Chapter 7
Responsible Research, Innovation, and Socioscientific Inquiry Approaches in a European Teacher Education Project

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Abstract Despite some decades of advocacy for the teaching of socioscientific issues in school science, science educators have struggled to establish these ideas as central to either curricula or teacher education. This chapter describes the experience of teacher educators in the EU-funded PARRISE project, working with pre- and in-service teachers to represent responsible research and innovation (RRI) through the development of a socioscientific inquiry-based learning approach to teacher education. The data for the research came from interviews with key players in the project, from 10 countries, describing their experience of the PARRISE process and of working with teachers to establish an inquiry-based learning approach to both scientific content and socioscientific issues (SSI). The chapter describes the challenges teacher educators faced in establishing SSI approaches in their courses, with constraints imposed by different curriculum framings and teacher education system factors that affected innovation. We describe the way in which the project framing developed over time in response to a variety of innovative approaches developed by members, with project meetings focusing on relations between inquiry science teaching, SSI teaching, the RRI construct, citizenship, and action. We describe the key aspects of the approaches to pre- and in-service education that proved successful in engaging teachers with this work, and particularly the value of co-design processes around local issues carried out with in-service teachers over time.

Keywords Responsible research and innovation · Inquiry-based learning · Teacher professional development · PARRISE project

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Y.-S. Hsu et al. (eds.), *Innovative Approaches to Socioscitific Issues and Sustainability Education*, Learning Sciences for Higher Education,
https://doi.org/10.1007/978-981-19-1840-7_7

7.1 Background

Over the past few decades, there have been many European Union (EU) funded projects in science education that involve multiple countries sharing and negotiating programs and ideas that promote innovation (http://www.scientix.eu/projects), as there have been in other areas. Such pan-European projects inevitably face challenges in exploring and advocating new practices while requiring collaboration between countries with differing histories and cultures, differing system features and constraints, different pedagogical traditions, and different languages. A large part of the design of such a project thus involves developing processes to maximize the possibility of achieving shared meaning, effective innovation that transcends these traditions, and effective collaborative and communicative opportunities (Bernard, 2013; Toprak & Genc-Kumtepe, 2014; Uhlenwinkel, 2017).

One such project is PARRISE (Promoting Attainment of Responsible Research and Innovation in Science Education: http://www.parrise.eu/), an EU-funded project that developed an approach to representing Responsible Research and Innovation (RRI) in schools. This was situated within increasing concern about the drivers of social impacts of science and technology research at industry and policy level, represented for instance by the European Union Horizon 2020 project (https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation), which described RRI thus:

> Responsible research and innovation is an approach that anticipates and assesses potential implications and societal expectations with regard to research and innovation, with the aim to foster the design of inclusive and sustainable research and innovation.

The PARRISE project, which ran from 2014 to 2017, involved 18 institutions across 11 European countries and was managed out of Utrecht University, Netherlands. An initial and ongoing challenge for PARRISE was to translate the RRI construct into the schooling context. This involved the creation and ongoing refinement of an innovative framework (SSIBL: Socioscientific Inquiry-Based Learning) that brought together RRI with Inquiry-Based Science Education (IBSE), Socioscientific Issues (SSI) and Citizenship Education (CE). The focus of PARISSE was on developing approaches to Teacher Professional Development (TPD: Pre-service and In-service) through the SSIBL framework, which was interpreted and developed using a design-based research approach (Plomp, 2013) across the three years of the project. The project involved clusters of teacher educator researchers at primary, lower secondary, and upper secondary levels, collaborating and communicating across three years with a system of reporting and discussion of initiatives at different levels. Some partners mainly worked with pre-service teachers, others worked also with in-service TPD, and some informal learning centers were involved. Partners' teams varied considerably in their past involvement in inquiry teaching (IBSE) and teaching of SSI. There were three major workshops held at yearly intervals to share

and coordinate ideas and ongoing activity, with smaller, more focused "work package" online meetings held semi-regularly between these. The project produced a large range of resources for teacher education and also for schools. It was evaluated as very successful by the funding body.

