

Insights Into a New Format of Education for Sustainable Nutrition in Teacher Education

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Abstract

Education for sustainable nutrition will only succeed if society is given direct access and experience to the obvious benefits of a sustainable lifestyle. An earlier personal and positive association to a sustainable lifestyle makes a dietary shift most likely. Here, the training future teachers plays a central role as a multiplier.

Project-based learning (PBL) is a well-known approach with the purpose of crosslinking theoretical knowledge with real-life practice. Despite many existing PBL approaches, there is a gap of conveniently applicable and easily transferable approaches for ensuring their sustainable integration into teacher education. This study aims to fill this gap by exemplarily leading students to experience edible plant diversity in urban environments via action-oriented learning and out-of-school learning places.

The present study outlines the methodological and didactic process and the practical implementation of an innovative sustainable approach of PBL for education for sustainable nutrition in the curriculum of teacher education. The results are discussed on the basis of student feedback and the evaluation of the recent course conducted in 2022 at the Technical University of Berlin. Measured by the outcome of the course, the new concept applied here has a personal impact by that having the potential to facilitate a more sustainable approach of nutrition in our society.

Keywords: Education for sustainable nutrition, project-based learning, sustainable development curriculum, teacher education.

Introduction

Education for Sustainable Nutrition Exemplified by Edible Plant Diversity in Cities

Climate change, loss of biodiversity, food scarcity, and waste are interwoven growing challenges for the human and animal population. A more sustainable lifestyle can help effectively use the resources being available and reduce the overall consumption. Prior to any change, awareness needs to be raised in the first place. The best way to promote the awareness of something that has become unsustainably and destructively “normal” is to teach people (Goller & Rieckmann, 2022).

To ensure a progressive discourse about sustainability, education forms the basis, and well-trained teachers function as change agents to accelerate the food system transformation. To achieve this aim, teachers are required to address sustainability related issues and gain the necessary competencies during their studies (UNESCO, 2024). However, there is a lack of meaningful evidence regarding the actual effectiveness of approaches to teaching education for sustainable nutrition in a sustainable way at school. Furthermore, sustainable issues are struggling to find their way in teacher education (Pegalajar-Palomino et al., 2021). To integrate sustainability, such as education for sustainable nutrition, into teacher education, an interdisciplinary topic with creative elements is a promising way (Carrasco et al., 2018). However, there are no systematic instructions to combine teacher education, future teaching, and the personal lives of future teachers in a consistent and harmonic way (Zhang, 2013).

To make sustainability and nutrition more digestible for future teachers, an approach was taken that was literally right before our feet: Edible plants in cities. By training teachers in specific areas, they will be able to transfer their skills to other areas in order to provide a holistic education (Echegoyen-Sanz & Martín-Ezpeleta, 2021). Future teachers are provided with theoretical knowledge about urban plants and are working in groups in self-determined directions to openly explore their project aim. Utilizing this approach, the students have a direct physical contact with nearly omnipresent plants and are provided with knowledge to effectively use resources provided in a sustainable way. Fundamentally, this encourages the future teachers to reflect where food is sourced from, what food is, and that alternative and sustainable sources do not downgrade taste experience. This makes it easier to accept and implement changes according to a sustainable nutritional lifestyle (Esteve-Guirao et al., 2022).

Future teachers are provided with a low threshold introduction to ultimately see what a sustainable nutrition can look like in real life. Although edible plant diversity in cities is a vast and interdisciplinary topic (Fischer et al., 2019) that can be an attractive and helpful tool to introduce students and people to sustainable nutrition, most people today lack knowledge about the tasty leaves, stems, flowers, and fruits (Carvalho & Barata, 2016). The present study aims at filling this knowledge gap.

Project-Based Learning Including Out-of-School Learning Places and Action-Oriented Learning (PLOLAL)

Due to climatic and economic changes globally and the relevance of social dynamics, educational approaches should be continuously reviewed and modified to be most effective for students. In this context, the linkage between theory and practice is often postulated as necessary but this is actually a huge challenge in teacher education (Risan, 2020). To overcome this obstacle, future teachers have to be sensitized during their studies and need to learn how to deal with a continuously varying “new reality” in schools by gaining their own experience (Gudjons, 2008). In other words, student-centered educational approaches that foster lifelong learning should be prioritized in teacher education (Islam et al., 2022). However, there is a general lack of studies on the effectiveness of practice linkage (Pohlenz & Boetcher, 2012). Hence, detailed studies on the content and the teaching and learning process of practical courses are needed (Baysura et al., 2015).

