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Review

The Learning City: Temporary Housing Projects as Urban Niches for Sustainability Experiments

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Abstract: It is widely acknowledged that real-world experimentation is essential for the advancement of sustainable solutions. Urban contexts are perfectly suited for this form of innovation, since they have a high demand for solutions and also offer the necessary resources for the development of new ideas. However, there is a need for a well-defined basis for the selection process of suitable experimental designs for specific cases. This paper presents a typology of various existing sustainability experimental designs, focusing on the distinct features between different types and their respective strengths and weaknesses. Using the case of temporary housing models for Vienna, this paper provides a step-by-step selection process based on a catalogue of questions to match various types of housing projects with experimental designs. By improving the understanding of what the defining features of existing experimental approaches are, more clarity is provided for the design and planning of sociotechnical experiments for greater sustainability.

Keywords: sustainability; transitions; niche experiments; sustainable innovation; temporary housing

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1. Introduction

As we are increasingly faced with fundamental sustainability challenges, awareness on the importance of sustainable urban development has increased. These challenges are highly complex and comprehensive, requiring solutions involving far-reaching changes on multiple levels [1]. Cities are central arenas where innovations in the areas of sustainable infrastructures for energy, mobility, buildings, waste, agriculture, and the food supply are explored [2]. Experimental spaces can facilitate a transition towards more environmentally and socially sustainable urban systems, allowing for an exploration of new approaches [3]. However, experimentation for sustainability transitions requires a well-defined basis for the selection process of suitable experimental designs for specific cases.

More sustainable ways to satisfy human needs and wants require not only new products and services but necessitate societal transitions to bring about changes in sociotechnical systems [4,5]. Sociotechnical systems are complex entities involving interactions between companies, consumers, rules and regulations, technologies, and infrastructures [6]. Over the past decades, it has become evident that small and incremental innovations based on the optimization and further development of existing products, services, or processes have not provided truly meaningful progress in the face of the ever-growing sustainability issues [7]. Consequently, over the past years, there has been greater interest in approaches concerning transitions that focus not only on the optimization of technologies but on the transformation of larger systems of production and consumption. In this context, concepts surrounding niches as spaces where fledgling technologies and ideas can develop and grow in experimental settings have gained in relevance [8–10]. Within these niches, more radical solutions and ideas involving significant change can be explored, as the confined nature of niches limits the risks and provides a protected space free from market constraints

(and other pressures). Funding schemes have been introduced at the international (e.g., JPI Urban Europe) and national levels (e.g., Stadt der Zukunft and Smart Cities Demo for Austria) to promote the implementation of such experiments, underlining their importance for urban development. These programs aim to create experimental environments where innovative solutions can be explored and where citizen involvement can take place.

Our analysis of the existing experimental designs confirmed observations made by Sengers et al. that "[...] many real-life transition projects described in the literature as one type of experiment could easily be described in the terms of any of the other experiment types" [11] (p. 9). The original concepts of these different experimental designs have distinct strengths and weaknesses, i.e., they should be suited to certain contexts and research questions. However, when applied without sufficient reflection, and with broad claims of what the experiment is capable of, the experimental designs end up only loosely relating to the original concepts. The term "living lab", for instance, has been applied very generously to various experimental designs, as criticized by Veeckman et al. [12], after the European Commission started promoting living lab research in 2006. When the terms are conflated in practice, the experimental designs cannot be utilized to their full potential. Care must be taken to retain the integrity and coherence of the different types. In practice, the challenge is usually to find an adequate model under the existing framework conditions and with specific goals to be achieved. This paper contributes to addressing this challenge by improving the understanding of what the defining features of existing experimental designs are, where their strengths lie, and how they fundamentally differ from each other. On this basis, both a reference table and selection process consisting of seven core questions were developed, which can aid practitioners in the choice, design, and planning of sociotechnical experiments. This paper addresses two research questions: (1) What are the strengths and weaknesses of the existing experimental designs for sustainability transitions? (2) What is a robust method when selecting between experimental designs for sustainability transitions?

To demonstrate the newly developed selection process, it was applied to three temporary housing models that differ in characteristics, contexts, and goals. The temporary housing models were developed within the interdisciplinary research project "Urban pop-up housing environments and their potential as local innovation systems" [13], funded by the Vienna Science and Technology Fund (WWTF). The project conceptualized temporary housing solutions as spaces for social learning and experimentation, with these "interim solutions" holding the potential to become new elements of local innovation systems, offering a wide range of possibilities to explore, apply, and evaluate new technical and social concepts. Temporary forms of housing are particularly suited as innovation niches for research into sustainable sociotechnical futures, because they have a number of characteristics that make them interesting as experimental spaces for urban innovation. They are temporary, provisional, sometimes improvised, and, to some extent, governed by regulations that are less strict [14]. While there is a long tradition of different forms of temporary use in the city of Vienna [15–17], there are yet some reservations towards temporary housing at the institutional level, with there being no mention of this form of housing in Vienna's urban development plans [18]. In the context of the WWTF project, the term "temporary" refers to an intended residence of up to a maximum of 10 years [19].

2. Background

This section provides a brief introduction to the following topics: sustainability transitions as the overarching transformation process towards more sustainable futures, experimentation as a means to promote sustainability transitions, and higher-order learning in niches as a core mechanism of experiments.

The past decades have produced a growing body of literature in the field of sustainability transitions, which addresses the transformation of current systems to more sustainable sociotechnical systems [20–24]. Markard et al. [5] (p. 956) described sustainability transitions as "long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production

and consumption." A core component is the utilization of sociotechnical experimentation as means for technological, social, and institutional learning, which is essential for fundamental and long-term changes [11]. Unlike technical experiments, which focus solely on the technical dimension, sociotechnical experiments include the dimensions of user practices and institutional structures and involve real-world actors and contexts [5,11]. A constructive technology assessment (CTA) can be considered as the source of many of these ideas, with the CTA approach opening up the process and decision-making of technology development to users, citizens, and policymakers in order to enable reflective forms of social learning to take place. Strategic niche management (SNM) is a specific approach stemming from CTA seeking to facilitate interactive social learning around sustainable innovations in protected spaces [25,26].