7.1.1 Description of the SSIBL Framework

The SSIBL framework (Amos et al., 2020; Levinson & the PARRISE consortium, 2014, 2017) drew strongly on a range of contemporary science education literatures including IBSE (Rocard et al., 2007), SSI (Hipkins et al., 2014; Levinson, 2006; Sadler, 2009) and the parallel construct of socially acute questions (Morin et al., 2017; Simonneaux, 2014), critical CE (Bencze & Carter, 2011; Johnson & Morris, 2010; Levinson, 2010) and post-normal perspectives on science (Ravetz, 1999). PARRISE also drew on activist-oriented science-technology education projects such as STEPWISE (Bencze, 2017; Bencze & Sperling, 2012). The first developed draft presented a framework that included an explication of the rationale for SSIBL, the nature of exemplar activities, criteria for successful implementation for teachers and students, and of possible pathways to developing SSIBL Teacher Professional Development (TPD). The document provided a focus for ongoing discussion and refinement over the three years of project meetings, and an updated version was developed following the meeting of the consortium in Toulouse in May 2017. This version was able to draw on the experience of partners over the project. A further and final refinement emerged in the final stages of the project (see Fig. 7.1) that emphasized the interactions between the different elements embodied in SSIBL. A key feature of PARRISE, therefore, was the existence of an innovative and challenging theoretical underpinning, that was not settled from the outset but was subject to refinement through the collaborative efforts of all partners.

The PARRISE project poses significant challenges to traditions in science education, combining a number of strands of theoretical and epistemological advocacy each of which calls for significant change in teacher beliefs and practices. The 18 partners across 11 European countries represented a diverse community across which varied responses to the project purposes were developed, compared and debated, and refined to produce a communal shared purpose. Analysis of plenary reports during the program of joint meetings of partners in the PARRISE project, supported by the informal observation of the discussion over three years of these meetings, demonstrated evidence of significant change in Teacher Professional Development (TPD) practices over two years, and in the growth of shared understanding of the core principles underpinning PARRISE. However, it was also clear that partners appropriated the SSIBL framework in ways that reflected their countries' curriculum practices and traditions, their TPD structures, and their epistemological beliefs concerning research practices, and the nature and status of science and scientific knowledge. This circumstance reflected the diversity of European traditions.

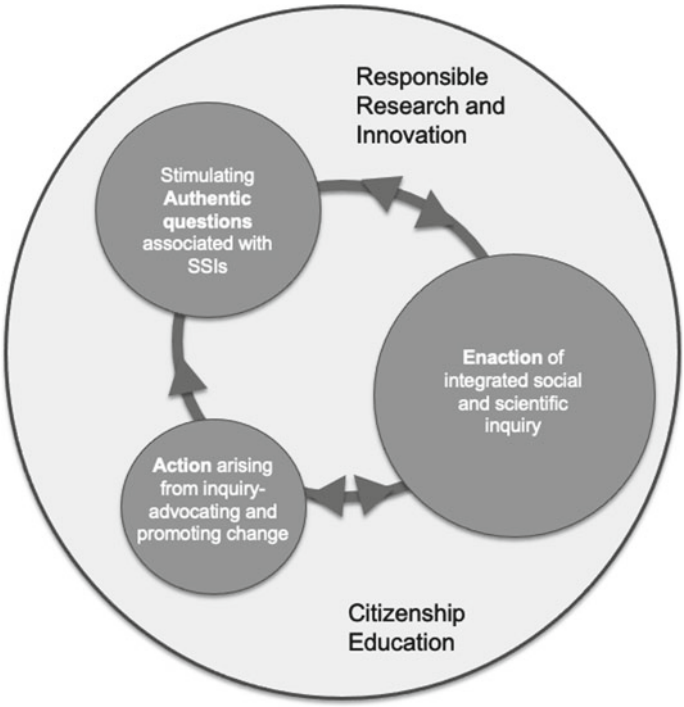

Fig. 7.1 Core features of the Socioscientific Inquiry-Based Learning (SSBL) framework, adapted from https://www.parrise.eu/our-approach/

Research findings reported in this chapter were collected through interviews with representatives from 10 partner teams. They illustrate the processes through which partners from varying educational traditions and contexts across Europe negotiate meanings and share processes of educational innovation. The interviews paid particular attention to partners' responses to the communication mechanisms and program structures, to the way meanings were conscripted within the different contexts, and the ways in which shared meanings were established. The study aimed to examine the processes by which the SSIBL pedagogy framework was employed by the different partner teams for their purposes, and the nature of the communal negotiation and individual pathways to understanding during the project development. The cases are presented as illustrative of change processes attendant on European innovation projects and intended to provide insights into the broader European union project and the way that innovation around SSIs, inquiry learning, and critical citizenship education intersects with different education and epistemological histories and beliefs. The research questions are:

1. What challenges did teacher educators face in establishing SSI approaches in their pre-service and in-service teacher education activities?

