Chapter 9
The Role of Subjectivity in Understanding Teacher Development in a Scientific Playworld: The Emotional and Symbolic Nature of Being a Teacher of Science

Marilyn Fleer

Abstract Many studies have been undertaken to better understand children's development. Yet, little attention has been directed to how children's development is reciprocally related to the development of the teacher. In this chapter, the concepts of subjective sense and subjective configuration as proposed by González Rey are drawn upon to analyse teacher subjectivity during periods of teaching science. The focus is not "the science teacher" but rather the "person who is a teacher of science". In this chapter, the lens is centred on the personal narrative of a preschool teacher who participated in a study designed to teach concepts, not as an objective body of knowledge, but rather as embedded in a series of Scientific Playworlds. Through following the teacher's emotions and the symbolic processes generated when implementing Scientific Playworlds over 2 years, insights were gained into the dynamic and evolving subjective senses of what it means to teach science to young children in play-based settings. In using a cultural-historical framing of subjectivity, as advanced by Gonzalez Rey, science knowledge was not conceptualised as an individual construction, but rather something that is historically located, emotionally charged, and socially produced through human relations. The findings show that the teaching of science concepts is connected directly to how the teacher and children together make meaning and how their motives change through their relations with each other and with the Scientific Playworld narrative that developed over time. Science was collectively conceptualised by the teacher and the children through how it was imagined, re-imagined, and emotionally and symbolically produced in the Scientific Playworld. Although subjectivity is rarely discussed in the teaching of science, it is argued in this chapter that it should take centre stage for better understanding practice and research in science education in early childhood settings.

M. Fleer (✉)
Faculty of Education, Monash University, Melbourne, Australia
e-mail: marilyn.fleer@monash.edu

F. González Rey et al. (eds.), *Subjectivity within Cultural-Historical Approach*,
Perspectives in Cultural-Historical Research 5,
https://doi.org/10.1007/978-981-13-3155-8_9

9.1 Introduction

Contrary to accepted beliefs about science revealing objective truths, Vygotsky (1987) argued that, "By isolating thinking from affect at the outset, we effectively cut ourselves off from any potential for a causal explanation of thinking" (p. 50). Contemporary research into science education is actively resisting this cognitive narrowing, and opening up spaces for contextualised and historicised knowledge, challenging assumptions about the neutrality and objectivity of scientific thought, and seeking to decentre the privileged position of the sciences and hegemonic notions of knowledge production (Strong et al. 2016). What is emerging in science education research is new methodologies that bring into the research paradigm a sense of place and a method that promotes, rather than removes, the participation of the researcher (Fleer and Gonzalez Rey 2017) as part of researching teaching and learning in science, where remarkable moments emerge (Carlone et al. 2016).

In humanising the research process, a fuller sense of the complexity and dynamics of thinking and feelings associated with the learning of science concepts emerges (Hadzigeorgiou 2016). Vygotsky (1987) argued that, "There exists a dynamic meaningful system that constitutes *a unity of affective and intellectual processes.* Every idea contains some remnant of the individual's affective relationship to that aspect to reality which it represents" (p. 50; original emphasis). The remnant of this affective relationship plays out in science education classrooms and early childhood settings where children are constantly constructing knowledge, but always in relation to how they feel about their own learning of science concepts (Solis and Callanan 2016). How early childhood teachers feel about the teaching of science is also of importance for understanding the experiences they organise and the ways that they interact with children (Garbett 2003). Teacher subjectivity and the social pathways that are generated through human relations are a key determinant of these subjective productions (Gonzalez Rey 2017). This chapter is concerned with these social productions, for better understanding the symbolic processes and emotions that are part of the teaching of science in early childhood settings (Gonzalez Rey 2017).

In contrast to previous research in science education which primarily follows a constructivist orientation (see Eshach and Fried 2005), this chapter seeks to study knowledge construction in early childhood settings as subjective productions and social pathways, as advanced by Gonzalez Rey (2017), for the learning of science. Hadzigeorgiou (2016) notes that, "the science classroom becomes a place where students and teachers negotiate ways of being, knowing, and acting" (p. 36). This humanisation of knowledge construction in science education is foregrounded in this chapter, where the subjectivities of teachers and children are captured and discussed as a key part of studying individual and social knowledge production. Both individual and social subjectivities are dynamically interwoven (Gonzalez Rey 2017) and, as such, must be studied as cultural practices, socially enacted and historically located human productions. These emotions and symbolic processes (Gonzalez Rey 2017) need to be captured in motion (Vygotsky 1997). This conceptualisation of research

has been theorised by Gonzalez Rey (2017) as studying these productions as the interweaving of individual and social subjective configurations.

The goal of this chapter is to better understand the development of teachers through examining the symbolic processes and emotions of one teacher who sought to introduce a new way of learning science through implementing a Scientific Playworld approach (Fleer 2017a). To achieve this goal, the chapter begins with a discussion of the context of the study where Scientific Playworld is theorised. This is followed by examples of social productions and pathways where symbolic processes and emotions are drawn out and analysed as units of affect and cognition (Gonzalez Rey 2017). The findings are discussed as interwoven individual and collective subjectivities dynamically produced in human relations within the Scientific Playworlds.