Nevertheless, project-based learning (PBL) is one of the most common highly effective approaches in this area (Fang et al., 2023) with a student-centered perspective and a dynamic teaching concept (Abandt et al., 1998). In PBL, the intention is to design

learning processes so that students in school as well as future teachers in their studies are actively involved in finding answers for and by themselves (Baysura et al., 2015; Guo et al., 2020). This allows students and future teachers' potential to be enfolded, which consequently increases motivation, promotes independent learning, and enhances critical thinking in a sustainable way (Ab Wahid et al., 2020; Stehling & Munzert, 2018). Next to self-responsible problem-solving, PBL promotes collaborative learning and, therefore, broadens learners' experiences (Vogler et al., 2018).

Overall, the interest in PBL is high since it has a wide range of applicability in teaching. However, there are different kinds of hurdles: there is a lack of skills in managing this approach, leading to difficulties in implementation in daily teaching (Alrajeh, 2020; Islam et al., 2022). Other studies came to similar conclusions by showing that teachers faced multiple challenges, such as a lack of knowledge, limited skills, corporate experience, and unawareness of their changing role (Liu, 2019; Baysura et al., 2015). One way to counteract the latter challenge is the transformation of the teachers' role and the corresponding practical experience at an earlier stage: already in the teachers' education studies (Liu, 2019). However, this raises several other issues. According to Savin-Baden (2007), it is usually challenging to implement PBL in the curriculum because hands-on and student-centered inquiries have to be central to a holistic learning approach (Savin-Baden, 2007). In addition, universities' conventional, mostly rigid, structures are not supportive of PBL approaches. These structures hinder students and lecturers from integrating student-oriented topics into their studies (Grützmacher & Willige, 2016).

One approach might be to combine PBL and out-of-school learning because there is a positive connection between the teacher's affinity with nature and the application of modern teaching approaches in the curriculum (Anđić & Mažar 2023). The term "out-of-school learning" includes all places outside the classroom or campus that stimulate, enhance, or smooth learning processes in students (Somrei, 1997). Here, "action-oriented learning" (KMK, 2021) can play an important role.

To sum up, following the idea of sustainability, sensitivity in personal and social interaction and environmental awareness should be taught at out-of-school learning places based on the principle of complete action in PBL already during studies and should play a central role in modern teacher education – especially in an applicable sustainable way.

Research Question

How can a course for future teachers be designed (1) to crosslink theory and practice for integrating sustainability topics and (2) to enable the students to build up competencies in education for sustainable nutrition?

To answer this question, this article aims to design and evaluate the implementation of a new course format, which utilizes project-based learning, including out-of-school learning places and action-oriented learning (PLOLAL), in teacher education in the field of education for sustainable nutrition demonstrated by edible plant diversity in cities.

Method

PLOLAL: Method of the New Course Format in the Curriculum

As there is no uniform definition of what PBL includes, this paper uses three PBL designs as outlined in Table 1 (PBL A–PBL C). In general, these PBL approaches include

five to six stages. However, every approach is missing one different stage (see 'x' in Table 1). To create the new introduced PLOLAL (see Table 1, PLOLAL row), these PBL approaches were merged with action-oriented learning based on the German principle of complete action (see Table 1, German principle of complete action row) and out-of-school learning places (see Table 1, Out-of-school learning places row). Now the new introduced PLOLAL approach integrates all six stages.

Table 1

Stages of PLOLAL: Merging the Stages of Three PLB Approaches with the German Principle of Complete Action and Out-of-School Learning Places. x – stage does not exist.

Approach	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Reference
PBL A	Preparation	x	Topic Definition	Creation and Test	Presentati on	Evaluation	Nilsook et al., 2021
PBL B	Selection	Modification	Dis-solution	Implemen-tation	x	Evaluation	Zhang, 2013
PBL C	Organi-zation and Information	Planning	x	Implemen-tation	Presentati on	Evaluation	Bron & Barrio, 2019
German principle of complete action	Information	Planning	Decision-making	Implemen-tation	Control	Reflection	KMK, 2021
Out-of-school learning places	Information	Organization	x	Implemen-tation	x	x	Freericks et al., 2017
PLOLAL	Organi-zation and Information	Planning and making	Decision-	Develop-ment	Presentati on	Evaluation	

To ensure that PLOLAL innovative approach is sustainably accessible to other universities, the five stages of PLOLAL are explained below.