2. How did understandings of effective approaches to SSI-focused teacher education/professional learning develop over the life of the PARRISE project?
3. What were the differences in context, the local factors, and the shared processes in the PARRISE community, that have influenced the pathways of change?

We believe that understanding the nature of differences in perspectives, beliefs, and practices opens the possibility of better understanding the challenges and possibilities of cross-European collaboration around SSI teacher education.

7.2 Methodology

The research utilized a phenomenological methodology, exploring participants' perceptions of the nature of the change process and the meaning attached to the SSIBL pedagogy within individual contexts. The data for the study were generated through interviews conducted by the authors using the zoom online meeting platform with representatives of 10 partner groups, from 10 different countries, and representing a mix of pre- and in-service TPL, and primary and secondary focused initiatives. The interviews were semi-structured and the questions related to interviewees' experiences of the project and nature of initiatives, project processes affecting these, the extent to which a common understanding of SSIBL was achieved, and sustainability issues. The interviewees also included two members of the PARRISE management team and the lead author of the SSIBL framework. Questions of the management team related to key successes, challenges, and perspectives on the diversity of response across the consortium, and on change. Questions of the SSIBL framework author focused on the background and context of the framework, its role in PARRISE, and the ongoing processes of refinement.

The transcripts were analyzed by the two Deakin researchers with RA support and preliminary themes identified and refined that represented all the interview data. These were then refined in collaboration with three critical friends who along with one author had been members of the PARRISE external advisory board, and "meta-themes" identified. Further refinement of the themes occurred after presentation to and feedback from the PARRISE community.

7.3 Findings: Themes Emerging from Participant Interviews

The interviewees illuminated change processes within PARRISE and provided fresh insights both into the broader European Union project, and the way that innovation intersected with different education and epistemological histories and beliefs. The themes were:

- The intent and nature of SSIBL;

- The structure of TPD initiatives;
- The development and use of exemplary activities;
- Key changes to practice;
- Responses to the SSIBL framework; and
- Experiences of communication and collaboration.

7.3.1 The SSIBL Framework

The perspectives of the main architect of the SSIBL framework provided insights into the genesis of SSIBL and the challenges. The genesis of the SSIBL framework stemmed from a desire to "*take what has been a conventional role of scientific inquiry and to see how you can make something which has a much broader significance.*" The intent was to provide room for consideration of social questions and move beyond empiricist notions of inquiry. The challenge in developing the framework was to bring what was considered the "three pillars" of inquiry, SSI and CE, together with RRI in a way that was meaningful. This represented a desire to move beyond SSIs to take up the broader European conception of social responsibility encapsulated in RRI. This was particularly expressed through the emphasis on action, going beyond understanding, and reasoning. The possibilities for this to occur varied across the partner countries. For instance, in one of the partner countries there were real possibilities because in the curriculum "*there is obviously a real commitment to interdisciplinary work and getting kids involved in environmental projects*," whereas in other countries the curriculum was, and remains much more rigid.

This variety of contexts and associated traditions across the European countries was increasingly recognized as a strength as the project progressed. Differences in experience and beliefs led, through dialogue at the annual conferences and smaller, regular sub-group meetings, to the forging of new understandings of how the approach could work. Partners who were initially conservative in their views were subsequently quite open and developed their practice to do interesting things. The project leadership:

> … provided an atmosphere where people can genuinely talk about problems without feeling unduly defensive about things … There've been quite interesting synthesis or synergies between different countries, different ideas. People are prepared to talk about the problems, now I think that has been extraordinarily impressive ... it's really got people with very different ideas talking to each other in a way that probably wouldn't be possible in another forum. (Interview: SSIBL main architect)

7.3.2 The Structure of TPD Initiatives

A major theme in the interviews concerning the structure of the PARRISE initiatives is that of fitting SSIBL approaches within existing structures, particularly those

concerning time. Partners mainly focused exclusively on pre-service or in-service TPD, although some were involved in both. The issues for each were distinct.

For partners who did not customarily run in-service TPD, exploration of SSIBL within the pre-service courses was the path taken. The main challenge for these was fitting it into the existing curriculum.

> We have the chance to introduce SSIBL activities within different subjects in the graduate or post-graduate course. In order to be able to do so, you have also to identify what kind of content within the graduate course or the post-graduate program can be aligned with a SSIBL model.