Experimentation in the context of sustainability transitions is an effort to fundamentally and radically change sociotechnical systems and explore opportunities that have not yet been realized. This requires new perspectives, alternatives, ways of framing problems, and ways of interpreting observations [25,27]. Gross [28] described these experimental approaches as using failure as a basis for learning, resulting in the seemingly paradox situation of failed experiments being simultaneously successful. As portrayed by Sengers et al. [11], a number of different experimental designs have been developed over the years. They operate according to different rationales and serve different, albeit sometimes similar or related, overarching goals. When planning an experimental process in practice, it is crucial that the main objective and existing contextual factors inform the choice of experimental design to allow for potential long-term effects.

Learning processes play a central role in all experiments. Mutual learning and collaboration are essential, with the importance of second-order learning being emphasized throughout the literature [25,27,29]. First-order learning describes learning that takes place on the basis of knowledge and insights gained from experimental results without questioning the governing variables. Second-order learning takes place when actors question the reigning values, frames, and paradigms [30].

3. Types of Experiments for Sustainability Transitions

This section introduces various experimental designs for sustainability transitions in detail. Each description follows this structure: historical background, starting points and main objectives, scope (addresses solely the technical or social innovation or can also address overarching institutional structures or broader forms of living and cooperation), learning processes, actors involved, implementing the actors' degree of control, strengths, and weaknesses. From these descriptions, we derived a reference table that allows for the direct comparison of the experimental designs (Table 1).

In their systematic review, Sengers et al. [11] presented an overview of existing experimental designs, which served as a starting point for our analysis. Their overview consisted of: "niche experiments", "bounded socio-technical experiments" (BSTEs), "grassroots experiments", "transition experiments", and "sustainability experiments". The authors also mentioned "urban living labs" (ULLs) as an emerging conceptualization of urban experimentation but did not present it in detail, as the concept was new at the time and not yet prominently featured in the literature. We included ULLs in our list of experimental designs, as we found enough distinguishing characteristics that could be featured in addition to the other concepts. We chose not to include sustainability experiments, because the available descriptions did not allow for a clear enough distinction from the other concepts for the purpose of this paper, often being used as an overarching concept. The use of sustainability experiments in a broader sense can be observed in, for example, van den Heiligenberg et al.'s study [31], where sustainability experiments were not clearly distinguished from transition experiments or living labs.

Table 1. Comparison of the types of experiments for sustainability transitions.

Core Characteristics	Niche Experiments	Urban Living Labs	Bounded Sociotechnical Experiments	Transition Experiments	Grassroots Experiments
Starting point	Development of sustainability-oriented technology or service	Development of innovative technology or service	Development of sustainability-oriented technology or service and sustainability visions	Societal challenge	Societal challenge, ideology
Main objectives	Successful introduction of sustainability-oriented technology or service	Successful and efficient introduction of innovative technology or service for sustainable and smart cities	• Higher-order learning on sustainability and transitions • Development of a socially-embedded new configuration of technology or service and new forms of living	• Contribution to a long-term sustainability vision • Development of new forms of living • Realizing a transition	Meeting social and environmental needs through flexible, localized services
Scope	Advancing knowledge surrounding a technology or service including user needs and preferences	Advancing knowledge surrounding a technology or service including user needs and preferences	Advancing knowledge surrounding a technology or service or new forms of living and cooperation with the potential of questioning existing systems, infrastructures, practices or paradigms	Advancing new forms of living and cooperation with the potential of questioning existing systems, infrastructures, practices or paradigms	Advancing new forms of living and cooperation with the potential of questioning existing systems, infrastructures, practices or paradigms
Learning processes	• Articulating & aligning expectations • Building actor networks	• C-production (user-engagement, multi-stakeholder participation) • Multi-method approaches	• Monitoring of learning processes • Coproduction	• Transition arenas (network of frontrunners & diverse actors) • Coproduction	• Capacity-building through learning-by-doing • Bottom-up • Needs-oriented

Table 1. *Cont.*

Core Characteristics	Niche Experiments	Urban Living Labs	Bounded Sociotechnical Experiments	Transition Experiments	Grassroots Experiments
Actors	• Government, industry, research, institutions, civil society (as users) • Outsiders of the traditional system and entrepreneurs	• Government, industry, research institutions, civil society • Role of civil society as users and cocreators	• Government, industry, research institutions, civil society (as cocreators)	• Government, industry, research institutions, NGOs • Involvement of actors who are engaged with the societal challenge driving the experiment	• Civil society and NGOs as initiators, coordinators and participants
Degree of control	High	High	Limited	Limited	Low
Strengths	• Governance tool addressing specific problems with a variety of options • Exploiting windows of opportunity at the local level	• Flexible problem-solving and innovative solutions through coproduction for specific local contexts • Exploiting windows of opportunity at the local level	• Breaking down wider sustainability-goals to specific local problems which are addressed with flexible problem-solving and development of sustainability-oriented technologies or services • Room to question wider contexts, such as existing systems, infrastructures, practices or paradigms	• Flexible governance with room for reflection, adaptation and learning • Reframing societal perspective • Long-term impact on societal systems development	• Innovative diversity and alternative pathways
Weaknesses	• Isolated events at small scales (low impact) • No questioning of wider practices, systems or paradigms	• High organizational costs (time, money) • Lacking ongoing commitment of participants • No questioning of wider practices, systems or paradigms	• High organizational costs (time, money) • Lacking ongoing commitment or participants	• Time-consuming and costly • Tendency towards failure	• Securing resources to maintain activities

A literature review was conducted on the selected experimental designs for sustainability transitions, starting with an initial structured search on ScienceDirect in August of 2018, yielding 116 publications accessible via open access. This list was expanded upon using the snowball method in the consecutive years up to May of 2021, yielding 70 more results. This review of the literature served as the basis for the description of the types of experiments for sustainability transitions.