9.2 Scientific Playworlds

Hadzigeorgiou (2016) has suggested that "Science learning is about knowledge and understanding, even though such learning is influenced in one way or another by emotions" (p. 143). In this study, the focus teacher, Rebecca, had expressed concerns about her approach to teaching and learning in early childhood settings. She wanted to change her practice. She had a strong motive orientation to engage in new ways with her children so that she could deepen their learning (Lewis et al. 2017). Rebecca was invited to join a study where she had the opportunity to participate in new ways of teaching science in her preschool. The overall study focused on imagination in science and imagination in play. The theoretical framing of emotions and imagination as introduced by Vygotsky (2004) and further advanced by Bozhovich (2009) resulted in the outcome of a Scientific Playworld approach (Fleer 2017a). In this study, the conceptualisation of emotional imagination for learning scientific concepts (Fleer 2017b) and the need for teachers to pedagogically position themselves inside of imaginary play situations for progressing scientific abstractions (Fleer 2015) were key aspects of working with Rebecca prior to and during the implementation of a Scientific Playworld approach. In addition, Rebecca's ongoing readings of cultural-historical texts, and her exposure to the outcomes of previous research into a Scientific Playworlds approach, and her own studies of her own practice as part of her own Ph.D. journey (Lewis et al. 2017), together developed a motive orientation for implementing a Scientific Playworlds approach. Rebecca participated in the implementation of a series of Scientific Playworlds and an emerging Engineering Playworld. The Playworlds approach for teaching science and engineering to young children informed Rebecca's new way of teaching. How she developed as a teacher of science during this process is the focus of this chapter.

Playworlds generally, and a Scientific Playworld specifically, focuses on the collective emotional imagination of the group where problem situations are introduced. The teacher selects a story that is engaging (Haakarainen et al. 2013), but also one that can be developed through the narrative of play and through dramatisation (Bredikyte 2011). The teacher has a central role in transitioning children between the real world

and the play world (Lindqvist 1995). Previous research in early childhood science education has shown that being inside the imaginary play, developing the play over time, is rarely undertaken by teachers in preschool settings (Fleer 2015). It is only in classrooms and centres which set up Playworlds that this practice is observed (see Bredikyte 2011; Hakarrainen 2010; Lindqvist 1995). What is known is that in scientific imaginary play situations, teachers appear to struggle and resist entering imaginary situations, despite the fact that children appear to enjoy their participation (see Fleer 2015). This is because most of the early childhood education literature positions teachers as being an authority figure, and therefore, their involvement in children's play is thought to interfere with their play (Lewis et al. 2017). But at the same time, teachers are expected to observe and carefully listen to the child and to follow their interests. This creates a contradiction between being authoritative and being disempowered to teach (Fleer 2009). Interestingly, Bredikyte (2011) and Haakarainen et al. (2013) have shown that when teachers step inside of the imaginary play situation as a play partner, the play appears to develop further, to deepen and to become more complex—supporting the view that teachers do have an important role in developing children's play.

A different theoretical perspective on child development underpins these two positions about involvement in children's play. In the general early childhood literature, children's play is theorised as following stages, aligned to a biological developmental trajectory, whereby play is conceptualised as being biologically determined—i.e. play changes in relation to a child's age (Vygotsky 1998). However, from a cultural-historical perspective of child development, which underpins a Playworlds approach, play is conceptualised as a cultural form of development that is socially produced (Göncü et al. 1966). This belief about play and children's development is difficult for teachers who are implementing a Playworlds approach, because this view of child development is different to what most teachers have previously learned and what has primarily been presented in supporting documentation for teachers (Fleer 2010)—even though broader definitions of child development are embedded in the national curriculum for early childhood educators in Australia (Australian Government 2006). A cultural-historical conception of child development demands a completely new world view of development (Fleer 2017b). Rebecca recognised this incongruence, but the contradiction was so great that she was unable to find a way forward without professional support (Lewis et al. 2017).

Rebecca participated in the study of the implementation of a Scientific Playworld into preschool (3–4 year olds) for 2 years. Her co-teacher Oriana was the class teacher for the children attending the first year of primary school (5–6 year olds). She was also involved in the research, as were some of her colleagues who worked in the school where the preschool was located. Their practices were digitally video recorded over that time, as Rebecca introduced a series of Scientific Playworlds into the preschool and into Oriana classroom. Two of the Playworlds she implemented were not caught on camera, but rather they were digitally recorded through weekly informal and semi-structured interviews conducted by the research assistant Sue, who interviewed the teachers in person or through Skype. At other times, the teachers self-recorded their

planning sessions. A final semi-structured interview with Marilyn was also done using digital video documentation processes.