For one partner this was done through an SSIBL day with the option of an action research project on SSIBL. For another partner, there was a problem with convincing colleagues to incorporate SSIBL activities, and they had more success in convincing other universities to innovate through their links into a national network of teacher educators. Thus, apart from structural issues, teacher educator beliefs were a challenge.

For incorporating SSIBL into in-service TPD, there were a range of challenges described that reflect findings in the research literature regarding SSI innovation. Several partners found the recruitment of teachers difficult. In some cases, teachers were resistant to spending time on approaches that were not directly applicable to the curriculum, given its overcrowded nature and their own lack of time. Some teachers were committed to laboratory work and reluctant to take time from this. For another partner, accreditation of the TPD was an issue. In at least three cases, a solution to recruiting and promoting SSIBL was to work through science centers, or teacher education centers with a special relation with teachers. Such strategic partnerships were a feature of many of the partners' strategies to promote the approach.

For others, the issue for teachers was epistemological, involving a belief that inquiry approaches do not generally, or at least efficiently, lead to robust scientific knowledge, and that the SSIBL approach would de-emphasize this focus on scientific knowledge.

One interviewee clearly articulated the different resistances from teachers that they had to overcome. These were:

1. A resistance to including non-objective knowledge into the science curriculum: "*Once we started to talk about atomic energy, nuclear energy, some of the TPD participants said, 'Oh, are you talking politics? It is simply not appropriate at this university. …We are scientists that try to be impartial'."* This team countered with the importance of citizens being able to engage with relevant science related issues that involve more than objectivity.
2. In a crowded curriculum, there was no time available if the standard of knowledge is not to be diluted. "*So, then we had to look at the different schools and the different school culture. Whether they have projects. Whether they have science center visits, and informal learning opportunities at the same time.*" This team tapped into this informal learning culture to support the introduction of SSIBL projects.

3. Some teachers were not drawn to discussing issues that had no clear resolution but were committed to describing what they considered as truths.

In this and other teams, partners learnt to adjust the TPD to teacher preconceptions, probing teachers' experience with elements of the framework and engaging them with co-design activities: "*… it's not just about informing but it's also about engaging them in how to put what they have been learning in[to] practice.*" Several partners worked closely with teachers through a type of design research cycle, learning to refine SSIBL activities to local contexts and teachers' growing experience.

7.3.3 The Development and Use of Exemplary Activities

An ongoing debate within the project was whether TPD should begin with an exposition of the SSIBL framework or with activities that exemplified the approach, and later examine the principles underpinning these. Most partners combined these approaches with some back and forth between the two. However, it was clear that partners who could talk of a developmental sequence in their TPD design were clear about the need to feed in examples of classroom practice and engage with teacher beliefs and concerns.

> I think the strength has been sharing our own experiences of the different teaching examples and the responses of our teachers and teacher students … having to really think harder about our own experiences and sharing our own experiences. I have learnt and realized that it is important to find ways to challenge the teacher's beliefs and working with them so that they also have the possibility to see the effects of different teaching traditions.

Over the course of the project, there was growing recognition of the need to produce clear criteria for SSIBL activities to guide teachers and guide the design and conduct of TPD. This attention to design principles took various forms in different partners' practice. For the two French partners, for instance, the "démarche d'enquête" (Simonneaux et al., 2017) was important as an investigative framework, separate from SSIBL, that was used to guide design of SSIBL activities. For another partner, there was an explicit movement in the TPD from discussion of the underpinning ideas, to engaging teachers as learners to work through SSIBL activities, then gradually to have them think about their own context, and work in small groups to redesign, or add to these activities or design new activities.

> And I think that they learn a lot during this process as well because it's a different thing hearing or acting as students and someone else designing for them, [compared to] if you try to design something for your own students that you are expected to enact.

Another partner was explicit about a similar development of their TPD, from focusing on illustrative activities to teachers designing their own activities.

> Instead of just presenting them the key features of the SSIBL model in a theoretical way and lecturing them about how wonderful our science education model is, we introduced them in

> a SSIBL scenario and asked them to explore it, discuss it, inquire about it, and looked for a solution. After that, we asked them to reflect on the educational potential of going through all these processes and try and identify the kind of contents and competencies that they are using when trying to solve the SSIBL activities.

The next phase involved having teachers design their own activities according to context.

