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Leveraging implementation science to enhance intensive longitudinal methods

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ABSTRACT

Despite extensive discussions in scientific literature regarding the design and analysis of intensive longitudinal method studies, the implementation of these methods remains underexplored. This work aims to bridge this gap by introducing implementation science in general and implementation mapping in particular as a systematic approach for implementing intensive longitudinal data collection in educational research. A practical example is provided to illustrate this approach. The advantages and disadvantages of implementation mapping for intensive longitudinal methods are also discussed. This study underscores the necessity for future research and the development of theoretical implementation frameworks tailored to the specific contexts of intensive longitudinal methods. We hope to facilitate the effective use of intensive longitudinal methods, such as diaries or experience sampling, in educational research.

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Intensive longitudinal methods; implementation science; data collection; diary; experience sampling; careless responding; implementation mapping

Introduction

The use of intensive longitudinal methods for analysing processes and clarifying causalities is becoming increasingly prevalent. Advanced technical solutions for complex data collections via smartphones and wearable assessment systems contribute to this development. In the field of education, learning analytics and the potential of explainable AI are among the key drivers for intensive longitudinal method studies. The design of data collection and the statistical analysis of longitudinal data in diary or experience sampling methods are well-described topics. However, the implementation quality of such complex studies in the field is neglected, especially when considering the maintenance of participant motivation as a predictive factor for careless responding (Hasselhorn *et al*. 2023). As early as 1990, David Farrington *et al*. (1990) wrote about data quality in longitudinal research:

> It is ironic that more books and articles have been written about technical problems such as sampling, research design, and statistical analysis than about practical problems that may be more difficult to solve and more important in their consequences for the validity of conclusions, such as tracing and securing cooperation. (p. 145)

More recent publications increasingly address the practical implementation of intensive longitudinal methods, providing recommendations based on practical experience (e.g. Arndt and Rose 2023). This study aims to propose a theory-based and systematic approach derived from

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implementation science for implementing intensive longitudinal methods focusing on educational research. Below, the meaning and relevance of intensive longitudinal methods for research in education is described. This is followed by a general introduction to the research field of implementation science and a more specific theory-based and systematic approach for implementing intensive longitudinal methods. Then, a practice example is used to illustrate the benefits of implementation science in implementing a diary study in higher education. Finally, we discuss the suggested approach.

Intensive longitudinal methods

Intensive longitudinal research designs aim to capture short-term dynamic processes (Martin *et al.* 2020). Such methods enable researchers to collect data in near real-time from individuals as they navigate their daily lives in the real world. Therefore, these designs are valuable tools for comprehending the variability in perceptions and experiences within individuals and how it relates to their context, e.g. their learning environment (Hektner 2018). Different intensive longitudinal methods and terminologies exist, including daily diary, experience sampling method, ecological momentary assessment, or ambulatory assessment (Walls and Schafer 2006, McNeish *et al.* 2021). Hektner *et al.* (2018) describe five dimensions for organizing different types of intensive longitudinal methods: content focus (experience, context, behaviour, or physiological functioning), perspective (self or observer), form of data (quantitative or qualitative), timing of data recordings (variable, fixed, event contingent, or continuous), and the role of the participant (active or passive) (for an overview please see Hektner 2018).

Although these methods can be categorized into different types of data, such as self-report data or data from wearable assessment systems (e.g. location data, accelerometer data; Nusser *et al.* 2006), they all result in a significant volume of data per individual, particularly when contrasted with conventional longitudinal designs for panel data, where each individual is assessed only a few times over an extended period. The greater number of data points per individual enhances the capacity to explore research inquiries centred on within- and between-person variability and offers avenues to examine the progression of within-person processes moment by moment, diverging from the typical emphasis on mean changes observed in panel data (McNeish *et al.* 2021). Initially, it was assumed that intensive longitudinal data should be treated similarly to traditional longitudinal data, with intensive longitudinal methods having more measurement time points. However, this view has changed, and many new methods of data analysis have emerged, such as incorporating measurement models into dynamic structural equation modelling or using multilevel latent class analysis for modelling careless responding (for an overview please see McNeish *et al.* 2021, Hasselhorn *et al.* 2023).

Intensive longitudinal methods must consider data quality, ethical considerations, and resources. First, data quality can be impaired by the following: (1) reactivity, which means that participants alter their behaviour or responses because they know they are being tracked. This leads to reporting bias, where their behaviour or experiences are not accurately represented (for details please see e.g. Walls and Schafer 2006, Iida *et al.* 2012, Mehl and Conner 2012, Bolger 2013); (2) careless responding due to various reasons, such as high cognitive load, amotivation, intensive experience of emotions, or unfavourable general conditions where participants might not have the capacity to report accurately (Cao and Henderson 2021, Hasselhorn *et al.* 2023, Ward and Meade 2023); (3) selective non-response, which means that data is missing in specific situations, e.g. in stressful periods or from certain types of participants, such as forgetful, non-compliant, or struggling participants (Eisner *et al.* 2019); and (4) selective attrition, where certain types of participants are more likely to drop out of the study, potentially leading to bias (Magnusson and Bergman 1990, Bolger 2013).

Second, the following ethical considerations must be considered: (1) participant burden, which can arise from lengthy data collection instruments, technical problems, frequent responses and interruptions or being in a mental state where active reporting is perceived as an additional burden (Iida *et al*. 2012, Mehl and Conner 2012, Bolger 2013, Cao and Henderson 2021); (2) privacy concerns, particularly regarding confidentiality (Mehl and Conner 2012); (3) distress or harm relating to sensitive topics, for instance, if participants become aware of a problem because of their involvement in the study and are left to deal with the problem on their own (Mehl and Conner 2012); and (4) power imbalance between students and teachers, which can lead to less drop outs but higher reactance and distress in students. Third, many resources are needed for intensive longitudinal studies. They can be expensive to conduct due to the need for frequent assessments, user-friendly technology, staff training, participant coaching and checking, participant compensation, and resources for data management and analysis (Iida *et al*. 2012, Mehl and Conner 2012, Bolger 2013).