The experimental designs are introduced in order of those that follow a stricter project rationale and are more focused and structured in their design, followed by those that are increasingly more open and flexible.

3.1. Niche Experiments

Niche experiments emerged from SNM, an approach developed in the 1990s within the fields of CTA, Science and Technology Studies (STS), and evolutionary economics, in order to manage the transition of new sustainability-oriented technologies from labs to real-world applications [11]. Hoogma et al. [32] further developed the SNM approach, emphasizing the link between the technical and the social. A niche is understood as a protected space where radical innovations can be developed and mature and where comprehensive learning processes can take place (for more on this and the multilevel perspective, see [4,25]).

The starting point for a niche experiment is typically found in the development of a sustainability-oriented technology or service and the creation of a market niche [11]. The experiment aims to introduce the social dimensions to a technological development or service and to support its successful introduction. The scope is limited to building knowledge around the technological or service innovation itself, with wider institutional or cultural innovations not being regarded. For example, a niche experiment around electric vehicles would examine the viability of the technology by involving various actors but would not provide a setting where the invited actors could rethink mobility itself, e.g., through the redesign of the infrastructure and land use.

The goal is to move beyond first-order learning and achieve second-order learning to increase the chances of success. Kemp et al. [23] considered the articulation of expectations and visions between actors and the building of networks as fundamental elements, ensuring learning processes can take place on multiple dimensions. While user needs are examined and user preferences can be questioned [32], participants remain in the role of "users", being monitored throughout the experiment. Niche experiments involve multiple actors, e.g., public authorities, industry, research institutions, and civil society. The importance of engaging "outsiders" and entrepreneurs is emphasized, referring to actors who are not traditional actors of the examined technology or service, in order to reduce the likelihood of vested interests in existing systems hampering innovative new ideas and developments [32]. Niche experiments closely follow a project rationale, having a high level of control over the conditions, with the duration typically spanning between two and five years.

A case example that can be considered as typical for a niche experiment was described by Potter [33] and Hoogma et al. [32]. The project titled "Accessible Sustainable Transport Integration" (ASTI) developed a small fleet of electric minibuses and minibuses powered by compressed natural gas (CNG), consisting of three vehicles each. This service was made available to people with reduced mobility in the London Borough of Camden and included the testing of telematics technologies to enable demand-responsive servicing, which constituted the primary goal of the project. The involved actors included the initiating community transport organization, suppliers, public authorities, and users. The project was considered a success in that it could show the viability of these technologies for its chosen context.

One of the strengths of niche experiments lies in their ambition to exploit windows of opportunity at the local level. Their focus on technology and service development allows for specific problems and needs to be addressed, gaining insights into the usability and conditions of a variety of specific options. This can be used to inform decision-making processes, making niche experiments a helpful governance tool. In terms of weaknesses,

niche experiments have suffered from a lack of impact. This is attributed to the fact that they take place as isolated events and are too small in scale. Niche experiments cannot call into question wider practices, systems, or paradigms.

3.2. Urban Living Labs

The term "living laboratory" was first used by Bajgier et al. [34], with Mitchell [35] subsequently developing the concept of the urban living lab (ULL), which was described by Bulkeley et al. as "an explicit form of intervention capable of delivering sustainability goals for cities" [36] (p. 13). The European Union adopted ULLs as a central tool for open innovation in 2006, aiming to integrate external stakeholders such as research institutes, suppliers, or customers [37]. This allowed the concept to gain traction in many fields, tackling complex problems like the transition to sustainable energy or health care.

The starting point for ULLs is the development of technologies or services. A key characteristic is the integration of this developmental process into real-world systems in urban settings. Solutions are better aligned with specific market conditions through collaborative approaches where information and communication technologies (ICTs) play a central role. This integration into "real life" goes hand-in-hand with the involvement of all actors throughout the trial process phases. The focus on developing technologies and services frames the projects in a way that prevents involved actors and participants from questioning and examining wider contexts or alternatives outside the system in question.

The process phases in the ULL approach are cyclical and made up of planning, implementation, evaluation, and acting phases [37,38]. Solutions (new technologies, products, or services) are not only validated and refined with participants but also designed and prototyped with them (codesign and cocreation) to promote an exchange of knowledge between all actors (for a detailed analysis of the coproduction in ULLs, see [37]). This process allows for higher-order learning to take place. The involved actors include ULL owners, ULL stakeholders in charge of organization and implementation, ULL users who test the innovations, and ULL customers who are expected to benefit. The stakeholders are typically made up of a mix of public authorities (initiators, promoters, and coordinators); firms (providers of technologies, products, and services); research organizations (coordinators); and citizens (users). The degree of control over the conditions of these experiments is high. ULLs are small-scale projects at the local level, with their duration spanning from six months to two years or, in some cases, longer [12].

A successful example of a ULL in the context of experimentation with innovative housing models is the "Housing Innovation Lab in Boston", as described by Nesti [37]. By first engaging with residents to grasp the existing problems of high-cost housing in Boston, the project was then defined on this basis by professionals, with new solutions being communicated back to the residents for feedback. A refined solution proposal was then tested in a real-life context in the form of a compact apartment on wheels that toured the city and collected resident feedback. The ULL managed to address the research question "What is needed for compact living in Boston?". This project could show that ULLs can be very effective but require much time for the codesign and coproduction processes to take place [37].