> One of the teaching skills that we have struggled with, and I think it has made us evolve our teacher professional development model, is a skill related to designing SSIBL classroom activities, because the first time we implemented our teacher professional development, we didn't pay attention to designing activities, we just gave concrete examples and asked teachers to work on them.

The results, measured against a set of "quality criteria" they had developed, were disappointing. However, in the next, third iteration teachers worked collaboratively with the criteria leading to impressive outcomes.

> … we gave the criteria in advance, and after their first design, we asked them to revise their own design according to the criteria again and try to improve it. We used self-evaluation and peer-evaluation for improving the designs of the SSIBL activities that the teachers made themselves. This last time, they produced an amazing set of really good SSIBL activities according to the criteria we drew from the SSIBL framework.

The quality criteria for designing SSIBL learning sequences were the focus of discussion throughout the project and varied depending on context. The developing SSIBL framework, however, proved useful in drawing attention to the major features: framing and stimulating interest in authentic questions of science-society scenarios; enacting an inquiry process through mapping controversies and generating data related to values as well as science, identifying risk and uncertainty; and deciding on appropriate action.

7.3.4 Key Changes to Practice and Consensus Over Time

Many of the changes partners talked about related to improvements in the way they ran their TPD initiatives and better understood the essence of SSIBL. Partners started at different points, so it is difficult to describe a simple change trajectory. In some countries, TPD practices had included IBL and SSI for some time. The most common change described was one from a focus on scientific inquiry structured around scientific ideas and laboratory-based evidence, to one where a socioscientific issue or question drove the investigation, often over a longer sequence.

> So, for instance, we had a project on DNA and it was all about letting teachers and children know what DNA is and how it works, and then for the PARRISE project we took DNA as an example project. For them, we said, okay, DNA, you have to know what it is first, sure, but then also we thought about if you can get the DNA and you can use it, for instance, to find murderers and they come to you and they ask you, "Do you want to give your DNA to us so we can look for a possible murderer in your family?"

With some interviewees there was a recognition of the paradigm change implied by the SSIBL framework, such as for pedagogy, moving away from lectures and laboratories to pedagogies and settings designed to promote critically informed citizens.

> This very different approach with very different learning outcomes requires a very different educational model. We have to somehow transfer this model to the way we work with teachers also, because the way we work with teachers from our point of view has to be consistent with the kind of science education model we want them to take into their classrooms.

Several interviewees talked about change in understandings over the three years of the project across the consortium more generally. They described:

- Developing understanding about how the pillars interrelate in practice; and
- Growing confidence with the nature of SSIBL activities.

> We evolved quite a bit. And then (at) the first meetings people were really concerned about whether or not they would be able to understand what they were talking about and what each of the four dimensions meant to one another. But now I feel that the questions and the issues that we raise are more fine-tuned.
>
> We have all been better at including more of the aspects of it but are doing it with different tools or different examples or different ways of running the workshops.

These reflect a growing understanding of the variety of practices and activities that came to exemplify the SSIBL framework, allowing discussion to be more grounded in TPD and school activity. There was a clear impression from the interviews that being part of PARRISE had widened the perspectives of individuals, through interacting with a diverse set of people and ideas, and contexts.

7.3.5 Changing Interpretations of and Responses to the SSIBL Framework

Partners' underlying views during the project were that the nature of the SSIBL framework was evolving. There was a tension between the need for clear prescriptions of what SSIBL should look like within a TPD course and within schools, and an acknowledgment that the role of PARRISE was to explore and refine the framework. Some interviewees were explicit about the strength of contextual variation in interpretations of the model.

> So, if we have a model that can be really useful in different contexts and can be enacted in very different ways, that tells me it's a powerful model. In this way, I think that because of the way the project has been designed, it gives room for a lot of freedom and flexibility, and it came out as a strength. On the other side, maybe this flexibility sometimes has drawbacks. For instance, if we think of evaluation, we didn't agree on a common framework for evaluating from the beginning.

A key challenge for interpreting the framework was to better understand how the SSI and IBL could be integrated in practice, and secondly how RRI was positioned in

the framework. Over the project, there were changes in perceptions of the role of RRI, which varied from regarding it as an overarching theme sitting in the background, to recognition of its significance as a pillar.