Despite these limitations, intensive longitudinal data collection remains a valuable approach for understanding dynamic processes and capturing fine-grained changes over time. Researchers should carefully consider these limitations and adopt appropriate action to mitigate them according to the different stages of the research process, namely study design, study conduct and study analysis. At the study design stage and before data collection begins, researchers can take attrition into account by calculating the sample size, choosing an appropriate assessment method, lengths of instruments, frequency and period of data collection, considering technical issues and conducting a pilot test (e.g. Mehl and Conner 2012, Bolger 2013); (2) At the study implementation stage and during data collection, researchers can take action by conducting participant training, regular check-in calls, proctoring, incentives, and data monitoring and documentation (Jaso *et al*. 2022, Ward and Meade 2023). (3) At the study analysis stage and after the data collection period (due to this retrospectivity, they are limited) researchers can analyse careless responding, non-response, attrition, and reactivity patterns (Eisner *et al*. 2019, McNeish *et al*. 2021, Hasselhorn *et al*. 2023). The limitations of the retrospective data analysis methods highlight the importance of a well-designed study and effective study implementation strategies.

While extensive literature on study design and data analysis approaches for intensive longitudinal data exists, research on how to design tailored implementation strategies for intensive longitudinal data collections remains insufficient. Recommendations are often based on practical experiences and include valuable tips and tricks for study implementation (Arndt and Rose 2023). We aim to propose a theory-based and systematic approach to develop tailored study implementation strategies for intensive longitudinal methods focusing on education. This aligns with recommendations that state that future studies should report how careless responses have been addressed (Ward and Meade 2023).

Educational settings, such as schools or higher education institutions, have specific contextual factors compared to research outside such institutions. Their advantages include better accessibility of study participants, the potential of integrating the study into everyday teaching and learning and of providing sufficient time for participation in the study. These factors are associated with a lower probability of attrition and missing values. From an ethical perspective, the power imbalance between teachers and students must be taken into account, without which the completion rate would be lower and attrition rates would be higher, resulting in higher levels of missing data. Therefore, collecting data in educational settings must also be associated with added value for those involved, for example by providing them with individualized reports and recommendations once the data collection is complete. However, the risk of increased bias due to reactivity and cognitive, motivational, or emotional challenges remains. Other disadvantages include interfering contextual factors, such as holidays, days off, organizational or technical problems, and a lack of commitment of school or higher education authorities or teachers.

In the next section, we introduce implementation science and implementation mapping, a concrete process model that guides implementing intensive longitudinal data collection.

Implementation science

Implementing complex activities, such as intensive longitudinal data collections, requires intensive preparation, attendance during the implementation process, and formative and summative evaluations of the process. Implementation science provides guidance on all these steps. Implementation science initially emerged from cumulative experiences with programme implementation (Fixsen *et al*. 2016) and now consists of a multitude of theories, frameworks, and models (TFM) that guide and inform implementation processes (Damschroder 2020). These TFMs are used to identify barriers and facilitators for implementation, guide the selection of implementation strategies, inform data collection on implementation progress and success, and frame project evaluations (Birken *et al*. 2017).

Nilsen (2015) divides implementation TFMs into five categories: (1) Process models, such as implementation mapping (Fernandez *et al*. 2019), provide step-wise instructions to guide the translation of research into practice, or, in the case of data collection, *research methods* into practice. (2) Determinant frameworks specify barriers and enablers to implementation, such as structural characteristics of the implementation setting. (3) Classic theories are used to understand implementation processes, e.g. for their explanation of individuals' behaviour change, but originate from other disciplines, such as psychology or sociology. (4) Implementation theories are newly developed or modified theories that explicitly focus on aspects relevant to implementation, such as implementation climate or organizational readiness. (5) Evaluation frameworks indicate implementation outcomes that should be evaluated to rate the effectiveness of implementation processes.

Implementation outcomes are indicators of the implementation process reaching its intended goals. A commonly used implementation outcome is *implementation fidelity*, which describes whether the implementation process was conducted according to plan (e.g. recruitment processes, number of participating institutions in the data collection, communication between researchers and institutions). An implementation outcome framework by Proctor *et al*. (2011) further describes seven implementation outcomes. *Acceptability* reflects the involved groups' potential satisfaction with an implemented activity. *Appropriateness* is the perceived compatibility of the activity with the setting in which it is to be implemented. *Feasibility* refers to an activity's applicability to an institution's everyday operations. *Adoption* represents the uptake of an activity by a specific institution, and *penetration* describes the uptake of the activity by several institutions within a setting, e.g. the number of universities within a country. *Sustainability* reflects the (potential) institutionalization of the activity. *Costs* describe the costs of implementing an activity, which can depend on the complexity of implementation strategies. Concrete examples of these outcomes in the educational context can be found in Schultes (2023) and in the practice example below.

Implementation mapping as a guiding approach for intensive longitudinal data collections

Implementation mapping is a compact process model that guides the participatory design and evaluation of implementation processes. Researchers can use implementation mapping both to plan new intensive longitudinal data collections (Fernandez *et al*. 2019) and to evaluate and improve ongoing data collections (Schultes *et al*. 2022). The participatory nature of this model includes mapping out the implementation process together with representatives of the persons involved, e.g. students and teachers (in the following called *representatives*). In this case, their needs and experiences with similar processes can be considered and incorporated in the implementation plan.

We adapt the implementation mapping model to plan, monitor, and evaluate intensive longitudinal data collections. The adapted model follows five sets of activities: (1) identifying representatives and collecting implementation determinants; (2) defining implementation outcomes and performance objectives; (3) designing implementation strategies; (4) creating an implementation plan; and (5) evaluating implementation outcomes. Afterwards, we describe the process in-depth; the steps are not always performed consecutively but rather in a back-and-forth manner.

Insert Figure 1 about here.

