



# Using Individualized Photobooks to Enhance 3- and 4-Year-Old Children's Science Identity Through a Science Outreach Program

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This paper describes how individualized photobooks were used to support 3- and 4-year-old children in demonstrating their science learning and developing their science identity through participation in a science outreach program. Photographic images stimulate children's visual thinking and allow them to provide explanations of complex concepts using their language, thus supporting children at their level of understanding. Twenty child/parent dyads were video-recorded interacting with the exhibits during a Science Outreach program into Western Australian community playgroups. Screen shots from the video-recordings were used to develop individual printed photobooks for each child. One week after the program, the photobooks were used in a photo-elicitation conversation with the children (accompanied by their parents) about how the exhibits worked. Children took their photobooks home and 7 weeks after the program parents were interviewed about how the photobooks were used. The photobooks were found to assist the children in demonstrating their science understandings by providing a context for conversation and allowing the children to show their competence, use multiple forms of communication (verbal, non-verbal and through parent), and participate or withdraw on their terms. At home, the photobooks were found to be a focus for the children to share their knowledge of the Outreach program with family members, give the children a voice, and provide them with time to express their understandings. Having the child as narrator of his/her story and the adult as listener empowered the child's sense of identity. The use of individualized photobooks was found to contribute to the development of the children's identity and increase their agency in science and enhanced the parents' perceptions of their children as young scientists.

**Keywords:** visual methodology, photo-elicitation, individualised photobooks, young children, science outreach program, science identity

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## INTRODUCTION

Science is the domain of the young as they strive to make sense of their world. The wonder and curiosity that motivate young children to play, explore, observe and question assist them to develop their own explanations and understandings of the world (Campbell and Howitt, 2021). Positive and developmentally appropriate science learning experiences in the early years can assist in developing "young children's scientific concepts, awareness of scientific explanations through engagement with

science phenomena, science process skills, use of scientifically informed language, scientific thinking skills and positive attitudes to science” (Howitt et al., 2017, p. 209). These, potentially, can contribute to a young child’s sense of science identity.

As discussed by Fenichel and Schweingruber (2010) in relation to informal contexts, science identity refers to how one perceives that he or she can do science and be successful at science, and how others perceive him or her being able to do science. Developing an understanding of science and a science identity is influenced by social interactions with others and science resources available within learning communities (Kim, 2018). Recognition of belonging to a science community, whether reflecting on past science events, engaging in current science activities, or imagining future science scenarios, can assist the development of science identity (Fenichel and Schweingruber, 2010). Family is the predominant social group to influence participation in, and learning of, science, with everyday parent–child interactions having the potential to influence science identity in young children through the interests, habits, and scientific thinking that can be developed (Crowley and Galco, 2001; Katz, 2011). This research explores how science identity can be fostered in young children through individualised photobooks that recorded children’s engagement in a science outreach program. The next section provides an overview of learning in informal contexts and the impact of outreach programs, followed by a description of visual methodologies for data collection, photo-elicitation and the creation of the photobooks.

Science learning that occurs outside of formal educational settings has been labelled ‘out-of-school learning,’ ‘informal learning’ or ‘learning in informal contexts.’ These environments could include science centres, museums, zoos, botanical gardens and family settings. Learning in such environments is characterised as voluntary and free choice as children chose where to direct their attention, which, in turn, can influence their motivation and interest in learning (Dierking et al., 2003; Rennie, 2007). This choice accommodates children’s different interests, “offering unique opportunities to engage in experiential learning” (Riedinger, 2012, p. 126). Stocklmayer et al. (2010) noted that the use of the affective domain to promote engagement, along with activities that not only engage children to learn about science but also do science, is essential to enhancing learning in informal contexts.

Many science centers seek to serve their community through the provision of outreach programs, such as taking interactive science exhibits into community settings. These programs can provide attractive opportunities to engage both adults and children in science. Research has demonstrated that the potential to learn from exhibits in community-based science outreach programs depends on the availability of people who can encourage or guide children’s exploration of the exhibits (Rennie et al., 2010). This outcome is consistent with findings from research in museums; that greater learning has been found to occur when exhibits encourage social interaction and collaboration among family members (Puchner et al., 2001; Meisner et al., 2007), highlighting the socio-cultural underpinnings to learning within informal learning contexts (Rennie et al., 2003). For young children in particular,

research with exhibits has pointed to the importance of family talk and guidance in science learning (Ash, 2003; Knutson and Crowley, 2010; Dooley and Welch, 2014). As Schwan et al. (2014) concluded, “conversations between child and parents [can lead] to a co-construction of science-related meaning” (p. 73). Similarly, findings from a synthesis of research on children’s learning in a range of informal learning environments emphasised the importance of scaffolding (Andre et al., 2017).

