after allocation, but before the intervention period for the first run begins.

The study has no trial steering committee or data monitoring committee as this is not required for behavioural interventions (Sydes et al., 2004).

Blinding

As the participants will be allocated to receive training in either the first or the second run, they cannot be blinded to allocation. When data is extracted for analyses the intervention and control groups are given two different colour names in the data system to conceal group allocation to the data analyst.

Data collection

Data are collected through online surveys at three time points: T0: baseline immediately before the intervention starts, T2: midway through the intervention after 4.5 months, and T3: when the intervention is completed after 9 months. The baseline questionnaire at T0 includes questions about educational background, occupational title and years of professional experience in the field.

Data are collected through a secured online survey database (SurveyXact), which is hosted at Fuzion in Aarhus, Denmark. A research assistant will monitor the data collection process at all three collection time points, and administer reminders every three days within each two-week data collection period. Data will be transferred to secure servers hosted by UCL University College [UCL Erhvervsakademi og Professionshøjskole]. The trial statistician and principal investigator (TN), the co-PIs (MRP and LA) will have access to the full dataset. We do not collect any biological data.

Measures/outcomes

Socio-demographic measures assessed at T0 include staff's educational background, occupational title, years of professional experience in the field, gender identification and age.

Baseline measures

In addition to the socio-demographic measures, we include the following measures at baseline to assess the initial level and to account for them as possible moderators in the effect analyses.

Expectancy-value Motivation for Engaging in Professional Development in Science (EMEPDS) is a 3-item measure of **motivation for professional development**. The EMEPDS was adapted to the target group from the Expectancy-Value-Cost Scale for students (Kosovich et al.,

2015). The three items are summed and the score range is 0–6 with high scores indicating higher motivation.

Science Capital for Professionals Inventory (SCPI) is a 49-item measure of **science capital**. The SCPI was adapted from the STEM Capital questionnaire developed from the ESRC-funded ASPIRES study at University College London (https://www.ucl.ac.uk/ioe/departments-and-centres/departments/education-practice-and-society/aspires-research) designed for adult higher education students to achieve questions aimed at professional early childhood educators and carers. For the Attitudes towards Science subscale, some items were also adapted from the Science attitude scales developed by Francis and Greer (1999) and Oon et al. (2019). The SCPI consists of five single item questions and three subscales: the Attitudes toward Science Scale (ASS), the Engagement with Science in the Work context (ES-work) (c.f. section 5.2.3 for details), as well as the Engagement with Science in the non-work context (ES-life) consisting of 17 items varying content and response scales, with a total score range is 0–36. Each subscale is scored by summing the items and higher scores indicate more positive attitudes or higher engagement. The SCPI is scored by summing the three subscale scores and the single items to a score ranging from 0 to 100. Higher scores indicate higher levels of science capital.

Primary outcome

The primary outcome is **science self-efficacy** measured by the Self-Efficacy for Science Approach (SESA) scale. The scale is a measure of profession-specific science self-efficacy in early childhood educators and carers. The scale has been developed for purpose with a basis in the National Strengthened Pedagogical Curriculum (Ministry of Children & Education, 2020). The scale consists of 21 items with profession-specific science-related activities. Participants are asked to rate their level of confidence in performing each of the activities using a four-point response scale: entirely confident (3), somewhat confident (2), not very confident (1), very insecure (0). Scores are summed to a total score ranging from 0 to 63 scale points, with higher scores indicating higher levels of self-efficacy.

Secondary outcomes

Attitudes toward science will be measured by the Attitudes toward Science Scale (ASS) from the SCPI (c.f. Section 2.5.1). The ASS consists of 10 statement items, five of which reflect general attitudes towards science, while the remaining five reflect attitudes towards science specifically with the ECEC context. The statements are rated according to whether they reflect the respondent's attitudes, using a three-point response scale: yes, definitely (2), partially (1), no, not at all (0), resulting in a total score range of 0–20.

Engagement with Science will be measured by the Engagement with Science in the Work context subscale (ES-work) from the SCPI (c.f. Section 2.5.1). The ES-work scale consists of 17 items varying content and response scales. The total score range is 0–36.

Science approach behaviours in the pedagogical work with the children will be measured by the Practicing Science Scale (PSS). The PSS assesses context-specific ECEC staff behaviours indicating a pedagogical approach implementing the National Strengthened Pedagogical Curriculum objectives with regard to science and technology (Ministry of Children & Education, 2020), and it was developed for purpose from the national curriculum objectives. It consists of 5 self-reported behaviour items, which are rated according to how often the staff member engages in this behaviour in his/her pedagogical work with the children using a four-point response scale: never/almost never (0), monthly (1), weekly (2), daily (3). Item scores are summed to a total score ranging 0–15. Higher scores are associated with behaviours more indicative of a science approach.

Administrative data

For both PSECEC and ECAU centres, we will also collect municipal data on which other professional training they have been offered during the intervention.

Sample size and power

Power analysis was carried out in the design phase to assess whether we would have sufficient power to detect even small effects with the available number of clusters (122 day nursery and/or kindergarten centres) and ECEC staff in these (n = 1456). The power analysis assuming a statistical power of at least 80%, a critical level of 5%, and an intraclass correlation no greater than 0.1, showed we would be able to detect a standardized effect size of 0.22.

Data analysis

Preliminary analyses

In order to obtain equidistant person scores/estimates of the primary and secondary outcome scales and ensure that subgroups of participating staff in the RCT can be compared unbiasedly on these, we will use the Rasch model (Rasch, 1960) and graphical loglinear Rasch models (Kreiner & Christensen, 2007), as the latter can adjust scores for any uniform local dependence between items as well as any uniform differential item functioning (e.g., across genders, occupational title, professional experience in the field, etc.), by including interactions (Kelderman, 1984, 1997). In line with Comins et al. (2019) and Nielsen et al. (2022), we will conduct item analyses on baseline (t0) data and then test the fit to the resulting model also with the end (t2) data (c.f. Table 1). Reliability of the scales will also be assessed. The resulting scale scores/estimates will be used in the primary and the secondary effect analyses as described in Sections 2.7.2 and 2.7.3.