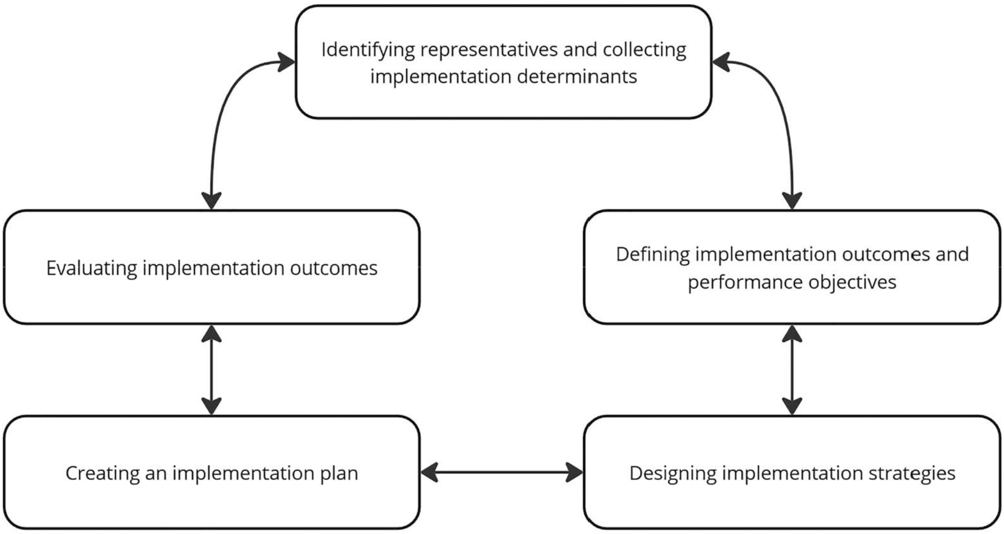

Figure 1. Steps of implementation mapping for enhancing intensive longitudinal methods.

(1) Identifying context representatives and collecting implementation determinants

Including representatives in terms of participatory research is key in successful implementations (Boaz *et al*. 2018, Potthoff *et al*. 2023). It fosters collaboration between researchers and groups involved, ensuring that the implementation process and outcomes are directly relevant to the needs and priorities of those affected. In a stakeholder mapping exercise (Bernstein *et al*. 2020), researchers identify representatives, which might differ between institutions but most likely involve students, teachers, course coordinators, the rector, IT staff, and, in the case of minor students, their legal guardians. Ideally, representatives from each institution build an implementation team (Fixsen *et al*. 2016) that serves as a local contact point throughout the study and can provide information on challenges that might arise.

In a literature review, researchers can derive potential barriers and facilitators for reaching desired implementation outcomes, which are called implementation determinants. Here, the updated *Consolidated Framework for Implementation Research* (CFIR; Damschroder *et al*. 2020) can serve as a guideline, as it provides a list of determinants at the individual, institutional, and system level. Facilitators at the individual level, for example, include the lecturers' commitment to supporting the data collection, while a barrier could be students' lack of interest in engaging in the survey (compare Haselhorn *et al*. 2023). At the institutional level, a potential facilitator could be the availability of devices for every student that allow them to fill out questionnaires simultaneously (Iida 2012). Meanwhile, an example of a barrier at the system level is a lack of funding to support the implementation. The CFIR framework also lists barriers and facilitators related to the activities to be implemented, such as the adaptability of the activities to the respective institution.

Research on barriers and facilitators can be achieved by drawing on the literature regarding implementation science and intensive longitudinal methods. We have summarized the challenge of balancing data quality, ethical considerations, and resources above; these challenges can also be considered implementation barriers. The implementation determinants from the literature can be discussed with the local implementation team, after which researchers and representatives can co-define potential further barriers and facilitators.

(2) Defining implementation outcomes and performance objectives

In a workshop and/or individual interviews, researchers and representatives discuss desired implementation outcomes. For instance, it should be clarified what constitutes acceptable levels of implementation fidelity in the context of the specific data collection process. These could include a certain number of completed questionnaires per participant per week. Researchers and representatives also determine other key implementation outcomes necessary for the successful execution of the data collection process, for example, its feasibility with daily teaching activities or high levels of acceptance of the study design by representatives. Moreover, they should define the performance objectives, which are the actions needed to reach implementation outcomes (Fernandez *et al*. 2019). These can vary between the different groups involved in the data collection. For example, for students to contribute to high levels of implementation fidelity, they must sign informed consent sheets, participate in technical checks, and complete the questionnaire every working day. For teachers, performance objectives include providing time for completing the questionnaire in their courses and commenting positively on the study.

(3) Designing implementation strategies

Implementation strategies are 'methods or techniques used to enhance the adoption, implementation, and sustainability' of activities (Proctor *et al*. 2013, p. 2), e.g. incentives for participating institutions or the provision of financial support for implementation activities. Implementation strategies should match prior defined barriers and facilitators and be tailored to the needs of the respective institution. Strategies that are already used by institutions for organizing data collections should also be assessed. Therefore, it is beneficial to include representatives in this step, preferably in a workshop that facilitates a collective creation of ideas through brainstorming sessions.

A helpful reference for selecting implementation strategies is the *Expert Recommendations for Implementing Change compilation* (ERIC, Powell *et al*. 2015), which provides a list of 73 implementation strategies. These have been bundled in a taxonomy by Waltz and colleagues (2015), who organize strategies in groups according to their goals, such as *train and educate stakeholders*, *change infrastructure*, *provide interactive assistance*, and *develop stakeholder interrelationships*. To promote the fit of strategies with determinants, the CFIR-ERIC matching tool (Waltz *et al*. 2019) provides a valuable source. For example, if the data collection's lack of adaptability is identified as a barrier (i.e. there is a standardized process that must be carried out in the same way at every institution), the matching tool would suggest conducting local needs assessments and tailoring the implementation to the local context as an implementation strategy.

(4) Creating an implementation plan

To create a comprehensible implementation plan, the previously defined implementation outcomes, determinants, and strategies from steps 1 to 3 should be recorded in a document. Here, the Implementation Research Logic Model (Smith *et al*. 2020) can be used as a template. Implementation strategies should be described in detail, including exact timelines and a guideline on how to report the conduction of strategies (Proctor *et al*. 2013). The document should also include information on how implementation outcomes will be evaluated (see step 5). When the implementation plan and evaluation design are discussed and further co-developed in a participatory process with representatives from institutions or local implementation teams, the plan has a higher chance of being implemented by all collaborators with fidelity (Schultes *et al*. 2018).