A total of 152.3 h of digital video data of practices were recorded of the Playworlds (50 sessions over 2 years), of which 32.5 h were the semi-structured and informal interviews. The research assistant, Sue, also supported the implementation of the Playworlds approach through advising and acting as a critical friend. She led the professional development process for both the science concepts being introduced to the children, and the readings about Playworlds and previous outcomes from the overall research project. Regular discussions with Marilyn also featured in relation to relevant cultural-historical concepts and the nature of Playworld practices and outcomes from previous research.

Recognition of the role of the researcher as part of the research process is grounded in cultural-historical theory (Vygotsky 1997). To understand how scientific thinking emerges in early childhood settings as teachers develop during the process of implementing new practices, it is important that the researcher be responsive and embedded in the research context (Fleer and Gonzalez Rey 2017). Their subjectivity is also key for the development of the research project over time, particularly during the process of implementing new practices (Scientific Playworlds) not yet examined across a range of early childhood centres for Australian conditions.

9.3 Social Productions and Pathways

As would be expected, in the study of Rebecca's development as a teacher of science over 2 years, there were many moments of contradiction that needed to be resolved in the process of moving from an imagined conception of being a "science teacher" to re-imagining being a "teacher engaged in the social production of science knowledge"—not as a narrowing of objective truth to be taught and learned, but as interweaving individual and social subjective senses that integrate both symbolic processes and emotions within a unit that is simultaneously symbolic and emotionally configured. This subjectivity was captured digitally, analysed (Gonzalez Rey 2017), and is discussed in this section under the following clusters:

Emotional nature of teaching and learning—doing something different as a source of development

Teacher as the authority or the play partner—performing who you are becoming

Conceptualising and enacting a new relation—the contradiction between the real role and the play role of the teacher

The contradiction of not interfering in children's play but intentionally teaching concepts—smuggling in content

Humanising science—the emotional nature of a Scientific Playworld.

9.3.1 *Emotional Nature of Teaching and Learning—Doing Something Different as a Source of Development*

The enactment of teaching and learning is filled with social phenomena. It does not exist as an objective truth, but rather it is an emotional and symbolic process that is both individual and collective, is emotional and cognitive, and is simultaneously inside and outside of the teacher. However, teacher development needs contradiction (Vygotsky 1987). In this study, it was found that whilst contradiction does act as a force to move development, it also needs particular conditions to productively support that movement. In the process of drawing upon a new practice, Rebecca said to Marilyn that, "*When we were first asked to enter the playworld, of course you know what that means, but you don't know what it feels like*". Rebecca went beyond a cognitive interpretation of the new experience of using a Scientific Playworlds approach, to an expression of her feelings towards the new teaching practice. She said, "*I think I had fears that I, I won't be very good at it, and as a teacher I am a professional, and a big part of your job is behaviour management, and being in a certain way to the parents and the children, and all of a sudden you are going into this silly character, and I wasn't quite sure how to do it*". Vygotsky (1971) has argued that emotions and imagination are not separable processes. Rebecca is relating emotionally to the new practice and imagining her own identity as a professional in contradiction with the new role expected of her to be a play partner inside of the imaginary play situation. She is imagining this as being "this silly character". She was imagining how this change in role might be viewed by the parents of the children she teaches and what it might mean for the children themselves—her playing out being a "silly character" in the story.

Gonzalez Rey (2017) has said that imagination is more than emotions. He suggests that imagination is "a subjective production that transforms and integrates images into concepts, and generates new concepts that lead to new models of thinking, turning emotions into symbolic processes, while symbolic processes become inseparable from emotions" (p. 10). Rebecca was imagining the possible scenario of teaching in a new way. The concept of a Scientific Playworld was subjectively reproduced by Rebecca as an emotionally imagined teaching practice—*being this silly character—being in a certain way to the parents and the children.* Symbolic processes of the imagined Playworld become tied with her fear of the unknown—*I think I had fears that I, I won't be very good at it.* However, in the practice of teaching in this new way, new concepts emerged about this new approach, which led to new ways of thinking and imagining of herself as a teacher inside of the imaginary play situation focused on teaching science concepts. She said, *"Then we experienced the fun of it. How the children respond. Just having the confidence to know that the children enjoy you having a go. It's not about being a perfect dramatization. It is about play" (RIP7).* What we observed in the study was the emergence of new representations, new imaginings, which Gonzalez Rey (2017) has suggested, "become sources of new concepts, images and other productions, leading to new imaginative creations" (p. 10). Throughout the study of Rebecca's development as a person using a Scien-

tific Playworld to teach science concepts to preschool children, she was constantly presented with new contradictions, which appeared to act as a productive force for her development. Imagining herself and emotionally relating to these images of herself in a new role were constantly in flux and evolving as "new cultural realities" of her own subjectivity.