The following quotes emphasize the focus on active citizenship implied by RRI:

> If I had to identify what kind of key features in our model could be directly related to responsible research and innovation, I would say that taking into account different perspectives could be one. Really appreciating democratic deliberation could be another one. The idea of a sharing ideas, debating, discussing, and looking for consensus on an appropriate decision of a group–by the way, contrasting views, different views could be another one. Taking action could be another one.
>
> … [the] part that's really differentiating us in the SSIBL framework from other people's and other RRI projects' approach, this emphasis on more active citizenship as the outcome of this engagement with the material. So, we want students to take action which can be demonstrated in many different ways.
>
> We don't explicitly address RRI … Maybe a good way into this is thinking about consumer risk because it's all about how products have been created and it's the decisions we make in relation to the stuff we consume that might have been produced in a responsible and ethical way.

There was a general view that partners had achieved a reasonably consistent view of the framework but that there was contextual variation in how it should or could be applied. It was acknowledged that flexibility in the interpretation of the framework was a strength and that because of this variation its role in the project had been stimulating.

> It's rich enough to be flexible.
>
> I could see that there were other partners in the consortium who interpreted some features in a very different way from mine, and the exchange of perspectives and ideas and conversations have really had an influence on my view also, and I could see that my view had evolved throughout the time of the project. I think it is always enriching, because you have the opportunity to look at things from different perspectives and to connect these different ways of looking at things with concrete examples from different people.

Partners described the value of realizing their own problems and solutions were shared by others even if the education context was very different.

> It is very interesting to witness that some of the problems that we encounter are actually common amongst partners regardless of the specificities of our specific school context. So, it's very useful to understand that people in other countries are actually dealing with the same problems our teachers are dealing with.
>
> It's been very useful to share ideas and to share materials … to hear about scenarios that other partners have been using. Then strategies like the SSIBL strategy that is included in the revised framework because we've been working with the teachers on how can you phrase good SSIBL questions? We found that really useful.

7.4 Discussion

Three circumstances were key to framing the PARRISE project: First, it followed a number of projects focused on inquiry science, that members of the consortium had previously participated in. Second, with bringing together several strands of science education pedagogy and beliefs, and linking these with the wider call for RRI within Europe, the project was complex, forward-looking, and challenging. The ideas being promoted, those of education of a critical citizenry through science education and linking responsible research with classroom processes, were both new, and challenged long-standing traditions within the subject. Third, the background and contexts of the partners varied widely. Some systems had established inquiry practices while others had not. Some partners had long experience with research in SSI. Some were from strong traditions of academic disciplinary knowledge. There was a variety of experience of sustainability project work.

Nevertheless, there is substantial evidence that partners developed over time a substantial commonality of interpretation of the SSIBL framework together with a variety of approaches to TPD that overall enriched the SSIBL conception. There is evidence that the project processes opened various lines of communication and collaboration that enriched partners' understandings and practices. Given this, it is useful to examine the evidence from these interviews to ask: What have been the enabling features of PARRISE, what have been the challenges, and what does the project tell us about the process of educational innovation in European science education?

7.4.1 Negotiating Complexity Through Diversity

Partners' experience of PARRISE was productive but varied. In many ways, the story of the project was one of response to complexity—in two senses.

First, there was wide variation among partners in their background regarding the SSIBL pillars of IBSE and SSI, and different commitments and beliefs about science education. There were also different traditions of TPD including primary–secondary differences, and different curricular and other structural constraints that imposed limitations on the possibilities of innovating around SSIBL. Access to teachers, and freedom to vary pre-service courses, were among these.

Second, the complexity and epistemological challenge presented by the SSIBL framework was a major factor in framing partners' experience of PARRISE. A key aim of the SSIBL framework was to move science education away from an empiricist framing and a predominant focus on positivist conceptions of knowledge and learning, toward a more socially critical conception of scientific practice with an orientation toward education for citizenship and responsible research and innovation. This conception provided a considerable challenge to existing traditions and proposed

an interaction between at least three different strands of reformist movements in science education.

Given these complexities and the relatively open form of the framework at the beginning, one might have expected that the project would have been in danger of dissolving into disparate camps. Yet the experience of consortium meetings, and the evidence from these interviews, indicate that a relatively robust commitment to the SSIBL vision was forged, and a reasonably consistent view of SSIBL was achieved over time. It is important to note that not one interviewee voiced concerns that the project had been unproductive. All seemed committed to its basic principles and spoke positively of their experience in the project. It is interesting to consider, given the contextual constraints, how this has occurred. What were the features of PARRISE that led to these outcomes?