1. Organization and Information

The starting point is a set of problem-oriented scenarios. The aim is to promote students to perceive learning and knowledge as flexible and individual entities. To achieve this aim, students learn and inform themselves by self-research about a specific and self-determined topic chosen under the guidance of the teacher.

At this stage, already subject-related practical excursions to out-of-school learning places play a crucial role in understanding the theory in a practical and issue-centered way. At the end of this stage, students formulate specific working hypotheses for edible plant diversity in cities.

2. + 3. Planning and Decision-making

In groups, students choose and plan their specific project topic by identifying aims and assignments. Students are inspired to make their own decisions by scheduling their workload and their didactic and subject procedures. If necessary, the teacher supports,

but the authors expect that the motivation is even higher when students organize and finally decide themselves.

4. Development

This stage is characterized by performing the formulated assignments. Students develop educational materials suitable for practical use in potential school lessons. This stage takes the longest time in the PBL process. Here, the focus is primarily on working in groups. The novelty is that weekly presentations, including an evaluation and feedback loop of the current status, regress and progress, challenges, and new opportunities of the project take place. This enables critical reflection, problem-solving, communication, and by that an improved learning processes and self-determination.

5. Presentation

The groups present their final project outcome: they review their original plan and aims, compare these with their final results, explain the challenges and strengths and reflect on the overall process.

6. Evaluation

Finally, the groups and the teacher give feedback on the final project outcome. They reflect on the entire PLOLAL process in plenary, oral, and anonymously written form.

Implementation of the New Course Format in the Curriculum

The presented PLOLAL method (see above) was performed in the course at Technical University of Berlin (TUB) in the winter semester of 2022. Table 2 shows an overview of the implementation of the course in the curriculum of TUB.

Table 2

Overview of the Implementation of the Course in the Curriculum of TUB

Topic	Way of implementation
Location in the curriculum	Free choice module in respective studies program (Bachelor's and Master's degree)
Structure	12 x seminar lectures, 3 h weekly
Number of students	30 students
Examination performance	Portfolio: - 50 % oral presentation - 50 % developed educational material
Material outcomes	Educational materials in the field of education for sustainable nutrition
Aims	To develop a basic understanding and awareness and gain associated competencies for sustainable behavior around the topic of biodiversity, regionality, seasonality, and its interactions (topics of education for sustainable nutrition)
Method	PLOLAL

There were twelve seminar lectures for three hours a week. It was a free choice module, i.e., Bachelor and Master students each grade level had the choice to

participate. The maximal number of participants are 30 students in free choice modules at the TUB. In the presented course, the maximal number of students was reached and all of the students finished the course by completing the examination. Here, it was a portfolio examination, which included creating an educational material (50 %) and oral presentation about the created individual educational material (50 %). As the students worked in 3-person groups, ten different sets of educational material in the field of education for sustainable nutrition were developed. Twenty-three Bachelor students (grade 1–6) and seven master students (grade 1) participated in this course. Students from any study program can participate in the module because it is a free choice module and there is no prior knowledge mandatory owing to the interdisciplinary subject area. This time, all Bachelor students and five Master students studied the school subject called “Economy-Work-Technology”, one Master student studied the subject on nutrition and one Master student studied the subject on food technology. The sample fitted to the aim of the presented course to create a basic understanding and awareness and to gain associated competencies for sustainable behavior around the topic of biodiversity, regionality, seasonality, and its interactions by using the introduced PLOLAL method.

Table 3 outlines the lecture schedule of the presented course, including the stages of the PLOLAL approach and their aims. The stages of PLOLAL are arranged according to the lectures and the topics addressed.