9.3.2 Teacher as the Authority or the Play Partner—Performing Who You Are Becoming

Lobman (2017) has argued that "Human beings are more than reproduction or even adaption to the current conditions" (p. 229). She suggests that humans through:

> …imaginative, creative, playful activity, [are] capable of creating new performances … collectively creating the environments where people are supported… individuals, communities, and societies can continue to develop ….development is understood, not as a set of stages that people pass through on their way to adulthood, but as the collective creation of stages (environments) where people can perform who they are becoming" (p. 229).

Performing who you are becoming is a very different view of conceptualising the contradictions between being a play partner and being an authority figure managing children's behaviour. When Marilyn asked Rebecca to talk more about her experiences with a Scientific Playworld approach, she drew attention to a tension between the authoritative role of a teacher and the performance role of being in character in a Scientific Playworld.

> Part of teaching is about having control, having to always facilitate. So to go into character, I felt I would lose control, and what happens if someone needed help, or they needed to go to the bathroom or—all of these things that you help children with all of the time as a teacher (RIP2).

Through implementing a Scientific Playworlds approach, where you can perform who you are becoming, a different image of Rebecca as a teacher was emerging. She had to find different ways to manage children's behaviour. The observations of the teaching practice revealed many moments where Rebecca managed children who were losing interest or being disruptive, by taking on a particular role, such as being the Mummy Dragon, and asking the baby dragons (children) to sit close to her. She told Marilyn, "*I realised that I could do it [managing group] in character and its fun!*" (RIP2). Rebecca learned that she could, as Bretherton (1984) has shown with children playing together, manage the children in character. Children with sophisticated play skills manage each others' actions from inside of the play narrative, where they act within the frame of the imaginary play by using their play role to change the narrative or to signal to other players that their offers or actions are not accepted (Fleer 2010). Rebecca also did this. Across the data set, there were many moments in which Rebecca used her play role, rather than her real role as the teacher to guide children's behaviours and to further develop the play narrative and to deepen the play practice.

The study found that it was through the play performance that a new pedagogical practice emerged, which she later analysed, and subsequently drew upon, to manage children's behaviour. In the performance of the Scientific Playworld, Rebecca was becoming a new kind of teacher. Implementing the Scientific Playworld had created new conditions, where new pedagogical practices were emerging and which in turn developed Rebecca into a different kind of teacher. Rebecca was becoming who she was performing inside of the play situation. Both the children and Rebecca were changing their imagined identity of what it means to be teacher holding an authoritative position.

9.3.3 Conceptualising and Enacting a New Relation—The Contradiction Between the Real Role and the Play Role of the Teacher

Rebecca also worried about the change in her real relations with the children as a teacher to a play role in the imaginary playworld of the Mad Hatter in the story of Alice in Wonderland with the children.

> I felt nervous that I had to convince the child that I was that character. The children know we are pretending. So some will say, "You are not really… the Mad Hatter", whilst others will call to you (in role) "Mr Mad Hatter" (RIP4).

Gonzalez Rey (2017) captures dynamic change, as we observe with Rebecca, as, "The subject of the action and the subjective configuration of the subject's action are configured by each other in such a process that transcends conscious representations and intentions" (p. 16). Rebecca is engaged in a system of relations with the children and her co-teacher. This relation is constantly changing, as children respond to Rebecca as "*Mr Mad Hatter*" or "*You are not really… the Mad Hatter*". Rebecca responds to them in her real role and in her play role.

The contradiction between the play role and real role of the teacher created new developmental conditions for the children (Fleer in press) and teachers alike. When Rebecca was the Mad Hatter, she was relating to the children in role—initially as a conscious act. In these situations, her relations with the children were as play relations. When she was the teacher, she was in her real relations with the children—a role she did not consciously need to consider, as it was assumed through simply being in the institution of a preschool. "Conscious and unconscious" as suggested by Gonzalez Rey (2017) "are not two separated instances; they are processes organised in two different and simultaneous moments that define two different sets of the same system" (p. 16). It was through these social productions and emerging subjectivies that a change in Rebecca's thinking about her role emerged. She said, "*So they relate to you on different levels, and all of that is fine. It's all part of the play. I didn't have to convince them, I was just playing with them. I understand that now*". The contradiction between a real role and a play was found to be constantly in motion throughout the 2 years, because both Rebecca and the children were developing inside

of the play, where contradictions between real roles and play roles of the teachers were ever present.

The Scientific Playworld is a system of relations between children and between teachers, but also between the teachers and the children. This system of relations is subjectively experienced, re-experienced, and is in constant motion between the imagining of the real role of the teachers and children, and the play role of the characters. Rebecca concluded that,

> … to take safe risk in play, we always talk to the children about that. Now I am talking to myself about it (laughs). We need to take safe risks in our play, give it a go, it doesn't matter how it turns out (RIP3).