(5) Evaluating implementation outcomes

Monitoring the implementation process in a formative evaluation supports the early detection of potential implementation problems. Formative evaluation activities can include daily or weekly completeness checks of the data base and check-in calls with the implementation team. If there are problems with the realization of planned implementation strategies, alternative strategies can be defined and the implementation plan adapted.

For a summative implementation evaluation, implementation outcomes that have been defined in Step 1 must be operationalized with suitable indicators. Here, the institutions' representatives or implementation teams can provide valuable input, for example, on how to operationalize the acceptance of the implementation process by different groups involved. Psychometrically sound implementation outcome measures have mostly been developed for healthcare, but some implementation outcomes can also be applied in education (Kien *et al*. 2018, Schultes 2023). Quality criteria for implementation outcome measures resemble usual psychometric measurement criteria; however, usability in an everyday work context is prioritized over psychometric measurement criteria (Lewis *et al*. 2021). Evaluating implementation outcomes is helpful in explaining problems, such as attrition, and provides learnings for future implementation processes.

Practice example

In this section, we present an example of an implementation of a quantitative daily diary study in higher education. This study collected self-reported data on different aspects of self-regulated learning of veterinary medicine students to answer research questions on the stability and variability of undergraduates' self-regulated learning in the workplace. In practice, we followed the five steps of implementation mapping in an iterative process and constantly revisited the individual steps.

(1) Identifying context representatives and collecting implementation determinants

Our project team identified different groups involved in the data collection: students, teachers, clinic staff, and decision-makers (including the vice-rector for study affairs, head of the educational working group, course coordinator, workplace managers, head of student council, and semester speaker). Representatives were not only involved in the implementation of the data collection procedure, but they were also part of the project team (student and teacher representatives) and the steering committee (decision-maker representatives). While the project team was responsible for planning and executing the project, the steering committee was tasked with supporting the project's integration into the institution's daily processes, analysing risks, and ensuring communication between the project and the institution.

The main barriers and facilitators were identified by the project team together with the steering committee. The researchers reviewed the literature and contacted colleagues who recently implemented intensive longitudinal data collections in educational settings to identify general facilitators and barriers. Student-, teacher-, and decision-maker representatives reached out to their colleagues (in team meetings, individual conversations, etc.) to consider the different groups' needs and the different workplace contexts to identify context-specific facilitators and barriers.

Facilitators identified at the individual level were the motivation to contribute to science, enhance teaching quality, and reflect the learning process to become better veterinarians. At the institutional level, major facilitators included the university's objective of fostering educational research, disseminating educational knowledge to a broad range of teachers and clinical staff, and advancing the curriculum based on the study's results. At the system level, facilitators comprised the university's accrediting body's ambition to foster evidence-based teaching, teacher education, and educational research among European veterinary higher education institutions.

Possible *barriers* identified at the individual level included a lack of information about the study, low priority, limited time, declining motivation, forgetfulness, cognitive overload and stress, technical problems (no access to electronic devices, internet, and the daily diary; difficulty in handling of electronic daily diary; etc.), and interruptions during completion of the diary entries. Barriers at the institutional level included difficulties in obtaining consent from all decision-makers, integrating the daily diary into the course structure, and having highly different daily routines at the workplaces involved. At the system level, barriers were those usually found in field studies where high scientific standards meet real-life environments. The most important barrier in our example was balancing the number of items between the criteria reliability/validity and feasibility/ethical considerations/reasonableness.

(2) Defining implementation outcomes and performance objectives

Implementation fidelity and cost were specified by the research team to meet scientific standards and funding limitations, respectively. Other outcomes were specified together with representatives of various groups involved.

Implementation fidelity was specified as (1) the completeness of the data set; (2) the representativity in terms of heterogeneity of participants (including motivated high performers and struggling students); and (3) the validity of data, which refers not only to the instruments' psychometric quality but also the thoughtful completion of the diary at a time when the participants have the necessary information to answer the questions (avoiding careless responding and memory bias).

The performance objectives regarding the completeness of the data set and representativity were specified to be 95% of students of the respective student cohort who signed the informed consent form and agreed to participate in the study, 95% of students who completed the daily diary until the end of the study, and a maximum of 10% missing data (expected sick leaves and night shifts where students might be tired, allowing students to skip occasionally). Regarding the outcome of data validity, the performance objective of thoughtfulness in completing the diary is difficult to assess because participants are already challenged by filling out a daily questionnaire. Adding items that assess careless responding seemed unreasonable. Therefore, we defined contextual factors that facilitate thoughtfulness: researchers provide a user-friendly technical diary solution and teachers provide time and support.

Cost was specified based on the financial plan defined in the project proposal. We established a hierarchy of priorities to reduce costs: high priority was placed on collecting representative data on the variables of interest (self-regulated learning) and data at various workplaces and from a sufficient number of participants regarding the requirements of complex statistical analysis. Low priority was placed on representativeness at the institutional level, i.e. collecting data from students at different universities.

The performance objective regarding cost involved the researchers defining the sample according to the established hierarchy (which resulted in about 200 students from a single institution learning at 15 different workplaces), ensuring that there are enough financial resources for various implementation strategies.

Acceptability was specified as the potential acceptance of the data collection by most people involved and especially by official student representatives and decision-makers, such as the vice-rector for study affairs and clinics, the clinical rotation course coordinator, and workplace managers.

The performance objectives for acceptability were the same as for data completeness (informed consent, few drop-outs, and few missing data). Additionally, teachers, clinical staff, student representatives, and decision-makers should either speak positively or neutrally about the study.

Appropriateness, defined as the perceived compatibility of the activity with the setting in which it is to be implemented, was perceived as given because we assumed that people at a university are familiar with conducting scientific studies and collecting data and hence understand the necessity of scientific rigour in data collection. We did not specify a performance objective for this outcome.