ULLs provide opportunities to circumvent red tape and provide a space where failures can take place, serving as a learning experience. When coproduction is successfully implemented, a major strength of ULLs is the generation of innovative ideas that are suitable for a specific local context. In practice, the flexibility required for ULLs is rarely provided, with traditional project management struggling with the open structures needed for coproduction processes to work [37]. The mortality rate of living labs is very high. This is interpreted as a natural progression within a "hype cycle" and attributed to both the substantial organizational efforts required, as well as a lack of public funding, which is the main source of funding for ULLs [39]. Another challenge concerns the involvement and commitment of stakeholders and users throughout the entire process [37]. ULLs are not designed to question wider practices, systems, or paradigms.

3.3. Bounded Sociotechnical Experiments

In 2003, Brown et al. coined the term "bounded socio-technical experiments" to describe a project with specific characteristics introducing a "new technology or service on a scale bounded in space and time" [40] (p. 292). Vergragt and Brown [41] proposed that participatory visioning and back-casting exercises should be conducted before BSTEs, defining desirable sustainable futures and translating them into concrete steps to achieve this future vision, serving as a starting point. The objective of BSTEs is to solve larger societal problems related to unsustainable technologies, services, and modes of living. They are therefore strongly driven by sustainability agendas. It is not the primary objective of BSTEs to implement new technologies, services, and systems in society but to achieve higher-order learning regarding sustainability, preferences, acceptance, and system barriers and transitions [41]. BSTEs serve to advance knowledge surrounding a technology or service or new forms of living and cooperation. The potential to question existing systems or practices is therefore given. They typically have a timespan of around five years and involve a small number of participants [29].

BSTEs facilitate higher-order learning, with a diverse range of actors collectively trying new solutions, learning-by-doing, self-evaluating, course-correcting, and problem-solving [42]. For social learning to take place, the actors within BSTEs must be diverse, with the participants including technical experts, educational and research institutions, governments, businesses, and NGOs [41]. The required degree of control is limited, with enough freedom being required for participants to call existing systems or practices into question, introducing a certain degree of unpredictability.

A good example for a BSTE was described by Vergragt and Brown [41], concerning the currently ecologically unsustainable mode of personal transportation through automobiles. Despite technological changes in automobile designs and the development of the hydrogen fuel cell, it is argued that these advancements will not suffice and that there is a necessity to address the entire personal mobility system as a whole. In addition to the technological solutions, there is the possibility of more radical solutions, such as the redesign of infrastructure and land use or the increased reliance on telecommunication technologies to reduce transportation needs, or of less radical solutions, such as shifting to other means of transportation (e.g., active mobility, public transportation, or mobility services) [41]. This example goes to show how entire systems can be challenged within BSTEs beyond thinking about technological solutions, shining the spotlight on larger underlying societal problems.

Vergragt and Brown [41] listed higher-order learning as an indication that a BSTE has been successful, along with a new configuration of technology or service becoming a commercial success or ideas having been diffused beyond the project boundaries. A strength of BSTEs is the possibility to radically call into question entire structures and frameworks and consider alternatives that fundamentally differ from anything existing in practice. Due to the high demand for discussion and exchange between participants, the effort and resources required are high. Successful BSTEs can contribute to higher-order learning and to sustainability visions, but there are certain requirements: "the presence of a clear focus and boundaries for the project [. . .]; intense and sustained interactions of several professionals with a commitment to the process and the goals of the project; a sense of urgency (rooted in the time and financial pressures); agreement among the participants about the vision for the project and its social mission, and about the process; agreement among them about the core social values, and overlap among the participants' interpretive frameworks" [29] (p. 126). These basic requirements highlight the challenges multidisciplinary experiments face.

3.4. Transition Experiments

The transition management (TM) concept is credited to Rotmans, Kemp, Geels, Verbong, and Molendijk [43]. It uses "a visionary, cyclical process of agenda building, learning, instrumenting and experimenting" [44] (p. 4) in order to steer towards more sustainable developments using a series of management instruments that includes a portfolio of

real-world experiments. Transition experiments are an element of transition management carried out on the operational level. They were first described by Rotmans as "practical experiments with a high level of risk (in terms of failure) that can make a potentially large contribution to a transition process. New transition experiments are derived directly from the developed sustainability vision and transition objectives and they fit with the identified transition paths" [44] (p. 50).

The starting point for transition experiments are societal challenges. It follows that the sustainability focus of transition experiments revolves mainly around sustainable ways to meet societal needs, concerning, e.g., housing, healthcare, agriculture, or mobility [45]. Transition experiments allow for institutional and cultural innovations and calling into question existing systems, infrastructures, practices, or paradigms.

Transition experiments are considered as elements of a larger transition management that follows a learning-by-doing and doing-by-learning approach [46]. Loorbach and Rotmans [47] (pp. 237–238) conceptualized a "transition arena", which describes a specific network of frontrunners and diverse actors as a central element where coproduction takes place. The participation of civil society is not essential. The case examples presented by Loorbach and Rotmans [47] described well-defined networks made up of actors such as public authority actors, experts and practitioners, consultants, industry, transition researchers, and NGOs. While the experiments themselves are small in scale, they are meant to form a portfolio of experiments all serving to transition towards a broader sustainability vision organized within a transition management process. Transition management itself allows only for a limited amount of control, as it is subject to much unpredictability [46], often being characterized as being chaotic due to unexpected developments.

A case study was described by van den Bosch [45] by the name of "Housing and Care for the Elderly", which took place in the district Hubertus Drieschoten in Apeldoorn, the Netherlands. The question of how the elderly can live independently with a higher quality of life at acceptable costs served as the starting point for the experiment. This experiment involved participatory processes to develop visions, which were, in turn, used to develop an integrated innovative housing and care concept that addressed the dimensions of structure, culture, and practices.

Regarding strengths, Loorbach [46] (pp. 281–282) described transition management as "provid(ing) a way of thinking about governance that is concrete enough for implementation but simultaneously allows enough room for reflection, adaptation and learning", stating that it "is also a way of thinking in which limitations to control are not seen as barriers but as starting point for exploring possibilities that lack of control can offer". They also have the potential for long-term impacts on societal systems development due to the ability to redirect governance processes and reframe societal perspectives. Rotmans [44] described transition experiments as being time-consuming and costly. In addition, there is a tendency for transition experiments to fail due to their nature as projects dedicated to deep learning processes.