9.3.4 The Contradiction of not Interfering in Children's Play but Intentionally Teaching Concepts—Smuggling in Content

A further contradiction that was noted by Rebecca, and which is experienced by many early childhood teachers in Australia, is of being asked to not interfere in children's play, whilst also being expected to use play as an approach to intentionally teach concepts to children. Rebecca indicated that she did not feel she could answer children's questions, but rather should listen and pose further questions to elicit their thinking (Lewis et al. 2017). She said that in a Scientific Playworld approach "*…when they [children] have questions, it is OK to answer them* (laughs)". This dynamic tension was captured by Rebecca through exploring the narrative in the story of Chalotte's Web and the scientific understandings of spiders:

> So you get a book, read a non-fiction book, watch a YouTube clip… An example of Charlotte's Web web—we watched really close detail of how they [spiders] spin webs, what is the anatomy, so they knew a lot of facts, they couldn't have come up with that on their own if they have never been exposed to it, and that ties in with the planning side, because Oriana and I had to make sure we felt comfortable with that as well; and its OK to say, "Let's find out together". If we knew it was coming, we made sure we felt comfortable with the knowledge (RIP9).

Hedges (2014) has referred to this contradiction of finding ways to teach concepts, whilst not appearing to lead conceptual development, as "smuggling in content". She argues that teachers do not feel comfortable with the contradiction of not interfering whilst also being expected to teach concepts. Rebecca illustrates this tension when she foregrounds how, "*Oriana and I had to make sure we felt comfortable with that* [content]". Rebecca also draws attention to how the Scientific Playworld approach created new developmental conditions for children for learning concepts, but at the same time it affirmed play as an important approach for learning, successfully resolving the conflict for her, as noted when she said, "*they couldn't have come up with that on their own if they have never been exposed to it*".

Dealing with contraction created through new policies from Government for more teaching, in a context of the Piagetian shadow of following from behind the child and

not being above the child's development as introduced by Vygotsky, is emotionally experienced by Rebecca. Bringing the contraction of teaching concepts together with the need for allowing children to play had an unknown outcome for Rebecca. She said, "*The thing that made me nervous at the beginning was the unknown. I didn't know how it was going to play out*". But through drawing on a Scientific Playworld to resolve this contradiction, it changed how she felt about her role in supporting children's learning of concepts:

> But now that's the bit that is really exciting…[explains what they will do on Monday], so we don't know how it will turn out. That would have terrified me before. Half the children will lose it; they will get silly. Whereas now I am thinking, it is just going to be good fun.

Marilyn asked, *What's made that change for you?* Rebecca responded, *"Just experiencing it. Just having some confidence. Having faith in the children. I have faith that we have front loaded them enough that they understand these concepts around greed, pollution, with factories, they have a strong grasp of these concepts, and the questions they are asking, are really big philospohical questions, I know they will be able to contribute to this form of play" (RIP2).*

The children's responses to how Rebecca was dealing with the contradiction were positive. This supported the development of Rebecca as a teacher of science, showing the interweaving of individual and social subjectivities, as she engaged with new practices, and developed a new image of herself as a risk taker.

9.3.5 Humanising Science—The Emotional Nature of a Scientific Playworld

Through experiencing the Scientific Playworld with the children, Rebecca was in a position to feel the emotional nature of the narrative of the story with the children. Charlotte is a spider—something that traditionally affords an emotional response from children and some adults. But in the story of Charlotte's Web, new imaginings were being created, resulting in a very different emotional response, as Rebecca explains:

> … you know they LOVED Charlotte, the spider. You know if we were just learning about spiders…and in the beginning they thought spiders were gross, to kill them all, they were saying "Squash it". Then we learn't about Charlotte from the story and her important role in the ecosystem, and then they had an admoration for spiders, understood their importance, and were very respectful, and felt they were BEAUTIFUL. Without the story, we wouldn't have been able to do that in a magical way. But—we all understand that spiders are important, but they really loved Charlotte, she's wise and kind (RIP13).

The book changed how the children emotionally related to spiders and opened up new possibilities for deep learning in science. A new emotional image of the spider emerged as a result of both the fiction and the science. The emotional imagining went beyond the character of Charlotte, to that of Wilbur the farm piglet, destined to be eaten, as Rebecca explains:

> …it is quite an emotional book, because Wilbur is almost killed. I could tell. We had to be very careful around, that this was just a story, and Wilbur was going to be OK, and sometimes that happens on farms…So I guess in terms of drama, it is about balancing, grabbing their emotions and having that…, but also that everyone feels really safe, and that that it is a Playworld (RIP17).

The Scientific Playworlds approach introduced a very different way of doing science. Recognising emotional imagination as subjective pushed against science as only an objective form of knowledge construction. The Scientific Playworlds approach created a dramatic tension that acted as a productive force for children's development, but also for the development of the teachers. The interweaving of individual and social subjectivities paved the way for a new way of learning science. During the weekly interviews with Sue, the research assistant, the social productions, the interweaving of individual and social subjectivities, and the emotional imagination of being a teacher of science emerge. The following extensive interview segments illustrate the dynamic tension and how this acted as a source of development for both teachers.