Feasibility was specified as the data collections' applicability during everyday operations at the different workplaces. Routines and procedures were highly different between workplaces; therefore, flexibility was necessary.

The performance objective was that the researchers should allow time flexibility for completing the diary and provide a previously tested, user-friendly technical solution for the diary through the use of various electronic devices and operating systems.

Penetration in the sense of the uptake of an activity by other institutions was not an implementation outcome because we focused on data collection within one institution only. However, to institutionalize the activity, during the limited period of data collection, we specified penetration as the daily routine in data collection where students complete the diary and teachers provide time on site in the clinic.

The performance objectives include: (1) representatives should report that the participants had integrated the collection into their daily routine and that after three weeks, the participants had few questions or problems pertaining to the study; and (2) students should provide complete data throughout the data collection period (maximum 10% missing data).

Sustainability for the limited period of data collection was specified by stable response rates and acceptance among persons involved during the final third of the survey period, where the participants are at risk of forgetting to continue their daily diary entries after Christmas holidays.

The performance objectives include stable response rates until the last third portion of the data collection period and acceptance of the study by the persons involved.

(3) Designing implementation strategies

Before we focus on implementation strategies, we would like to give a more general recommendation. We integrated student, teacher, and decision-maker representatives into the project team and the steering committee, respectively. While this might not be a pure implementation strategy, this overall strategy, which improves the quality of the scientific project, was the most crucial one for the data collection part of the project (compare Ramanadhan *et al*. 2024). Most barriers were addressed by multiple implementation strategies. Figure 2 illustrates the connection between barriers and implementation strategies. The implementation strategies are described in detail in the Appendix.

(4) Creating an implementation plan

An implementation plan was created based on the results of Steps 1 to 3 (see the sections above). The implementation plan also includes a timeline and responsibilities for implementing the

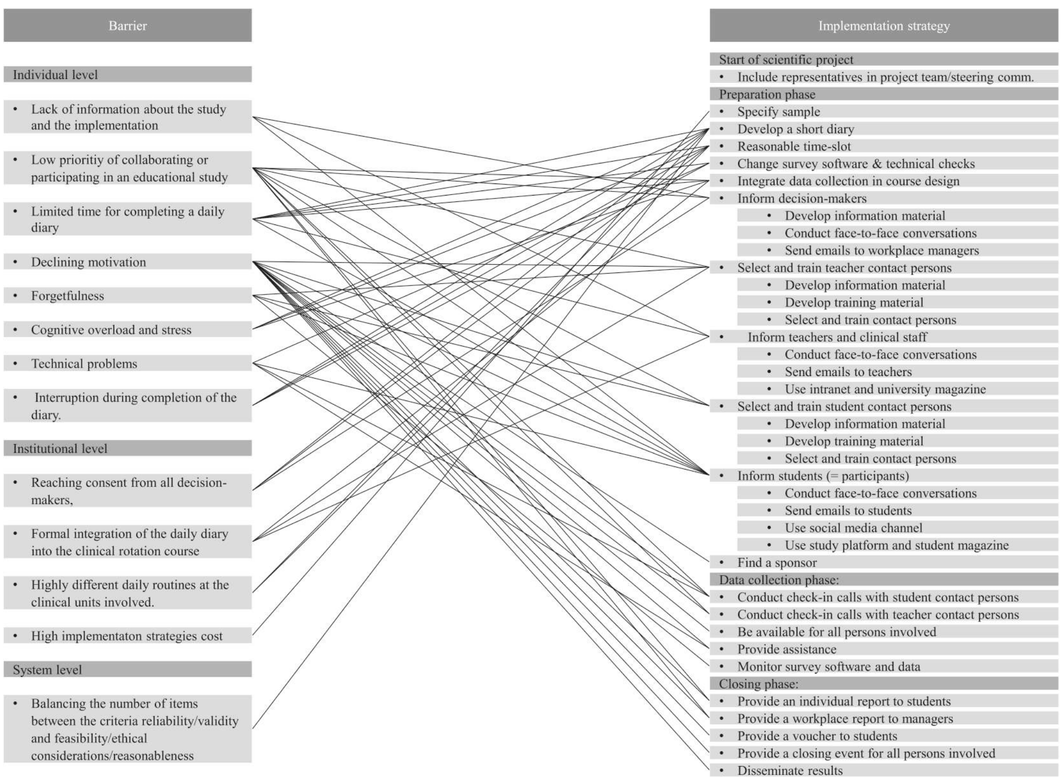

Figure 2. Illustration of the relationships between barriers and implementation strategies. For details please refer to the supplementary material.

strategies and reporting to the principal investigator. Table 1 shows the implementation strategies, the timeline, and the responsibilities. The evaluation methods for the performance objectives, which should also be integrated into the written plan, are outlined below in Section 5.

(5) Evaluating implementation outcomes

For each implementation outcome one or several evaluation methods were conducted. Table 2 shows an overview of evaluation methods per implementation outcome.

Table 1. Implementation strategies, timeline and responsibilities.