It is not surprising, then, that a detailed study by Howitt et al. (2017) concluded that science outreach programs aimed at young children should provide emotional support to encourage children’s exploration of the exhibits, incorporate modelling to demonstrate how exhibits work, and use open-ended questions to extend children’s thinking. Further, outreach staff should assist adult carers to understand and acknowledge the place of play and learning as complementary; encourage active adult engagement with the children and the exhibits; and acknowledge children as capable and competent science thinkers, learners and communicators. How such science outreach programs can assist young children to develop their science identity was explored using photobooks as a visual method to investigate the science-related outcomes of participation.

The term ‘visual methodologies’ refers to the collection of methods used to understand and interpret images, including photographs and videos, that have emerged from anthropology and sociology (Glaw et al., 2017). The affordances of visual methods have been highlighted in research with children: capitalising on children’s multimodal meaning making, positioning children as capable communicators, acknowledging children as experts in their own lives, providing children with a voice, building understanding of children’s lived experiences, positioning children as co-researchers, and upholding children’s rights (Clark, 2011; Heydon et al., 2016; Rose, 2016). The use of visual methods encourages a postmodern perspective of childhood, where children are considered “knowledgeable, competent and powerful members of society” (Einarsdottir, 2006, p. 525).

Photo-elicitation is a visual method in which photographs are used during interviews to prompt responses from participants (Meo, 2010). There are many variations in how the images can be used: photographs taken and assembled by adults (Smith et al., 2005), photographs taken and assembled by children (Einarsdottir, 2005), or a combination of these approaches (Pyle, 2013). Photographs have been found to be an effective way of locating a conversation in children’s experiences because they provide a focus and context for the interview (Stephenson, 2009) and allow children to communicate through visual and verbal means (Clark, 2011). Due to their ability to evoke feelings and memories, photographs can produce more and different kinds of information and responses to those obtained through conventional interviews (Harper, 2002).

Photographs have been found to enhance children’s comfort level, engagement, and position within the research process. With attention placed on the images rather than themselves, children can express their ideas and feelings more freely (McIntosh and Stephens, 2012). Images produced by children or of children and their contexts enhance engagement due to familiarity (Pyle,

2013). As both the researcher and participant have some knowledge of the images, photo-elicitation becomes a collaborative effort to develop shared understanding where children are involved in both data collection and data interpretation (Glaw et al., 2017). Further, when children can take the lead in describing the photographs and may enter and leave the photo-elicitation session as they chose, the power relationship between researcher and child can be shifted (Epstein et al., 2006).

Pyle (2013) used photo-elicitation to obtain the perspectives of 32 children aged 4 and 5 years on their classroom-based learning experiences. Both children and the researcher took photographs, which were discussed across three photo-elicitation sessions. The affordances of the photo-elicitation technique were found to relate to the children's competence and ability to actively guide the process, appropriate contextualisation with the photographs which led to insightful comments from the children, and the use of children's verbal and non-verbal communication in analysing the photographs.

Creating a photobook involves selecting, annotating and organising photographs so they are presented and bound as a book, giving them permanence and importance. Katz (2011) investigated how a printed photobook designed around a 6-year-old boy's exploration of the world impacted his identity as a scientist. The 20-page book contained chronological photographs of the boy participating in science activities, each captioned with an open-ended question relating to science. Photo-elicitation was then used to establish the boy's perceptions of what he was doing, what he was learning, and what science was. The findings highlighted that repeated reading of the photobook supported both the boy's vision of himself, and the adults' vision of him, as a scientist. Through ongoing conversations around the photobook, "adult attention and childhood experiences" were brought together to "create a socio-cultural environment conducive to learning science" (Katz, 2011, p. 534).

Photographs have much potential to encourage children to explain complex science concepts using their language, and to support their visual thinking and understanding. The research in this paper is guided by the following question: How does the use of individualised photobooks support 3- and 4-year-old children in demonstrating their science learning and developing their science identity through participation in a science outreach program?

## MATERIALS AND METHODS

### Context

This research was part of a larger project that aimed to understand and find ways of improving parents' and young children's interest and engagement in science through their participation in an Australian science center's Early Childhood Outreach program. This program (subsequently referred to as the Outreach program) delivered a set of science-related interactive exhibits into community playgroups. Playgroups are weekly community events where parents and their young children

meet to interact in a wider social environment with a focus on play. Findings relating to young children's interactions with the Outreach exhibits are presented in Rennie and Howitt (2020). This paper presents information relating to the use of photobooks to enhance young children's science identity.