3.5. Grassroots Experiments

Grassroots activities towards sustainability are community-based as opposed to market-based and have been taking place for several decades—for instance, within Agenda 21 programs, which launched in the 1990s [48]. Seyfang and Smith [49] (p. 585) defined grassroots innovations as "networks of activists and organizations generating novel bottom-up solutions for sustainable development; solutions that respond to the local situation and the interests and values of the communities involved". A focus is typically placed on social innovations and greener technologies. Grassroots experiments represent an alternative to science and industry-based innovation, relying on resources such as grant funding, voluntary input, and mutual exchange, whereby the forms of organization can differ substantially [49,50].

The starting points for grassroots experiments are values, social needs, and ideology, making them dependent on a strong commitment of activists and involved communities.

While some grassroots movements may wish to grow and disseminate, others may opt to help other initiatives grow while maintaining their own limited size or do not nurture any ambition for growth at all, with a focus placed on local issues. Grassroots address social and environmental needs to provide flexible and localized services [49]. While most activities are a response to articulated problems and needs, there can be overarching political goals [51]. Grassroots experiments are needs-oriented and seek to advance new forms of living and cooperation. Within these experimental existing systems, infrastructures, practices, or paradigms are often questioned.

Capacities are built through learning-by-doing, with grassroots experiments being organized bottom-up. They are driven by NGOs or citizens, although there is typically no central innovation actor. NGOs and citizens take the role of initiators, coordinating and participating in the experiments. This affords grassroots experiments certain advantages, such as being able to tap into specific local knowledge, which is crucial for problem definition and solving [52]. The degree of control over grassroots experiments is very low because of the low predictability of their development. This is also due to the bottom-up approach and their often-precarious financial situations.

An example for a grassroots experiment was described by Seyfang [49,53] as the NU Spaarpas green loyalty card in the Netherlands, which discounts public transport tickets, for instance, when points have been collected through activities such as purchasing fair trade products or recycling household waste.

The strength of grassroots experiments lies in their function as a source of innovative diversity. They are also open and flexible enough to allow for different social, ethical, and cultural rules to be observed, which can lead to new incentives outside of what can be done within the mainstream economy. Difficulties are largely related to the resources and skills needed to keep activities going. Funding is a fundamental challenge for most grassroots innovations, affecting their ability to remain viable, as prospects for institutionalization and the diffusion of ideas into society are closely linked [54]. The local focus also causes difficulties when attempting to scale up, and the, often radical, values these experiments are built on can clash with already established commercial or policy interests [49,50].

3.6. Comparison of Concepts

All five experiment types share some core attributes; for instance, they all address complex problems with high uncertainty and revolve around learning processes involving a mix of actors. They are also all embedded in real-world settings. Regarding the innovation focus, most of the concepts deal with either ecologically sustainable development (e.g., niche experiments), socially sustainable development (e.g., transition experiments), or a combination of both (e.g., BSTEs and grassroots experiments). However, there are also some striking differences, resulting in unique types with different potentials. Table 1 gives an overview of the types of experimentation for sustainability transitions as understood within this paper, allowing a comparison.

Niche experiments focus on new products or services as parts of new systems of production and consumption and are mainly driven by the industry. They aim to include user needs and preferences to optimize the introduction of a sustainability-oriented technology or services, placing an emphasis on engaging outsiders of the traditional system. The strong focus on the development of a new technology or services with the potential for creating revenue is also found in ULLs, which show many other similarities, such as a high degree of control. The main differences are found in the stronger participatory nature of ULLs, which place an emphasis on coproduction approaches, incorporating a multitude of stakeholders not only to test and validate but also to actively create and prototype.

BSTEs differ from the previous two concepts in multiple respects, aiming to support the development of radically different sustainable ways of living. The concept encourages participants to radically question the solutions offered, a possibility not found in niche experiments or ULLs. The social dimension takes up a prominent role in BSTEs, a similarity shared with transition experiments and grassroots experiments, whereby BSTEs

are typically still tied strongly to new technologies or services in contrast to the other two concepts.

Transition experiments are driven by normatively defined sustainable futures and not by technological innovation, providing the freedom to call existing systems into question and pursue institutional or cultural innovation. Coproduction processes play a central role, with the flexibility of transition experiments leading to a high unpredictability. While grassroots experiments share a similar driver, being propelled by a desire to seek solutions for local problems, there is a core difference in all other types concerning the roles actors may take. Grassroots experiments are bottom-up processes, with there being no central innovation actor. The experiment typically starts with tangible problems being taken up by local initiatives. This is the source of both the main strengths and weaknesses of this experiment type: the bottom-up process allows for an incredible range of innovative diversity, which, in turn, allows alternative pathways to be explored, even if they run opposed to the existing dominating solutions or policies. In turn, however, this often results in a lack of support over the long term, with the required resources to keep the experiment running becoming difficult to secure.

This section has detailed the existing concepts of experimentation in length to establish their weaknesses, strengths, and fundamental differences. These make them suitable for different contexts addressing different objectives. In Section 4, this paper describes three innovative temporary housing models and then matches these with suitable experimentation types on the basis of a selection process developed from the findings of this section.