Implementation Strategy	Timeline	Responsibility
Start of scientific project		
Include representatives in project team/ steering comm.	from the beginning of the project	include representatives in project team/ steering comm.
Preparation phase		
Specify sample	as soon as possible	PM reseacher
Develop a short diary	6 months before	PM reseacher
Reasonable time-slot	6 months before	PM teacher and PM student
Change survey software & technical checks	3 months before	PM researcher and PM student
Integrate data collection in course design	6 months before	PM researcher, PM teacher, course coordinator
Inform decision-makers		
Develop information material	6 months before	PM researcher and PM teacher
Conduct face-to-face conversations	6 months before	PM researcher
Send emails to workplace managers	3 months before	PM researcher
Select and train teacher contact persons		
Develop information material	3 months before	PM researcher and PM teacher
Develop training material	3 months before	PM researcher and PM teacher
Select and train contact persons	3 months before	PM teacher
Inform teachers and clinical staff		
Conduct face-to-face conversations	1–2 months before	Teacher contact persons
Send emails to teachers	1 month before	PM researcher and PM teacher
Use intranet and university magazine	1 month before and at the beginning	PM researcher and PM teacher
Select and train student contact persons		
Develop information material	1 month before	PM researcher and PM student
Develop training material	1 month before	PM researcher and PM student
Select and train contact persons	1 month before	PM researcher and PM student
Inform students (= participants)		
Conduct face-to-face conversations	½ month before and at the beginning	Student contact persons
Send emails to students	1 month before and at the beginning	PM researcher
Use social media channel	1 month before, at the beginning and during	PM student and semester speaker
Use study platform and student magazine	1 month before	PM researcher and PM student
Find a sponsor	As soon as sample size is specified	PM reseacher
Data collection phase		
Conduct check-in calls with student contact persons	weekly	PM student
Conduct check-in calls with teacher contact persons	biweekly	PM teacher
Be available for all persons involved	on demand	PM all
Provide assistance	on demand	PM all
Monitor survey software and data	daily	PM reseacher
Closing phase		
Provide an individual report to students	after four weeks, 2 days before the closing event	PM reseacher
Provide a workplace report to managers	after eight weeks	PM reseacher
Provide a voucher to students	after four weeks at closing event	PM researcher / sponsor
Provide a closing event for all persons involved	after four weeks	PM researcher / sponsor
Disseminate results	after 12 weeks	PM all

Note: before means before the data collection starts and after means after the data collection ended; PM = project member; if there is more than one responsible representative then the second one assists.

Table 2. Evaluation methods for each implementation outcome.

Implementation outcomes	Evaluation methods
Implementation fidelity (completeness of the data set and representativity)	Daily data monitoring Analysis of diary data regarding possible patterns in students who do not agree to participate in the study Data analysis regarding possible patterns in students who drop-out
Validity of data	Instrument pretest Weekly reports from students (check-in calls) Biweekly reports from teachers (check-in calls).
Cost	Prospective evaluation of the financial plan regarding resources for the implementation strategies Summative evaluation of costs
Acceptability	Before data collection: reports from the representatives about the response to the study in general and the data collection in particular in the groups involved and from the decision-makers
Feasibility	Technical checks, which showed that the diary works on various devices and operating systems Weekly reports from students (check-in calls) Biweekly reports from teachers (check-in calls)
Penetration	Starting from week three of the data collection period: representatives' reports (check-in calls) to examine if persons involved had integrated data collection into their daily routine and had only few questions through data monitoring
Sustainability	Throughout the final third portion of the survey period: Representatives' reports (check-in calls) Data monitoring to investigate if persons involved were still committed to the data collection

In conclusion and as mentioned above, the steps were not always performed consecutively but rather in a back-and-forth manner. This was especially true for Steps 1 to 3. For example, when we were discussing implementation strategies to deal with the very different routines in the different workplaces, we defined a time frame when students could complete the diary (afternoon). Later on, we realized that one of the workplaces had a night shift and we had to find a different solution (extending the period to the morning and actively communicating to the students that they could skip completing the diary if they felt too exhausted).

Discussion

The discourse on intensive longitudinal methods has primarily concentrated on aspects of study design and data analysis, with implementation receiving only cursory attention (Arndt and Rose 2023). However, a well-designed implementation contributes to a complete and valid data set (Ward and Meade 2023). Implementation science offers various theories, frameworks, and models (TFM) as starting points. Implementation mapping is particularly suitable because of its systematic and flexible approach (Fernandez *et al*. 2019). The *systematic* approach minimizes the risk of overlooking key steps or strategies and ensures clear alignment between outcomes, barriers, implementation strategies, and evaluation methods. Hence, this systematic approach adds to the existing general study implementation strategies outlined in the introduction (Jaso *et al*. 2022, Ward and Meade 2023; see introduction section). The *flexible* approach allows for the selection of an appropriate framework for each step in the intensive longitudinal method study context (regarding the study focus or the level of education). In addition, implementation strategies are flexible depending on the educational institution's context. While the study design should remain standardized across institutions to ensure a scientifically sound approach (e.g. Mehl and Conner 2012, Bolger 2013), the design of implementation strategies can or should vary depending on the culture of the respective institution, for example by adapting information materials and channels to the institutional practices.

One limitation of the use of implementation TFMs in general and implementation mapping in particular for implementing intensive longitudinal methods is that they focus on the sustainable implementation of interventions in practice while the data collection phase is constrained by temporal limitations. Moreover, a significant number of TFMs concentrate on the implementation of measures within the health sector, which can only be partially transferred to the implementation of intensive longitudinal methods and the educational sector. Furthermore, implementation mapping is incompatible with conventional project management concepts (e.g. regarding terminology like implementation strategies vs. work packages, evaluation vs. control, and barriers vs. risks), which can cause confusion with terminology. Finally, implementation necessitates the allocation of resources, the availability of which must be clearly communicated to funding bodies. There is a potential risk that these resources may not be funded.

Regarding the practice example included above, the strategies implemented were extensive but successful, resulting in a complete and representative data set. However, the evaluation methods for the outcome of validity must be viewed critically. Numerous measures were taken to contribute to valid data, but it was ultimately not possible to analyse thoughtful or careless responding. We recommend integrating a short scale on the topic of 'careless responding' in future intensive longitudinal data collections.

Theoretical and practical implications

Further research is needed on the integration of intensive longitudinal methods and implementation science. For the implementation of intensive longitudinal methods and the educational sector, specific frameworks regarding, for instance, the implementation outcomes, phases, and strategies are necessary. *Implementation outcomes* in the context of intensive longitudinal methods and education could be based on the quality criteria of psychological diagnostics (validity, reliability, fairness) and standards for test administration (American Educational Research Association 2014) and on further ethical and legal criteria, such as data protection (which was implicitly taken into account in the above practice example). *Implementation phases* for intensive longitudinal methods should include a closing phase. Data collections have a clear end, while the goal of implementing health programmes is to reach sustainability and, in an ideal scenario, not to end at the completion of a piloting phase. *Implementation strategies*, such as incentives, might differ as they are conducted not only during the preparation or implementation phase but also in the closing phase.