The Outreach program was designed for children up to 4 years of age. Designed around free play and guided play, the hour-long program encourages children to use their senses to better understand the world through a range of hands-on exhibits. One of two presenters introduced the program to the children and their parents, using a puppet to focus the children's attention on their senses of hearing, sight, smell, and touch. Children then have 30-40 min of play with 11 exhibits that include investigating moving objects with magnets, creating sounds, identifying smells, exploring how air can move objects, testing floating and sinking, exploring cogs and ramps, and observing the characteristics of living things. The presenters are available to interact with the children and encourage parents' participation to support their children's learning as they engage with the exhibits. The program concludes with the children gathered to hear a story related to the senses.

### Research Design

A multiple case study research design was used in this research. Case studies provide an holistic means of describing and interpreting phenomena in context, providing an in-depth understanding of those phenomena (Merriam and Tisdell, 2015). The phenomena of interest here were how individualized photobooks, developed from video-recordings of children and their parents interacting with the exhibits in the science Outreach program, assisted the children to demonstrate their science understanding and how the photobooks were later used at home. Within this research, the child/parent dyad was considered the case as children and parents tended (and were encouraged) to interact with the exhibits together. The multiple case design allowed common themes across the individual cases to be identified and described in a cross-case analysis.

### Data Collection

Data were collected during the Outreach program's visit to five playgroups (four metropolitan and one regional) across an 18 months period. Approval for the research was obtained from an institutional human research ethics committee, the playgroup, and the parents involved. One week before the intended visit by the Outreach program, the researchers attended each playgroup to provide parents with an information booklet about the research and it was described to them verbally. Parents were invited to ask any questions and encouraged to discuss the research with family members before agreeing to participate. Children also had the research described to them through watching and discussing a digital story (Mayne et al., 2017).

As shown in **Table 1**, data collection consisted of video-recording child/parent dyads interacting with the exhibits, preparation of the photobooks, photo-elicitation sessions and interviews with parents. In these playgroups, all of the parents were mothers. Each of these aspects are described below.

**TABLE 1** | Summary of data collection.

Timeline	Activities relating to data collection
During program	Video-recording of child/parent dyads interacting with exhibits
2–5 days after program	Preparation of photobooks from video stills
1–2 weeks after program	Photo-elicitation with child/parent dyads to determine how the photobooks assisted children in demonstrating their science understanding ( $n = 20$ , 11 boys and 9 girls). Photobooks taken home
7 weeks after program	Interview with parents ( $n = 15$ ) to determine how the photobooks were used at home. (Five parents not available)

**FIGURE 1** | A sequence of photographs showing a child and parent interacting with plastic insects.

### Video-Recording of Child/Parent Dyads

At least two researchers attended each playgroup during the Outreach program for observation and video-recording the interactions of those children whose parents had given their permission to be involved in the research. Video-recordings were made using tablets, which were selected due to their portability and unobtrusive nature, as opposed to a video camera mounted on a tripod. Also, due to the pragmatics of a playgroup setting, where young children move freely around a room crowded with science exhibits, a standing tripod was considered unsafe. The portability of the tablet allowed the researchers to follow specific child/parent dyads to individual exhibits and record detailed interactions between the child and parent with the exhibit. Additionally, the tablets were held at chest height to record interactions, reducing any possible anxiety associated with holding a camera at eye level (Flewitt, 2006).

Short (ranging from 8 s to 7 min) video-recordings were captured of the child, and where possible the parent, interacting with the various exhibits. These video-recordings attempted to capture an entire sequence from the start of the interaction with an exhibit, any discussion or problem solving occurring between parent and child, through to the completion of the activity or until the child walked away. Most children in the playgroup moved between the different exhibits according to what interested them, although they were sometimes guided by their parents. In this manner, the children could come back to an exhibit several times. The number of video-recordings made for the child/parent dyads ranged from 4 to 13.

### Preparation of Photobooks

The week following the Outreach program, individual printed photobooks were prepared for each child/parent dyad to provide a summary of their interaction with the science exhibits. Each video was observed by the researcher who made it, and screen shots were taken to capture actions that characterised children's

interactions with the exhibit. Using screen shots from the video allowed the researchers to select only those images that had the participating children and/or parents in them. This overcame one of the ethical limitations attached to using photographs in research; that is, children whose parents had not given permission for them to be recorded were excluded (Pyle, 2013). Up to four screen shots were obtained from the video for each exhibit in order to highlight a sequence of events. For example, one sequence of three photographs was a child placing a feather in a bottle, squeezing the bottle, and watching the feather fly out. Another example was a sequence of four photographs of a child and parent interacting with plastic insects. **Figures 1A–C** show three of these photographs, with the fourth photograph not presented as it shows the participants' faces. In the first photograph (**Figure 1A**), the child and parent are using magnifying glasses to explore the insects. The second photograph in the sequence, which is missing, shows the child pointing to a plastic ant. The third photograph (**Figure 1B**) shows the parent holding a plastic fly and the child pointing to it. The fourth photograph in the sequence (**Figure 1C**) shows the child tapping his shoulders as if to indicate where his wings might be.