4. Temporary Housing Experiments for Sustainability Transitions

Three of the six models formulated within the WWTF-funded project are drawn upon to serve as cases of how these models, which differ in characteristics, contexts, and goals, can be matched to the varying existing experiment approaches and be conceptualized as such experiments. The three models that were chosen were the furthest developed at the time and provided a high variety in their core characteristics, which suited their purpose well: to serve as examples for the application of the proposed selection method. The working titles of the chosen three models are "Beat the Heat", "Gap Module", and "Life Sharing" (see Table 2). "Gap Module" and "Life Sharing" originated from a stakeholder workshop that was held in February 2019. Eleven experts and practitioners from different fields contributed with their expertise and practical experience. After a collective session examining potential areas, user groups, and framework conditions, smaller expert groups developed models ('stories') that would be interesting to explore with relevance for Vienna. The three developed models were sociotechnical in nature, with technical and social solutions being interwoven in order to address sustainability issues, which address wicked problems (i.e., there are no single solutions due to complex interdependencies) and require changes on multiple levels [55]. These models were assessed in an internal project meeting and chosen to be developed further. The model "Beat the Heat" was developed by the project team in a similar fashion. Through cooperation with TU Wien, architecture students in the "POP-UP SHELTER–Design Studio" course by the Japan Austria Science Exchange Centre (JASEC) provided architectural design proposals for the three models during the winter semester of 2019/2020. These designs explored different architectural visions for the models, which greatly aided the translation into concrete ideas for implementation (for more information on the developed models, see Bertino et al. 2021 [56]).

Table 2. Overview of 3 temporary housing models for Vienna.

Model	Beat the Heat	Gap Module	Life Sharing
Description	Temporary housing environment with a natural cooling system and circularity solutions for individuals at particular risk during heat waves	Housing on temporarily unused building gaps in a densely populated area with a mix of user groups, including refugees with positive asylum status	Housing solutions in industrial buildings with mix of user groups including refugees with positive asylum status and individuals currently not well-integrated into society
Focus	Increasing urban heat islands and rising average temperatures in summers	Existence of vacant building gaps which remain unused for several years	Vacancy activation or temporary use of former industrial buildings

4.1. Method

The paper applies a two-step process after first briefly portraying the key characteristics of each housing model. The first step consists of a selection process of an experimental design for the temporary housing model. Within this selection process, the objective is to determine what type of experiment is compatible with the model and what concepts can be ruled out because of a lack of congruence. To conduct the first step in a systematic way, we drew on the descriptions of the experimental designs to create an overview of their core characteristics (see Table 1). The core characteristics were made up of the starting point, main objectives, scope, learning processes, actors, degree of control, and strengths and weaknesses. Based on this table, questions A-G were formulated in order to identify similarities with specific types of experiments. The questions are as follows:

1. Does the research interest primarily revolve around the functionality and acceptance of a technology or service?
2. Does the research interest primarily revolve around new forms of living and cooperation?
3. Does the experiment aim allow actors and participants to question overarching practices, systems and infrastructures?
4. Does the experiment aim require monitoring of user behavior and acceptance? (e.g., when testing a novel technology or service in real-world conditions)
5. Does the experiment require a cocreation or coproduction process? (e.g., seeking flexible problem-solving for specific local contexts or exploring alternative pathways)
6. Does the experiment involve participants as initiators of core elements of the experiment? (e.g., needs-oriented experiments exploring alternative pathways)
7. Does the experiment require a high level of control? (taking into consideration factors such as, e.g., available project budget, involved actors and user groups, and main objectives)

While this represents a simplification, it serves to break down a project idea into fundamental qualities that can aid in the decision regarding the type of experiment. Questions A and B relate to the starting point and main objectives, questions C and D to the scope, question E to the learning processes, question F to the actors and their roles, and question G to the degree of control. These questions have been chosen based on the assumption that different combinations of these features are characteristic for specific types of experiments.

Table 3 presents an overview of the five types of experiments organized according to these questions, allowing for a comparison with an emerging project idea. The same categorization according to the questions A–G was performed for the three temporary housing models depicted in Table 4. It is likely that two or three types of experiments can pose viable options for an experiment idea, depending on the experiment aim.

Table 3. Characterization of the types of experiments according to the list of questions A–G ("x" represents "yes").

Question	Niche exp.	ULL	BSTE	Transition exp.	Grassroots exp.
A	x	x	x		
B			x	x	x
C			x	x	x
D	x	x	(x)	(x)	
E		x	x	x	x
F					x
G	x	x	(x)		

Table 4. Characterization of the temporary housing models according to the list of questions A–G ("x" represents "yes").

Question	Beat the Heat	Gap Module	Life Sharing
A	x	x	
B		x	x
C		x	x
D	x	(x)	
E		(x)	x
F			(x)
G	x	(x)	

The second step involves a more detailed description of the model conceptualized as a specific type of experiment. This illustrates how the selection of a specific type of experiment affects how a project idea is further developed.

Within the next subsections, the three theoretical temporary housing models are briefly introduced, and the two-step process is applied for each model. Within step 1, the selection process that produced Table 4 is described in more detail for each model. Within step 2, the models are then conceived of and described as the selected type of experiment.

4.2. Beat the Heat

Heat waves are becoming an increasing issue for many cities around the world, with predictions from Bastin et al. [57] showing a substantial increase of temperature for Vienna during the hottest summer months of 2050. "Beat the Heat" is a model exploring temporary housing options in Vienna during heat waves for particularly vulnerable individuals, such as small children, pregnant individuals, or senior citizens. A mix of single, twin, and family housing units of up to four people are provided. A community unit for shared use can hold up to 50 people. The units are assembled before the first heat wave and disassembled and stored for the next season after the last wave. Residents inhabit the units for a few weeks. The choice of building materials places a strong emphasis on sustainability, incorporating recycled and reusable materials. Special foundations are used to preserve the quality of the ground. A cool indoor climate is achieved without using external energy, relying on mechanisms such as evaporative cooling. The locations for these units are carefully chosen to ensure the possibility of using natural cooling systems.

This experiment involves new institutional arrangements and explores the following questions: What are the health and social benefits? How can the technical aspects of the experiment be optimized regarding construction and deconstruction, as well as sanitary solutions and energy provision? How can the target group effectively be reached and mobilized? What activities can be provided on-site to increase well-being and promote social interactions?