> Rebecca: Oriana did a really outstanding job of Farmer Zuckerman [in the story of Charlotte's web].
>
> Sue: So how did you feel about being Farmer Zuckerman?
>
> Oriana: I loved it because… you know, just walking up; when I've gone out to get ready and put myself in costume and come back—as I was walking I felt angry that my crop had been infested with these coddling moths. So it totally, instead of being nervous of, **the scientific facts of teaching whatever**, totally **I was that person** and I just felt angry and passionate and it just all came out. But of course, having said that we did think carefully about it before we did it, and what we were going to talk about. But having all of that, it was just, it was able to come out in a different way, you know—
>
> Sue: Yes, very emotionally by the sounds of that.
>
> Oriana: Yes emotionally, yeah.

A very different enactment of "teaching science" is presented through Oriana's response. She no longer worries about the content knowledge associated with teaching science—something that the literature has always blamed teachers for not knowing much about (Garbett 2003). Rather, the Scientific Playworld has allowed her to draw upon her strengths in drama and play to open up a new way of teaching science content, and a new image of science teaching. Rebecca positions Oriana carefully, as is shown in the next part of the interview:

> Rebecca: I think Oriana really is quite a skilled actress so it works really well, so I've had a lot of practice of being with the children as well so I think… and we're so lucky because we work so closely together and we're good friends so intuitively we're understanding the pedagogy much better. Who steps in when, kind of juggling that better.
>
> Oriana: Absolutely, and even knowing our role, like if we're going to be, you know, above, with or below the children you quickly… even if I'm more in that secondary role with Rebecca like if Rebecca's leading it I can see quickly her positioning in her questioning with the children. You know, I quickly get that, so you're more aware.

Sue then invites both Rebecca and Oriana to reflect upon this strength:

Sue: What impact do you think that's making on your teaching or to the way the children are receiving it?

Rebecca: I think the project feels much tighter, because we have a clearer idea of how to drive it and I think we feel **much more confident with these concepts** and with the microbes [previous Scientific Playworld of Alice in Wonderland], everything was new and I think we didn't feel confident enough. And I know that was our fault because it was made really clear that we needed to be confident. But for this it's just easier to run with.

Oriana: And too, we did say, you know, it was very literal in some ways, we'd stuck very closely to the story. But I think that was our—

Rebecca: We eased ourselves into this project.

Oriana:—yeah, it **was a bit like having training wheels** for when you ride a bike, you know, let's see how we can really make this.

Rebecca: But it's helped our confidence.

Sue: So, the story was like the training wheels to immerse yourself in the concepts.

Oriana: And the process, you know, the whole thing of acting out.

Rebecca: **I think the science concept was the training wheels**, having something that was a more entry level science concept was the training wheels does that make sense? (P006).

The metaphor of the training wheels to describe science concepts is illustrative of how the teachers were imagining new ways of teaching science. The study found that this constant emotional imagining was always in the context of the dynamic tensions between the fiction of the story and the science concepts that were being explored to deepen the play. The contradiction between fiction and non-fiction narratives generated new emotional images, as we heard when Oriana said, "*It was a bit like having training wheels for when you ride a bike, you know*", and Rebecca reinforcing this image when she said, "*I think the science concept was the training wheels*". The teachers were constantly re-configuring the nature of science teaching. They showed through their discourse throughout the study, the humanising of science concepts—not as facts to be learned by children, but as concepts with remnants of emotions—Charlotte the spider is beautiful, kind, responsible, but also a part of an ecosystem. The teaching of science concepts was an emotionally charged situation, as they were remembering being inside of the imaginary situation of Farmer Zuckerman with his coddling moth problem—something that needed science to solve, as we heard when Rebecca invited Oriana to talk about the Scientific Playworld, *"I felt angry that my crop had been infested with these coddling moths… instead of being nervous of,* ***the scientific facts of teaching whatever****, totally* ***I was that person*** *and I just felt angry and passionate and it just all came out*". The humanising of science through the fiction of the story is also reflective of how science is used in everyday life—with remnants of emotions, with everyday life connections, and as part of the subjectivities—social and individual—which are always in the process of developing.

9.3.6 Conclusions

The study reported in this chapter sought to better understand teacher development when introducing a new approach for teaching science concepts in preschool settings. Through following Rebecca over a period of 2 years as she implemented a Scientific Playworld, it was possible to gain insights into the symbolic and emotional productions of her experiences and to identify the reciprocity of individual and social subjectivities (Gonzalez Rey 2017) of herself and her children. Studying the emotions and symbolic processes of Rebecca as she entered into imaginary play situations with her co-teacher and the children helped build an understanding of Rebecca's psychological development and emotional imagining of herself as a teacher of science concepts.

It was found that the Scientific Playworlds approach created a dynamic contradiction between fiction (Playworld narrative) and non-fiction (science content). This contradiction appeared to act as a productive source of development for Rebecca (and Oriana) and, through this, created new emotional images about the nature of teaching science. Science concepts had become interwoven in the narrative of the storyline, positively drawing upon Rebecca's strength of teaching in play-based settings. Understanding the symbolic processes and emotions that are part of the teaching of science in early childhood settings (Gonzalez Rey 2017) was an important outcome of this study. Understanding the contradictions within a Scientific Playworld and how this contradiction was experienced by Rebecca gives new insights into how to support teachers' development in the context of science education.