Table 3
Lecture Schedule of the Conducted Course at TUB in 2022

Stage	Lecture	Aims
Organization and information	1–3	- Theoretical input (education for sustainable nutrition and edible plant diversity in cities) - Practical input (visiting out-of-school learning places to regional wild herb walks in cities, excursions to publicly accessible parks, forests, and gardens)
Planning and decision-making	4–5	- Group organization, group-based activity and time planning - Decision-making of specialist focus and type of educational material (educational video, cartoon, photo series, podcast...)
Development	6–10	- Project development in groups with weekly presentations on the current status, evaluation, and feedback loops
Presentation	11	- Presentation of the final project results (material outcomes)
Evaluation	12	- 1st evaluation: written; official, anonymous, and free - 2nd evaluation: oral discussion about the course format

Evaluation of the New Course Format in the Curriculum

The course was evaluated in two ways:

(1) The quantitative evaluation was a written official standardized evaluation of the university in lecture 12. This evaluation is anonymous, free and identical for each seminar at the university. A total of 25 students completed this questionnaire. 21 questionnaires were completed in full and used for this article. On average, it took 35 minutes. The statements regarding the seminar are grouped in three headings: Subject didactic processing, didactic processing, and overall assessment. The specific statements are listed in Table 4. The students’ agreement regarding the statements was measured on a 5-point inverted Likert scale, using 1 as “agree” to 5 as “disagree”. The

evaluation was done by an internal university program and transferred to the course instructor after the end of the seminar.

(2) The qualitative evaluation included three interviews with three groups of the students who attended the course. In each group, there were three students. These three group interviews were conducted by the course instructor after the end of the course (in the period of 1–3 weeks after the course); participation was voluntary, not grade-relevant and lasted 30–60 minutes. Three identical questions were asked in each of the interviews:

- What is your opinion on the implementation of the PLOLAL method in the course?
- What is your opinion of the selected topic “edible plant diversity in cities”?
- Did you like this course?

Interviews were recorded. The results of the interviews were summarized in a written form. Quotes from these audio files were used for this article and presented in the Results and Discussion Section below.

Results and Discussion

Evaluation of the Implementation of PLOLAL in the Curriculum

The results of the course evaluation are summarized in Table 4. Overall, it became clear that students perceived the seminar as good (all mean values were between 1.24 and 1.95). Analogous to the qualitative study of AlRasheed and Alghamdi (2023), the positive ratings on the overall assessment are good (AlRasheed & Alghamdi, 2023). The students evaluated both the overall course ($M=1.48$; $SD=0.87$) (M being the mean value and SD being the standard deviation) and the learning outcome as good ($M=1.57$; $SD=0.68$). In the category “subject didactic processing” it can be observed that they experienced the learning atmosphere as appreciative ($M=1.24$; $SD=0.54$). These findings are in line with the statements about the time ratio of discussion and teaching performance ($M=1.57$; $SD=0.87$) and the proportion of student and teacher contributions ($M=1.48$; $SD=0.81$). This indicates that the methodological approach in PLOLAL worked efficiently.

The structure of twelve seminar lectures of the presented course, which includes the PLOLAL process, is mandatory at the TUB. Course duration was perceived adequate to experience the PLOLAL process in its completeness. To underline this finding, a student’s comment in the interview was: “We had enough time to work out the material.” Depending on the maximum number of seminar units, Stage 1 “Organizational and Information” could cover a larger scope (see Table 3). Regarding the integration of out-of-school learning places in this stage, we received similar positive feedback in the group interview analogous to Bürgener (2023) from students: “The visit to the herb garden influenced our initial idea greatly” and “After taking a city tour with Ms. [...], we got the idea to develop our own educational rally for children” (Bürgener, 2023). Thus, out-of-school learning places are useful for creating collaborations with real-life practice. Moreover, the integration of them in the first stage raises students’ interest and has a motivating effect. The students mentioned: “I especially enjoyed the excursions at the beginning of the course”; “The excursions helped us to better understand the issue of wild herbs”. This supports the statement that the practical application of out-of-school learning places generates an active attitude on the part of the students (Bürgener, 2023). Following Freericks et al. (2017),

now we consider that the following characteristics of out-of-school learning places are relevant by using the PLOLAL approach (Freericks et al., 2017):

- Authentic and real-life experiences;
- Participation with all senses in society relevant subjects;
- Independent awareness of and reflection on the local environment;
- Interdisciplinary learning.