4.2.1. Step 1: Selection

"Beat the Heat" explores short-term sustainable housing options with appropriate climate comfort for vulnerable individuals. This starting point frames the experiment in

certain ways. It provides a good opportunity to explore several subjects, such as circular building concepts, low-tech green technology, or the recruitment process. The model does not aim to explore new forms of living and cooperation, not involving cocreation or coproduction processes but monitoring user behavior and acceptance. Overarching practices, systems, and infrastructures are not questioned. The experiment is government-initiated and requires a high level of control and structure.

When comparing "Beat the Heat" in Table 4 with the types of experiments in Table 3, it shows the most similarities with niche experiments, with ULLs also being a viable option. Due to the short duration of the housing phase of this experiment (days to weeks), no coproduction processes are planned, and well-being is assessed via monitoring. Therefore, the choice is made to conceptualize "Beat the Heat" as a niche experiment.

4.2.2. Step 2: Experiment Description

"Beat the Heat" as a Niche Experiment

The initiators and coordinators of the experiment are individuals from government and interdisciplinary research institutions. The implementation team on-site includes medical, care, and facility staff to ensure the safety of the participants. The recruitment and registration of participants take place months before the housing phase during which different ways of identifying and recruiting participants can be explored. A focus is placed on the districts most affected by heat islands in Vienna. The construction of the building units takes place between June and August. The housing stage itself is relatively short, spanning two weeks. The experiment assesses the effectiveness of the model as a solution for particularly vulnerable groups during heat waves in Vienna; therefore, the health and social benefits are assessed using both quantitative and qualitative methods. The air temperature differences between the apartments of the inhabitants and the "Beat the Heat" housing units are measured, as are key data for the applied technical solutions and observations concerning their use. Members of the medical and care team perform check-ups on the participants and assess their perception of the thermal environment and well-being. An important aspect to explore involves activities for the inhabitants. At the end of the housing phase, the inhabitants provide feedback on their lived experience within a brief concluding interview. The building units are deconstructed and transported for storage, and the research team analyzes the collected data. This concludes with concrete suggestions for adaptations to be incorporated in future implementations.

4.3. Gap Module

"Gap Module" describes a temporary multi-story building with private units that is placed in a vacant lot in an urban context. The private units are very compact, maximizing functionality in a minimal space. In order to promote social integration, a resident mix of students or individuals in higher education, individuals with an interest in intercultural exchange and sustainability projects, and refugees with approved asylum or individuals affected by homelessness or longtime unemployment is introduced. Larger community rooms, such as cooking and dining areas, workspaces, or storage spaces, are also part of the housing environment. Next to the concept of minimalism and collectivism as a strategy for sustainability, this model also focuses on the possibilities of integrating temporary housing into the neighborhood and promoting exchange by offering various events or services to the public. The duration of residence and stay of the building spans 2–5 years.

The experiment pursues the questions: How small can private living spaces be, provided there are sufficient shared spaces (in the context of minimalism and shared spaces as a sustainability strategy)? What kind of integration potential do different services, events, and activities hold? What does sustainable urban living mean in a densely populated area?

4.3.1. Step 1: Selection

The research focus is placed on neighborhood integration, testing the acceptance and resonance of different offers and services provided by inhabitants. While some activities are

predetermined by the project team, inhabitants can also develop and realize project ideas. A fundamental element is the exploration of new forms of living and communication with a great emphasis on communal spaces. This model can revolve around the functionality and acceptance of a technology or service and around new forms of living and cooperation. Actors and participants have the possibility to question overarching practices, systems, and infrastructures. When testing novel technologies or services, user behavior and acceptance can be monitored. The required level of control is limited, with possibilities for cocreation and coproduction processes. Inhabitants do not act as initiators of the core elements.

Comparing the "Gap Module" in Table 4 with the types of experiments in Table 3, we find that it is well-suited as a BSTE.

4.3.2. Step 2: Experiment Description

"Gap Module" as a BSTE

The initiators and coordinators of the project are individuals from the government, interdisciplinary research institutions, and NGOs. Social workers are incorporated to ensure that the needs of vulnerable inhabitants with limited options regarding housing are met. The duration of this experiment spans 2 years. Different recruitment strategies are explored for the different groups in the resident mix. To examine the effects of small private living spaces, units of different sizes are compared by observing frequency and type of use of shared spaces, as well as well-being. Inhabitants have the opportunity to actively engage in and provide services and activities for the neighborhood to promote exchange and integration. Four activities are initiated and organized by the project team: a paid storage service managed by the inhabitants, weekly joint cooking and dinner events with the neighborhood in the community kitchen, creative workshops surrounding sustainable urban living, and an annual open house event, where inhabitants share their experiences with this form of living. New ideas for activities and projects can be initiated by the inhabitants with the available rooms and resources.

It is feasible that not all offers will be taken up by the inhabitants and that some activities may fail. To assess the different types of activities, the research team will continuously observe their development throughout the housing phase. The neighborhood response will be queried to gain insights on the impacts of different activities.

4.4. Life Sharing

"Life Sharing" explores innovative and sustainable housing solutions to promote the social integration of refugees with positive asylum status and individuals affected by homelessness or long-term unemployment. The resident mix also includes young individuals with high motivation for intercultural exchange and an interest in exploring new communal ways of living. Temporary housing units are built within preexisting (temporarily) unused buildings, such as industrial halls, which did not function as living quarters in their previous use. Private living modules are placed within these buildings. The private units are small, while the shared common space is large, providing much room for common areas, e.g., community kitchens. Flexible shared spaces where social interactions can be organized and take place have an important role. Much freedom is provided for the inhabitants to self-organize, including possibilities to structure a space and do-it-yourself building. At maximum capacity, the environment houses around 80 people. The duration of stay should span between several months and one year, while the units have a lifespan of one to two years on-site.