Furthermore, a discourse is needed to establish reporting standards for the implementation process of intensive longitudinal data collection in scientific manuscripts. In most manuscripts, the procedure section is notably brief, which results in a lack of comprehensibility, particularly in complex studies such as intensive longitudinal methods studies. Soicher and colleagues (2020) discuss extended reporting guidelines for the implementation of evidence-based practices in college classrooms based on the CONSORT guidelines (Glasgow *et al*. 2018). These can be used as a starting point for reporting standards of intensive longitudinal data collections. Until this issue has been resolved, we recommend the inclusion of the implementation plan and the evaluation report as supplementary material for intensive longitudinal studies or adapting the CONSORT guidelines.

In this study we focused on the study implementation stage of intensive longitudinal methods. However, inspired by participatory research, future research could expand the application of implementation science to inform also other research stages and to design strategies for these stages; for example to inform the study design (co-designing the study with representatives of groups involved) as well as the data analysis and interpretation (involving affected groups to explore possible context factors that need to be considered in data analysis and interpretation).

The practical implication of this work is the provision of clear strategies for the implementation of intensive longitudinal methods. On a larger scale, this requires the sensitization and training of researchers regarding implementation processes. Training in implementation science is becoming available at an increasing number of institutions (Schultes *et al*. 2021). Implementation science networks and organizations can offer support in finding suitable training opportunities.[1] A welcome development would be a larger offering of training opportunities for educational researchers. To enhance applicability, participants could also engage in case studies where implementation frameworks, such as implementation mapping, are applied to the implementation of intensive longitudinal data collection, allowing them to practice these approaches in the context of complex educational settings.

Furthermore, financial resources from funding bodies are crucial for the implementation process. Expenditure on implementation strategies should therefore not only form part of the funding for applied projects but also for research projects. If funders place more emphasis on the description of implementation strategies in grant applications, this can also enhance the quality and impact of research results.

Conclusion

While the design of intensive longitudinal method studies and the analysis of intensive longitudinal data have been extensively discussed in the scientific literature, the implementation of these methods has been largely overlooked. We addressed this gap by presenting implementation mapping as an approach for the systematic implementation of intensive longitudinal methods and by providing a practical example as an illustration. However, future research and application of theoretical implementation frameworks to education and, more specifically, to intensive longitudinal methods are still necessary.

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Note

1. Please see for example: European Implementation Collaborative (https://implementation.eu/), Center for Implementation (https://thecenterforimplementation.com/), Society for Implementation Research Collaboration (https://societyforimplementationresearchcollaboration.org/) or Global Implementation Society (https://globalimplementation.org/resources/).

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Ethics

The study regarding the practical example was submitted to the Ethics Committee of the Medical University of Vienna. The decision was that no ethical approval was required according to the Declaration of Helsinki. The following ethical standards were met. Participation in the study was completely voluntary. Written consent was obtained for participation in the study and for the use of the data. Participants were assured that their responses would remain confidential and would only be used for scientific purposes. Complete anonymity was ensured by not publishing any data that would allow conclusions to be drawn about the identity of the respondents. Moreover, the study was approved and supported by the project steering committee, including the Vice-Rector for Study Affairs of the University of Veterinary Medicine, Vienna.

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References

American Educational Research Association, American Psychological Association, and National Council on Measurement in Education, 2014. *Standards for educational and psychological testing*. Washington, DC: American Educational Research Association.

Arndt, H., and Rose, H., 2023. Capturing life as it is truly lived? Improving diary data in educational research. *International journal of research and method in education*, 46 (2), 175–186.

Bernstein, S.L., Weiss, J., and Curry, L., 2020. Visualizing implementation: contextual and organizational support mapping of stakeholders (COSMOS). *Implementation science communications*, 1, 48. doi:10.1186/s43058-020-00030-8.

Birken, S.A., *et al*., 2017. Criteria for selecting implementation science theories and frameworks: results from an international survey. *Implementation science: IS*, 12 (1), 124. doi:10.1186/s13012-017-0656-y.

Boaz, A., *et al*., 2018. How to engage stakeholders in research: design principles to support improvement. *Health research policy and systems*, 16 (1), 60. doi:10.1186/s12961-018-0337-6.

Bolger, N., 2013. *Intensive longitudinal methods: an introduction to diary and experience sampling research*. New York, NY: Guilford Press.

Cao, X., and Henderson, E.F., eds. 2021. *Exploring diary methods in higher education research: opportunities, choices and challenges*. New York, NY: Routledge.

Damschroder, L.J., 2020. Clarity out of chaos: use of theory in implementation research. *Psychiatry research*, 283, 112461. doi:10.1016/j.psychres.2019.06.036.

Eisner, N.L., *et al*., 2019. A practical guide to the analysis of non-response and attrition in longitudinal research using a real data example. *International journal of behavioral development*, 43 (1), 24–34. doi:10.1177/0165025418797004.

Farrington, D.P., *et al*., 1990. Minimizing attrition in longitudinal research: methods of tracing and securing cooperation in a 24-year follow-up study. In: D. Magnusson and L.R. Bergman, eds. *Data quality in longitudinal research*. New York, NY: Cambridge University Press, 122–147.

Fernandez, M.E., *et al*., 2019. Implementation mapping: using intervention mapping to develop implementation strategies. *Frontiers in public health*, 7, 158. doi:10.3389/fpubh.2019.00158.

Fixsen, D.L., Schultes, M.-T., and Blase, K.A., 2016. Bildung-psychology and implementation science. *European journal of developmental psychology*, 13 (6), 666–680. doi:10.1080/17405629.2016.1204292.

Glasgow, R.E., Huebschmann, A.G., and Brownson, R.C., 2018. Expanding the CONSORT figure: increasing transparency in reporting on external validity. *American Journal of preventive medicine*, 55 (3), 422–430. doi:10.1016/j.amepre.2018.04.044.