The didactic approach at Stage 1 was successful, as implied by the statement on the development of new ideas and concepts ($M=1.62$; $SD=0.74$). This supports the required problem-oriented learning, which focuses on practical challenges (Reusser, 2005). Hence, we can confirm that the activity level in teacher education increases (Abandt et al., 1998).

The freedom of choice which material outcomes focused during Stage 2 “Planning and Decision-making” creates an environment that dissolves the regular study program (Kramer, 2020). In addition to the practical components, the general subject student-centered content was enhanced in the field of education for sustainable nutrition ($M=1.57$; $SD=0.75$). The chosen topic “edible plant diversity in cities” was therefore well introduced because students were able to prepare and structure it scientifically ($M=1.75$; $SD=0.79$) and were neither over- nor under-challenged.

Stage 3 “Development” and Stage 4 “Presentation” enabled the students to deepen their knowledge independently ($M=1.86$; $SD=1.15$), which was in line with the increase of professional knowledge ($M=1.38$; $SD=0.59$). In addition, the context corresponds to the students’ interests ($M=1.57$; $SD=0.75$). This target-oriented context ensures the success and anchoring of sustainability (Parinya et al., 2021). The students’ statements on the didactic preparation were also top-rated in broad terms. However, in comparison with other groups they were slightly weaker. For example, the teaching methods used could be applied in a more sensible manner ($M=1.95$; $SD=1.16$). Nevertheless, through the open exchange in this approach, students were encouraged to participate in discussions ($M=1.48$; $SD=0.93$) and to contribute freely to their own experiences and learnings ($M=1.48$; $SD=0.68$). This is similar to Almulla’s (2020) findings, where knowledge sharing, discussion and presentation promote engagement in the PBL approach (Almulla, 2020).

Stage 5 “Evaluation” encouraged the reflection of the course, including the specific topic and the PLOLAL method and the critical reflection of the topic ($M=1.76$; $SD=0.89$). This fits with the statement that the diverse student contributions enrich the content ($M=1.71$; $SD=0.72$). Following Cramer’s (2014) approach, we agree that reflection on the scientific theoretical context plays a central role in high quality courses (Cramer, 2014). Analogous to Jurs & Špehte (2021), giving feedback in courses is consistently positively highlighted by the students (student’s comment: “The continuous feedback among each other and from the lecturer encouraged us in our approach. However, it meant we had to change our ideas quite often.”) (Jurs & Špehte, 2021). This allows the teacher and the other student groups to learn about the current status of the group work and can support them as needed.

Two core characteristics of the course, the theory-practice linkage ($M=1.48$; $SD=0.75$) and the group work ($M=1.3$; $SD=0.47$), were perceived positively. This succeeded by the integration of out-of-school learning places as well as by the free design of the students’ project results ($M=1.43$; $SD=0.75$). One student commented: “The best part of the course was the group work. Working with peers helped me a lot both personally and professionally.” Another student added: “Yes, the group work and

the integration of out-of-school learning places were the best things of the course and I will recommend the course to my other friends as well."

Table 4

Results of the Evaluation of the Conducted Course at TUB in 2022

Topic	M	SD
Subject didactic processing		
I perceive the learning atmosphere as very pleasant.	1.24	0.54
I am able to increase my expertise over the specifications by myself.	1.38	0.59
I am encouraged to participate in discussions.	1.48	0.93
I feel free to contribute with my own input.	1.48	0.68
The contents to be processed correspond to my interest.	1.57	0.75
I understood the content taught well.	1.57	0.75
I can develop new ideas and concepts on the topic.	1.62	0.74
I can prepare and structure topics scientifically.	1.75	0.79
I study topics that I would like to explore in more depth on my own.	1.86	1.15
Didactic processing		
Design suggestions from students are addressed.	1.43	0.75
A theory-practice linkage is established.	1.48	0.75
The proportion of student and teacher contributions is balanced.	1.48	0.81
The time ratio of discussion and teaching performance is optimal.	1.57	0.87
The diverse student contributions are an enrichment with regard to the content.	1.71	0.72
Critical reflection on the subject is encouraged.	1.76	0.89
The teaching methods are used effectively.	1.95	1.16
Overall assessment		
I appreciate the implementation of the group work.	1.3	0.47
I evaluate the course as good overall.	1.48	0.87
I evaluate my own learning outcome as good.	1.57	0.68
5-point inverted Likert scale: 1= Statement applies; 5= Statement does not apply. n=21.		