7.4.2 Diversity of Responses to the SSIBL Framework

Response to the SSIBL framework over time developed in different ways for different partners. For many, who had experience of and commitment to inquiry science (IBSE), the issue became how to expand notions of IBSE into socioscientific issues. For others with an SSI background, the challenge was to link socially acute questions with IBSE activities. Interviewees described a process of gradually coming to understand how to link these two major traditions into a coherent whole. A further challenge was to come to understand how these related to citizenship, and to RRI for which there were changing views over the course of the project. In the conversations that took place in consortium meetings and in work package online meetings, partners had access to, and needed to come to terms with, other educators with particular expertise and beliefs in the different SSIBL pillars, and it seems that this diversity performed a generative function.

A large part of the reason for the flexibility partners experienced in responding to SSIBL was the way in which it was created and viewed as a draft document, able to be negotiated and interpreted sufficiently flexibly to accommodate partners' differing beliefs and contexts. In a project such as this, built around a theoretically complex and challenging innovation, there is an inevitable tension between offering a tightly specified framework that offers a prescription of process and illustrative, clarifying exemplars, as against offering a framework conceived of as "in process" with members themselves part of a design experiment (Fig. 7.2).

On the one hand, it was important that partners were able to develop responses to SSIBL that reflected their particular contexts. On the other hand, they struggled at times to work through what was the essence of a SSIBL activity and how teachers and students could be effectively engaged through such activity. Having exemplars would have been valuable, but at the start, they had not yet been developed. It was only after several cycles that partners developed and shared explicit criteria and approaches, and exemplar activities. Evidence from these interviews indicates that

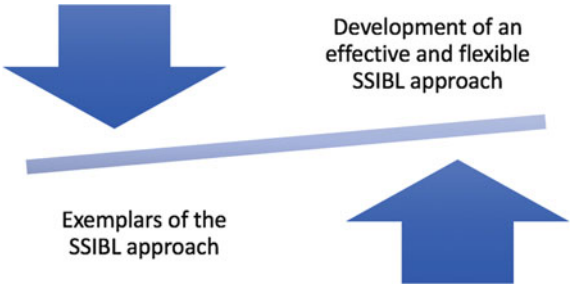

Fig. 7.2 Balancing the needs for flexibility and specificity

the open approach to the framework allowed room for coherence to develop through these diverse TPD developments.

From the interviews there was evidence of broad agreement about the essential core of the innovation, and of growing commonality of vision. However, there was diversity in what was emphasized and how it was implemented in practice. A number of interviewees claimed this variation in practice as a strength. Within the project, the discussion of SSIBL was a central and generative focus.

7.4.3 Diversity Within TPD

There was considerable variation of structure within the PARRISE TPD models. Within pre-service courses this related to different curriculum constraints, and to whether colleagues were willing to entertain time allocation to SSIBL. Within in-service, it related to access to teachers and constraints offered by teacher beliefs and curriculum alignment. The issues and possibilities for pre- and in-service SSIBL development were different. For pre-service the issues mainly related to how to structure and balance theoretical and practical experiences of SSIBL activities, within a constrained time. For in-service teachers, there were sometimes strategic partnerships formed with teacher education centers, in one case with a national online TPD. In a few cases partners were over time able to develop a cycle of collaborative development of approaches with teachers, beginning with developed exemplars of SSIBL activities, to teachers designing their own contextual activities, alongside the development of criteria for the SSIBL approach. There were two levels of the challenge presented by SSIBL that needed to be addressed for both pre- and in-service TPD: at the level of beliefs about the purposes of science education and the in-principle structure of an SSIBL approach; and at the level of context-specific enactment in real classrooms. A number of partners addressed these in a cyclic process, illustrated by Fig. 7.3.

The classroom enactment cycles became very important for exemplifying the core nature of SSIBL. For the "belief" level the challenges were: "It's politics, not science," "There's no room in the curriculum," "I'm not the sort of person who runs such discussions." For the 'enactment' level the challenges were: "How do we