The experiment strives to enhance the capacity for inclusive, integrated, resilient, and sustainable urban living. The inhabitants are actively engaged in shaping their living environments in the context of more sustainable lifestyles, characterized by communal living, waste prevention, recycling, and reuse. A particular focus lies in the integration of individuals who find themselves in a phase of transition.

4.4.1. Step 1: Selection

"Life Sharing" does not primarily revolve around the functionality and acceptance of a new technology or service but provides a frame, space, and materials for participants to create and explore new forms of living and interaction, allowing the possibility to develop alternative ideas of how sustainable living can be organized. Overarching practices, systems, and infrastructures can be questioned. The experiment includes a strong cocreation aspect, with participants being empowered to initiate their own activities. Participants are given a central role as initiators of the core elements of the experiment, allowing the processes to be needs-oriented and creative. The level of control is therefore inherently low.

When comparing the column of "Life Sharing" in Table 4 with the types of experiments in Table 3, we found that we can exclude niche experiments and ULLs. Transition experiments or grassroots experiments both appear to be a good fit. The starting point is a societal challenge, with the experiment attempting to innovate how integration can take place through new forms of living, which is characteristic for both types of experiments. This paper conceptualizes "Life Sharing" as a grassroots experiment, exploring an innovative variety and alternative pathways for sustainable and communal living through a do-it-yourself approach. This exercise explores to what extent it is possible to introduce grassroots elements into a research project by providing a space with resources that can be freely organized to support bottom-up solutions. It is evident that an authentic grassroots experiment cannot be planned as a research project, because research projects possess structures not compatible with bottom-up processes. This should therefore be regarded as a hybrid between transition and grassroots experiments.

4.4.2. Step 2: Experiment Description

"Life Sharing" as Grassroots Experiment

The initiators and coordinators of the project are made up of individuals from the government, research institutions, and NGOs. The research team should be interdisciplinary, possessing competence in social science methods and expertise in organizing participatory processes. Since the target group involves individuals with limited options regarding housing, care must be taken that participation is optional and informed by the expertise of social workers. Inhabitants must be able to end their participation without facing uncertainty regarding housing. This experiment attempts to capture elements of the grassroots spirit, introducing a sandbox component within the model where inhabitants can freely create and shape, led by their own needs and creative energy. More specifically, "Life Sharing" contains a do-it-yourself building and self-organization approach, allowing for the generation of novel bottom-up solutions and learning-by-doing. Space is provided in the form of a building with all the necessary fixtures and resources made available. The project also provides flexible modules for both private and communal units, which can be arranged to serve a multitude of different purposes, such as creating spaces for living, relaxation, doing group or sports activities, pursuing creative or educative activities, and more. The inhabitants are actively involved in the planning process and are given complete control over these multifunctional modules, restricted only by the given infrastructure that predetermines the arrangement of the private units, bathrooms, and kitchen appliances. The role of the research team is restricted to introducing the project, managing the available resources, organizing workshops, serving as contacts, and monitoring developments to ensure safety and well-being. During the planning phase, they provide guiding information, and practical workshops are organized for the participants to acquire and learn building skills. The construction phase takes place under the supervision of professionals to ensure the safety of the construction. During the housing phase, members of the project team regularly visit and monitor the site, and a house manager is assigned.

This experiment is explorative in nature, making it difficult to predict its development and requiring much flexibility from the project team. Near the end of the experiment interviews are held with the inhabitants, exploring their experiences in greater depth and

elaborating on the questions of community-building and integration, decision-making processes, and encountered challenges.

5. Conclusions

In this paper, we compared the existing concepts of experimental designs in the field of sustainability transition, detailing their strengths and weaknesses to highlight their differences and draw attention to their special features. We also introduced a process for the selection of suitable experimental design, answering the question "What is a robust method when selecting between experimental designs for sustainability transitions?" The method we developed consisted of seven questions that focused on the core characteristics. We applied this process to three temporary housing models differing in their framework conditions and aims in order to test and demonstrate its effectiveness. We observed the selection process to work well, allowing to exclude experimental designs that did not match the framework conditions and aims, thus leaving only one or two types for further consideration. The chosen examples still had some open questions concerning details of their designs. For example, when selecting the process for the "Gap Module" housing model, the possibilities for cocreation and coproduction processes were given, but no decision had been made concerning their incorporation, and the corresponding question E was marked with an x in parentheses. We attempted to create a selection process that could work with a few select characteristics, as not all decisions surrounding the experiment would have been made at this stage in the selection process. What is important to consider is what possibilities are given. In the second step of the process, we specified the examples further as the experimental designs we chose through the selection. With this exercise, we demonstrated how the selection of a specific experimental design influences the further development of a project idea by affecting the possibilities and limits. An important next step would include a closer examination of the project management side regarding the concrete planning of such an experiment.

The chosen seven questions represent a simplification, breaking down a project idea into fundamental qualities. As such, they are subject to criticism and change. The introduced selection process requires validation beyond the models they were tested on within this paper in order to explore whether the appropriate and most suitable questions are being asked or whether the set of questions should be expanded. It would be interesting to closer examine the aspect of scaling, for instance, which may hold potential in this regard. Another significant limitation is that the concepts for experimentation for the sustainability transitions are continuously evolving. Consequently, this work will require future updates.

The main purpose of the selection process is not necessarily to identify the one perfectly suitable experimental design—it is more about promoting conscious decision-making where each experimental design is recognized as having unique strengths that are suited to specific framework conditions. We therefore consider the improving of the concepts as an important contribution.

Future research can build on these findings and further explore the distinctive methodological features of the different experimental designs. Further analysis of the respective potentials and framework conditions of real-world experiments could also contribute to the improvement of known designs or even to the development of new forms of experimental designs. Regarding the further development of the selection process proposed in this paper, it would make sense to use sustainability experiments that have already been conducted and evaluated as an empirical basis to further address this question, e.g., by comparing the initial expectations with the actual outcomes.

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