Primary effect analyses

The effect of the intervention on the primary outcome of ECEC staff's self-efficacy for science approach will be assessed with change scores calculated as the standardized effect size (ES), either as the difference between the intervention and the control group scores relative to the standard deviation of the pooled data (i.e. Cohen's d) or in case of relevant differences in the standard deviations of the two groups as the difference in their scores over the standard deviation of the constrol group (i.e. Class'Δ) (Lenhard @ Lenhard, 2016). In addition, we will perform subgroup analyses using multivariate analyses of variance to examine potential differences if the effect for subsets of participants. Hence, we analyse subgroups according to the following characteristics: motivation for professional development in science at baseline (median-cut low versus high), level of science capital at baseline (median-cut low versus high), initial general and ECEC context-specific attitudes towards science at baseline (midpoint-defined dismissive versus positive), occupational title (pedagogues, assistants, assistant teachers, daily leaders), years of professional experience in the field (median-cut short versus long).

The primary analysis will be based on the intention-to-treat (ITT) principle, aiming to include all participants in the arm they were

Table 1
The timing of the administration of measures.

		T0	T1	T2
Measures				
Socio-demographic information	Age, education, etc.	√		
Science capital for professional	SCPI	√		
Motivation for professional development in science	EMEPDS	√		
Self-efficacy for science approach	SESA	√	√	√
Attitudes toward science	ASS	√	√	√
Engagement with science in the work context	ES-work	√	√	√
Science approach behaviours				√

originally allocated to irrespective of the amount of treatment received. Missing data is handled using multiple imputations using all available baseline data. Analyses to determine whether missing data is missing completely at random (MCAR), at random (MAR) or not at random (NMAR) will be performed to determine whether attrition bias is an issue needing attention.

Secondary effect analyses

The effect of the intervention on the secondary outcomes of attitudes towards science and engagement with science in the work context, will be assessed in the same manner as the effect on the primary outcome (c.f. Section 2.7.2), except that subgroup effect will only be examined for motivation for professional development in science at baseline (median-cut low versus high).

The effect of the intervention on the secondary outcome of science approach behaviours will be assessed using again standardized effect sizes (ES), but in this case calculated as the difference between the intervention and the control group scores relative to the standard deviation of the pooled data/the standard deviation of the control group using only end data, as this is only measured at the end of the intervention. Subgroup analyses will be conducted as was the case with the primary outcome effect (c.f. Section 2.7.2).

Decision level

Two-sided tests are applied throughout, and as recommended by Cox et al. (1977), we do not apply a critical limit of 5% for p-values as a deterministic decision criterion. Instead, in line with Poulsen et al. (2018), we distinguish between weak to moderate evidence against the model (in item analyses) or against the null-hypothesis of no difference (in primary and secondary effect analyses) when p-values were larger than 0.01, and stronger evidence when p-values were lower than 0.01.

We do not expect that participants will be harmed by the study, and therefore have no predefined stopping guidelines.

Software

Rasch and Graphical loglinear Rasch modelling will be done using the DIGRAM software package (Kreiner, 2003; Kreiner & Nielsen, 2013, 2023). SPSS will be used descriptive analyses and evaluation of attrition bias. Effect sizes will be calculated using Lenhard and Lenhard's (2016) calculators.

Discussion

There are no previous studies on the effectiveness of professional development in science for ECEC staff within the Danish context. Hence, we rely on international research in the development of the intervention (c.f. the previous sections). We are aware that conclusions from these contexts might not be fully applicable to the Danish ECEC context due to cultural and curricular differences. Experiences from previous professional developmental programs consisting of e-learning modules, respectively workshops have been positive, and thus we expect the current design, which includes both to be effective. The participants cover four categories of ECEC staff in the Danish context and comprise all staff in these categories in the municipality.

In conclusion, this is a protocol for a trial aimed at assessing the effectiveness of a professional development program to improve early childhood educators' and carers' self-efficacy for science approaches, engagement with science, and attitudes toward science in ECEC to ultimately provide all children in municipality day nursery and/or kindergarten centres enhanced educative and playful experiences with science. We expect the results to add to the literature on professional development in science and provide useful evidence for future geographical expansion of professional development of ECEC staff in the field of science, as well as professional development within the field of science for other groups of educators.

Trial status

This is the first version of the protocol. Randomization is planned for January 2023, and the first run of the intervention starts in September 2023. Data collection starts in September 2023 and is expected to be completed in May 2024.

Protocol amendments

Amendments and changes will be transparently described in the publications following the trial.

Dissemination of results

Study results will be published in peer-reviewed papers and presented at relevant national and/or international conferences. Authorship will follow the Vancouver guidelines.

Declarations.

Ethics approval and consent to participate

Institutional review board approval was obtained from UCL University College. Written and oral information is given to participants.

Data availability

The minimal datasets needed to replicate our analyses will be made available to researchers in anonymous form through a data depository, once the study is completed and published.

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Authors' contributions

MRP obtained the funding. TN, MRP and LA developed the initial study protocol. TN, MRP, LA and MP contributed to the design of the study. TN, MRP and LA contributed to recruitment and data collection. TN provides statistical support for the project. TN, MRP, LA and MP wrote the first draft of the manuscript. All authors critically revised the manuscript and read and approved the final version.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijedro.2023.100268.

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