Finally, in the qualitative evaluation of the course format, the students were explicitly asked whether edible plant diversity in cities was a fitting topic for education for sustainable nutrition: The fear of picking poisonous plants by mistake or of picking up pollutants or pathogens is quite high among students (student's comment: "I didn't know you could eat so many plants and they even taste good. Nevertheless, I am afraid of eating poisonous plants by mistake."). Thus, conscientious identification, collection, and processing of edible plants play an important role in this field of education for sustainable nutrition. Hereby the PLOLAL approach raises awareness and skills for regionality and seasonality by implementing out-of-school learning places (student's comment: "I will definitely go to parks more in the future and look for edible plants there."). This allows for a more effective use of domestic food resources among the

students (student's comment: "The homemade nettle tea tasted better than I thought and it was easy to make. I made a nettle-banana smoothie from the remaining nettles. I will definitely continue to do that."). In addition, self-awareness of sustainable behavior regarding personal (eating) habits and nature's resources was enhanced (student's comment: "I definitely walk through urban nature with open eyes now."). Buying, eating, and throw-away behavior are critically reflected (student's comment: "I will try to pick more fruits and herbs outside and not just buy everything in the supermarket."). In summary, education for sustainable nutrition exemplified by edible plant diversity in cities is accepted by students as a good option. These results are in line with the study of Ameli (2022) showing that personal interactions are essential for a sustainable lifestyle (Ameli, 2022).

Characteristics of PLOLAL

We define five characteristic features of PLOLAL in teacher education. These features merge the results of the qualitative evaluation and the characteristics of different PBL approaches (Abandt et al., 1998; Bereiter & Scardamalia, 2000; Nilsook et al., 2021; Mitchell & Rogers, 2019):

- **Out-of-school learning places:** Experiencing real-life situations is the starting point of PLOLAL. These places help students understand the context of the topic authentically. Then, these topics do not represent global, abstract goals for the students, but problems they face in their daily lives.
- **Theory-practice linkage:** Due to the theoretical disciplinary input of the teacher in combination with the practical experience of the same topic, the theoretical contents of the subject are treated in a more practical and student-oriented way.
- **Self-responsibility and self-control:** Students take responsibility and control for their learning. They need to be aware of what knowledge gaps they need to fill and what information they need to collect for answering project specific questions. This allows for a high level of identification with their own projects. Thus, learning takes place based on one's personal/individual experience, in a self-determined, flexible way.
- **Group work:** Working in small groups is a necessary tool for discussing individually identified issues and finding possible solutions as a team organizing together, sharing information, sharing demands, and giving/receiving feedback to each other develops social and personal competencies.
- **Reflection and feedback loops:** Through regular reflection and feedback loops, students' ideas and project implementation are continuously optimized and reflected upon. This enables the learning of a feedback and reflection culture.

Limitations

The small sample size confines confident and broad generalization. For this reason, this approach should be applied and replicated nationally and globally to other universities to validate the results and to demonstrate proof of concept. Another critical factor is that the implementation of this format in higher education requires competent lecturers, who can offer this practice to future teachers. This is linked to a change in thinking, acting, and an investment of time from a teacher's perspective. Nevertheless, the evaluation of the course and the oral feedback encourage integrating this approach into teacher education.

Conclusion

A sustainable nutrition can only be achieved when society is reframing the current concept of food supply. In the present approach, we are aiming at teaching teachers to effectively transform towards a more sustainable and extended sourcing of food preparation with a concept developed at the TU Berlin and applied at urban plant discovery as a guideline for future and further development of teaching settings. PLOLAL demonstrates high usefulness to the professionalization of future teachers. Using student-oriented topics in the field of education for sustainable nutrition students were willing to explore their environment with surprisingly impressive outcome. By collecting relevant competencies in their self-determined studies, they are able to disseminate them as change agents at schools in the future and support the dietary shift (Bedford, 2022). PLOLAL supports this process because of its specific and unique characteristics to promote the systematic transfer between university education and everyday work. According to the author, further research should be conducted, building up and modifying this approach by applying this concept to a wider range of teaching lectures in the curricula globally and providing an effective way to transform nutrition to a more sustainable one by means of education.

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