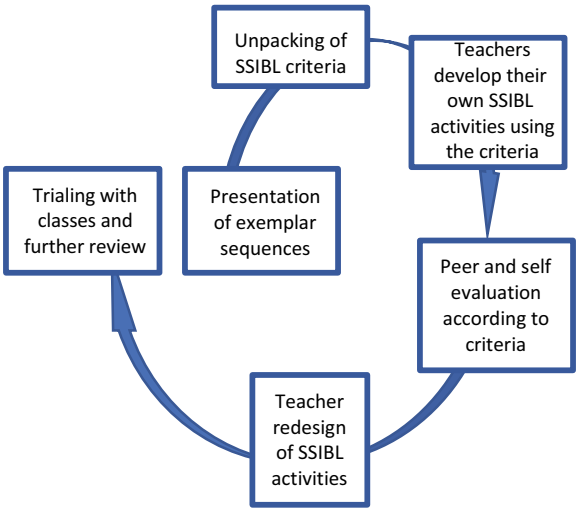

Fig. 7.3 Cyclic development of SSIBL criteria and activity design in SSIBL TPD

coordinate the pillars, with the need to teach content"; "What issues/controversies will be accessible and productive?", "What are the criteria for designing a good SSIBL sequence?"

7.4.4 Enlisting Diversity Through Layered Communication

Interviewees talked about the generative nature of communication with various colleagues within PARRISE, and its operation at different levels: consortium meetings, online work package meetings, smaller online group meetings, and individual communication with like-minded partners. Some spoke of the skill of project management for creating an environment where people could speak openly and discuss the difference. There is evidence that the complexity and diversity discussed above were generative forces when the communicative structure was both open and diverse. Partners indicated they were both challenged and enriched by discussions in the wider meetings with others of different viewpoints and ideas about pedagogy and curriculum purposes, yet could find like-minded colleagues with whom they could discuss and jointly plan activities. In the end, a good deal of commonality of beliefs and vision were evident in partners' responses to the framework and beliefs about the purposes of science education.

7.5 Conclusion

The study revealed a range of challenges associated with the complexity and challenging epistemologies of the SSIBL framework, combined with variation in experience and beliefs across the partners, and their diverse curricular settings. Key challenges faced by partners included teachers' and colleagues' traditional beliefs about the nature and purpose of science education, and resistance to change offered by existing teacher education, and school curricula. The study has demonstrated the range of epistemological beliefs and histories of practice that underpinned the variety of responses to the framework, and the variation in the context of pre- and in-service TPD that led to a variety of approaches within and across work packages.

An important variation in partners' experience concerned whether their focus was on pre-service TPD or whether they had the capacity to work with in-service TPD over time. Each partner had in common the strategic development of alliances and opportunities over three annual cycles to put in place effective and individual responses to the challenge of PARRISE. These include alliances with science education TPD centers, alignment with national TPD initiatives or school curriculum initiatives, extensions of existing partnerships focused on sustainability, and cyclical refinement of in-service TPD practices focused on innovation.

There was a need across the project to balance the generation of exemplars of the approach but also to allow for complexities of contexts to move toward a robust and flexible model. Partners worked in their TPD innovations with a dual focus on beliefs and perceptions of teachers and the development of activities and classroom approaches. Time was an important factor in the development of understandings across the project of the key issues at stake and of the variety of approaches that could be taken that preserved the integrity of the project vision.

A major advance in interpretation of the framework over the course of PARRISE involved the development of criteria and processes by which teachers could become relatively autonomous in developing their own SSIBL sequences based around local context. Through sharing and discussing the variety of activity, over time partners developed a more robust and coherent perspective on the SSIBL framework and its possibilities for guiding practice. The openness of the framework to variation was an important feature that allowed these innovations to develop and be shared.

The SSIBL framework sat within the project as the subject of a design experiment where the diverse contexts of the partners fed into progressive refinement of the framework and the development of exemplar TPD activities. While this open structure has at times created discomfort, ultimately it has proved an effective strategy for accommodating the diversity of partners' beliefs, experiences and contexts to forge a framework sufficiently rich and flexible to be applicable across these diverse systems.

A key to this was the creation of a community with layered communication processes, where partners felt able to express their views and negotiate difference and feel able to interpret the framework in ways that matched their context while acknowledging the need for coherent representation of the central pillars. A very positive aspect of the PARRISE project was this dual attention to the need for coherence,

and acknowledgment of diversity. Sharing and negotiation of ideas across multiple platforms was key to this.

In conclusion, PARISSE demonstrated the importance of refined communication and collaboration processes to support the development of a challenging pedagogical innovation that is both robust and sufficiently flexible to support innovation in a variety of contexts.

Acknowledgements With acknowledgment of critical friends:
Doris Jorde, University of Oslo
Isabel Martins, Federal University of Rio de Janeiro
Pedro Reiss, Instituto de Educação da Universidade de Lisboa

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