The chapter reflects on the power and place of the interrelated concepts of "subjective senses and subjective configurations" (Gonzalez Rey 2017) for moving understandings forward for the teaching of science concepts to preschool-aged children, where existing debates need to move beyond the current simplistic focus on the teacher's competence and confidence to teach science in the early years (Garbett 2003). What this study confirmed was that teachers and children are constantly negotiating ways of being, knowing, and acting in early childhood settings (Hadzigeorgiou 2016). But what is NOT known, UNTIL NOW, is how this is negotiated during the teaching of science concepts in an emotionally charged and contradictory context of a Scientific Playworld. What was observed was how the images of science teaching changed as the evolving narrative developed. A new sense of science as meaningfully embedded in a narrative for the children and the teachers was emerging—Charlotte is beautiful and responsible, but Charlotte is also a spider who has a place in an ecosystem. A diversity of subjective productions and social pathways was constantly evolving in the teaching of science. Knowledge construction in science was initially imagined in traditional ways and associated with worry about knowing enough about the concepts. However, what emerged through this study was a new image about what it means to be a teacher of science, and not a science teacher. The study identified the process of the humanisation of science knowledge construction, and this is important for science education generally, and science education research specifically.

Like a shadow from the past, scientific ways of constructing knowledge have foregrounded a view of knowledge construction as objective. Yet, this study has shown that it is a subjective process with many different pathways, symbolic and emotional processes and a constant interweaving of individual and social subjectivities. What is key here is how the emotions associated with teaching of science content were always subjectively experienced and symbolically produced. The subjective senses formed from the process of teaching science content were always in flux, unfolding and re-folding into each other, and appearing to form real changes in how teachers think about themselves as they move from the role of a science teacher to a teacher of science. That is, the teachers in this study appeared to be forming and re-forming subjective configurations of the nature of science and the nature of science teaching. Gonzalez Rey's (2017) concept of subjective senses captures and makes visible the many emotions and symbolic processes that emerge during teaching.

Emotional imagination was central for understanding the identities that were introduced and re-imagined in the production of learning science through a Scientific Playworld. Rebecca's development as a "teacher of science" was constantly evolving and re-imagined, at the same time as she was actively discarding the negatively imagined role of herself as a "science teacher". Although subjectivity is rarely discussed in the teaching of science, it was found to be a central concept for understanding how teachers develop when exploring new ways of teaching science concepts to young children in early childhood settings. However, further research into this phenomenon is still needed.

Acknowledgements The study reported in this chapter was supported through an Australian Research Council Discovery Grant (ARC DP140101131). Sue March acted as the senior research assistant. The research assistance of Taj Johora and Junqian Ma and data scribing and organising by Freya Fleer-Stout and Ainslie Holland are acknowledged. Last but not least, is the contribution of the two lead teachers who actively constructed an innovative teaching programme and who were prepared to continually develop their programme over the course of the 2 years.

References

Australian Government. (2006). *Department of education, employment and workplace relations, being, belonging and becoming: The early years learning framework for Australia*. Canberra, Australia: Council of Australian Government.

Bozhovich, L.I. (2009). The social situation of child development. *Journal of Russian and East European Psychology, 47*(4), 59–86. doi:https://doi.org/10.2753/rpo1061-0405470403.

Bredikyte, M. (2011). *The zones of proximal development in children's play* (Doctoral thesis, University of Oulu, Oulu, Finland).

Bretherton, I. (1984). *Symbolic play: The development of social understanding*. New York: Academic Press.

Carlone, H. B., Benavides, A., Huffling, L. C., Matthews, C. E., Journell, W., & Tomasek, R. (2016). Field ecology: A modest, but imaginable, contestation of neoliberal science education. *Mind, Culture, and Activity, 23*(3), 199–211.

Eshach, H., & Fried, M.N. (2005). Should science be taught in early childhood? *Journal of Science Education and Technology, 14*(3), 315–336.

Fleer, M. (in press). Children and teachers transitioning in playworlds: The contradictions between real relations and play relations. In M. Fleer & M. Hedegaard (Eds.), *Children's transitions in everyday life and across institutions.* UK: Bloomsbury Publishers.

Fleer, M. (2017a). Scientific playworlds: A model of teaching science in play-based settings. *Research in Science Education* (pp. 1–22). https://doi.org/10.1007/s11165-017-9653-z DP140101131 2014-2016; DP110103013 2011-2013.

Fleer, M. (2017b). Foregrounding *emotional imagination* in everyday preschool practices to support emotion regulation. In M. Fleer, F. Gonzalez Rey, & N. Veresov (Eds.), *Perezhivanie, emotions and subjectivity: Perspectives in cultural-historical research* (pp. 85–103). Amsterdam: Springer.