Hasselhorn, K., Ottenstein, C., and Lischetzke, T., 2023. Modeling careless responding in ambulatory assessment studies using multilevel latent class analysis: factors influencing careless responding. *Psychological methods*.

Hektner, J.M., 2018. Diary studies, event sampling, and smartphone apps. In: P. Brough, ed. *Advanced research methods for applied psychology*. New York, NY: Routledge, 158–169.

Iida, M., *et al*., 2012. Using diary methods in psychological research. In: H. Cooper, P.M. Camic, D.L. Long, A.T. Panter, D. Rindskopf, and K.J. Sher, eds. *APA handbook of research methods in psychology, Vol 1: foundations, planning, measures, and psychometrics*. Washington: American Psychological Association, 277–305.

Jaso, B.A., Kraus, N.I., and Heller, A.S., 2022. Identification of careless responding in ecological momentary assessment research: from posthoc analyses to real-time data monitoring. *Psychological methods*, 27 (6), 958.

Kien, C., *et al*., 2018. German language questionnaires for assessing implementation constructs and outcomes of psychosocial and health-related interventions: a systematic review. *Implementation science: IS*, 13 (1), 150. doi:10.1186/s13012-018-0837-3.

Lewis, C.C., *et al*., 2021. The psychometric and pragmatic evidence rating scale (PAPERS) for measure development and evaluation. *Implementation research and practice*, 2, 26334895211037391. doi:10.1177/26334895211037391.

Magnusson, D., and Bergman, L.R., eds. 1990. *Data quality in longitudinal research*. Cambridge: Cambridge University Press.

Martin, A.A., Grünenfelder-Steiger, A.E., and Allemand, M., 2020. Longitudinal research. In: B.J. Carducci and C.S. Nave, eds. *The Wiley encyclopedia of personality and individual differences*. Hoboken, NJ: Wiley, 25–30.

McNeish, D., *et al*., 2021. Measurement in intensive longitudinal data. *Structural equation modeling: a multidisciplinary journal*, 28 (5), 807–822. doi:10.1080/10705511.2021.1915788.

Mehl, M.R., and Conner, T.S., 2012. *Handbook of research methods for studying daily life*. New York, NY: Guilford Press.

Nilsen, P., 2015. Making sense of implementation theories, models and frameworks. *Implementation science: IS*, 10, 53. doi:10.1186/s13012-015-0242-0.

Nusser, S.M., Intille, S.S., and Maitra, R., 2006. Emerging technologies and next-generation intensive longitudinal data collection. In: T.A. Walls and J.L. Schafer, eds. *Models for intensive longitudinal data*. Oxford, NY: Oxford University Press, 254–277.

Potthoff, S., *et al*., 2023. Towards an implementation-stakeholder engagement model (I-STEM) for improving health and social care services. *Health expectations: an international journal of public participation in health care and health policy*, 26 (5), 1997–2012. doi:10.1111/hex.13808.

Powell, B.J., *et al*., 2015. A refined compilation of implementation strategies: results from the expert recommendations for implementing change (ERIC) project. *Implementation science: IS*, 10, 21. doi:10.1186/s13012-015-0209-1.

Proctor, E., *et al*., 2011. Outcomes for implementation research: conceptual distinctions, measurement challenges, and research agenda. *Administration and policy in mental health*, 38 (2), 65–76. doi:10.1007/s10488-010-0319-7.

Proctor, E.K., Powell, B.J., and McMillen, J.C., 2013. Implementation strategies: recommendations for specifying and reporting. *Implementation science: IS*, 8, 139. doi:10.1186/1748-5908-8-139.

Ramanadhan, S., *et al*., 2024. Using participatory implementation science to advance health equity. *Annual review of public health*, 45, 47–67. doi:10.1146/annurev-publhealth-060722-024251.

Schultes, M.-T., *et al*., 2018. Attitudes toward evaluation: an exploratory study of students' and stakeholders' social representations. *Evaluation and program planning*, 70, 44–50. doi:10.1016/j.evalprogplan.2018.06.002.

Schultes, M.-T., *et al*., 2021. Competences for implementation science: what trainees need to learn and where they learn it. *Advances in health sciences education*, 26 (1), 19–35. doi:10.1007/s10459-020-09969-8.

Schultes, M.-T., *et al*., 2022. A modified implementation mapping methodology for evaluating and learning from existing implementation. *Frontiers in public health*, 10, 836552. doi:10.3389/fpubh.2022.836552.

Schultes, M.-T., 2023. An introduction to implementation evaluation of school-based interventions. *European journal of developmental psychology*, 20 (1), 189–201. doi:10.1080/17405629.2021.1976633.

Smith, J.D., Li, D.H., and Rafferty, M.R., 2020. The implementation research logic model: a method for planning, executing, reporting, and synthesizing implementation projects. *Implementation science*, 15 (1), 84. doi:10.1186/s13012-020-01041-8.

Soicher, R.N., Becker-Blease, K.A., and Bostwick, K.C.P., 2020. Adapting implementation science for higher education research: the systematic study of implementing evidence-based practices in college classrooms. *Cognitive research: principles and implications*, 5 (1), 54. doi:10.1186/s41235-020-00255-0.

Walls, T.A., and Schafer, J.L., eds. 2006. *Models for intensive longitudinal data*. Oxford, NY: Oxford University Press.

Waltz, T.J., *et al*., 2015. Use of concept mapping to characterize relationships among implementation strategies and assess their feasibility and importance: results from the expert recommendations for implementing change (ERIC) study. *Implementation science: IS*, 10, 109. doi:10.1186/s13012-015-0295-0.

Waltz, T.J., *et al*., 2019. Choosing implementation strategies to address contextual barriers: diversity in recommendations and future directions. *Implementation science: IS*, 14 (1), 42. doi:10.1186/s13012-019-0892-4.

Ward, M.K., and Meade, A.W., 2023. Dealing with careless responding in survey data: prevention, identification, and recommended best practices. *Annual review of psychology*, 74, 577–596. doi:10.1146/annurev-psych-040422-045007.