Fleer, M. (2009). Supporting scientific conceptual consciousness or learning in a 'roundabout way' in play-based contexts. *International Journal of Science Education, 31*(8), 1069–1089. https://doi.org/10.1080/09500690801953161.

Fleer, M. (2010). *Early learning and development: Cultural-historical concepts in play*. Cambridge: Cambridge University Press.

Fleer, M. (2015). Pedagogical positioning in play—teachers being inside and outside of children's imaginary play. *Early Child Development and Care, 184*(11–12), 1801–1814. https://doi.org/10.1080/03004430.2015.1028393.

Fleer, M. (2017). Digital playworlds in an Australia context. In T. Bruce, M. Bredikyte, & P. Hakkarainen (Eds.), *Routledge handbook of play in early childhood*. London: Routledge Press, Taylor and Francis Group.

Fleer, M., & Gonzalez Rey, F. (2017). Beyond pathologizing education: Advancing a cultural historical methodology forthe re-positioning of children as scucessful learners. In M. Fleer, F. Gonzalez Rey, & N. Veresov (Eds), *Perezhivanie, emotions and subjectivity. Advancing Vygotsky's legacy* (pp. 145–171). Dordrecht: Springer.

Garbett, D. (2003). Science education in early childhood teacher education: Putting forward a case to enhance student teachers' confidence and competence. *Research in Science Education, 33*(4), 467–481.

Gonzalez Rey, F. (2017). The topic of subjectivity in psychology: Contradictions, paths and new alternatives. *Journal of Theory and Social Behaviour.* https://doi.org/10.1111/jtsb.12144.

Hadzigeorgiou, Y. (2016). *Imaginative science education. The central role of imagination in science education*. Switzerland: Springer International Publishing. https://doi.org/10.1007/978-3-319-29526-8.

Hakkarainen, P. (2010). Cultural-historical methodology of the study of human development in transitions. *Cultural-Historical Psychology, 4,* 75–89.

Hakkarainen, P., Bredikyte, M., Jakkula, K., & Munter, H. (2013). Adult play guidance and children's play development in a narrative play-world. *European Early Childhood Education Research Journal, 21*(2), 213–225.

Hedges, H. (2014). Children's content learning in play provision: Competing tensions and future possibilities. In L. Brooker, M. Blaise, & S. Edwards (Eds.), *Sage handbook on play and learning in early childhood* (pp. 192–203). London, England: Sage.

Lewis, R., Fleer, M., & Hammer, M. (2017). The challenges for conceptual learning: Examining the role of teachers' 'subject positioning' for creating conditions for children's development at group-time. Unpublished Paper.

Lindqvist, G. (1995). The aesthetics of play: A didactic study of play and culture in preschools (Doctoral dissertation). Uppsala Studies in Education, 62, 1–234. Uppsala, Sweden: Acta Universitatis Upsaliensis.

Lobman, C. (2017). Performing on a wider stage: Devleoping inner-city Youth through play and performance. *Mind, Culture, and Activity, 24*(3), 217–231.

Solis, G., & Callanan, M. (2016). Evidence against deficit accounts: Convesations about since in Mexican heritage families living in the United States. *Mind, Culture, and Activity, 23*(3), 212–224.

Strong, L., Adams, J. D., Belino, M. E., Pieroni, P., Stoops, J., & Das, A. (2016). Against neoliberal encolosure: Using a critical transdisciplinary approach in science teaching and learning. *Mind, Culture, and Activity, 23*(3), 225–236.

Vygotsky, L. S. (1966). Play and its role in the mental development of the child. *Voprosy Psikhologii, 12*(6), 62–76.
Vygotsky, L.S. (1971). *The psychology of art.* Cambridge, MA: MIT Press. (Original work published in 1925).
Vygotsky, L. S. (1987). The development of scientific concepts in childhood (N. Minick, Trans.). In R. W. Rieber & A. S. Carton (Eds.), *The Collected works of L.S. Vygotsky: Problems of general psychology* (pp. 167–242). New York: Plenum Press.
Vygotsky, L.S. (1997). The history of the development of higher mental functions. In R.W. Rieber (Ed.), *The collected works of L. S. Vygotsky* (Vol. 4). New York: Plenum Press.
Vygotsky, L.S. (1998). *The collected works of L.S. Vygotsky*, "Child Psychology." (Vol. 5). Trans. M.J. Hall & R.W. Rieber (Ed. English translation). New York: Kluwer Academic and Plenum Publishers.
Vygotsky, L. S. (2004). Imagination and creativity in childhood. *Journal of Russian and East European Psychology, 42*(1), 7–97.

Marilyn Fleer holds the Foundation Chair of Early Childhood Education at Monash University, Australia, and is a past President of the International Society for Cultural Activity Research (ISCAR). Her research interests focus on early years learning and development, with special attention on pedagogy, play, culture, science and design and technology. She can be contacted at marilyn.fleer@monash.edu.