Photographs were printed in full color as either A4, A5 or A6 size and placed into plastic sleeves of a folder. Each book had the child's name on the cover and the pages numbered. There were no words in the book. Photobooks of children engaging with the exhibits ranged from seven pages with 10 photographs to 16 pages with 27 photographs. The number of exhibits in the photobooks varied from one to eight.

### The Photo Elicitation Process

This photobook was used as the basis for the photo-elicitation conversation with children and parents at the next visit to the playgroup. All conversations with the children were conducted by the first author and audio-recorded. They occurred in a separate place to the main playgroup, at a time when both child and parent

**TABLE 2** | Description of child/parent dyads in photo-elicitation process.

Dyad number*	Child's age	Child's gender	Child's confidence during photo-elicitation conversation	Number of different exhibits in photobook	Length of conversation (min:s)	Parent interviewed at 7 weeks
Dyad 1.1	3 years 6 months	M	Confident	7	6:20	Yes
Dyad 1.2	3 years 7 months	M	Quiet	2	8:02	Yes
Dyad 1.3	3 years 5 months	F	Confident	6	8:34	Yes
Dyad 1.4	3 years 9 months	F	Did not engage	4	6:09	Yes
Dyad 1.5	3 years 3 months	M	Confident	5	4:12	No
Dyad 2.1	4 years 6 months	M	Confident	7	12:33	Yes
Dyad 2.2	4 years 4 months	M	Quiet	7	13:11	Yes
Dyad 2.3	4 years 4 months	F	Quietly confident	6	8:17	No
Dyad 2.4	4 years 4 months	M	Confident	7	13:40	No
Dyad 3.1	4 years 0 months	F	Confident	8	11:06	Yes
Dyad 3.2	3 years 11 months	M	Quiet	1	6:44	Yes
Dyad 3.3	3 years 11 months	M	Confident	8	9:16	Yes
Dyad 3.4	3 years 2 months	M	Quietly confident	8	9:38	No
Dyad 4.1	3 years 2 months	F	Quiet	7	13:59	Yes
Dyad 4.2	3 years 4 months	F	Confident	6	9:51	Yes
Dyad 4.3	3 years 2 months	F	Quiet	7	8:46	Yes
Dyad 5.1	3 years 7 months	F	Quietly confident	7	9:56	Yes
Dyad 5.2	3 years 11 months	M	Confident	6	9:00	Yes
Dyad 5.3	3 years 6 months	M	Confident	8	11:41	Yes
Dyad 5.4	3 years 7 months	F	Confident	8	12:40	No

were ready to engage. The children were asked to describe who was in the photograph, what they were doing in the photograph, and how the exhibit in the photograph worked. The children used a wide range of non-verbal communication, such as pointing, turning the page, gross motor actions such as pumping, and showing affective responses such as laughing. These were described verbally by the researcher for the benefit of the audio recording. The children were told that if they did not know the answer that was okay. Notably, the children were also asked “Would you like to turn the page?” to check their ongoing willingness to participate.

The child's parent was always in attendance, usually encouraged their child, and often was also a participant in the conversation. These conversations were guided by the children's ability to converse and their interest in the photobook. When children said they did not wish to turn the page, or walked away from the photobook, the conversation ended. Conversations lasted between 4 and 14 min. At the end of the conversation the children were presented with their photobooks to take home.

All conversations were fully transcribed by the first author who had conducted them to capitalize on her familiarity with the children's language and context. This transcription included copies of the images from the children's photobook. The children's observed confidence during these conversations was recorded as confident (spoke freely), quiet (provided short answers through parent) or quietly confident (spoke freely but with some assistance from parent).

Seven weeks after the program a final visit was paid to the playgroup to interview those parents who attended. Parents were asked if their child had shared the photobook with anyone and how it had been used at home. These audio-recorded interviews lasted from 5 to 10 min and were later transcribed.

At all times while attending the playgroups, the researchers demonstrated a listening and respectful approach to both children and parents. This was reflected in a flexible and welcoming approach to data collection that invited the children to look at their individual photobooks. It also included close observation of the children's body language to check for engagement with the process. An example of this was children looking and pointing at the book, rather than looking away.

**Table 2** provides an overview of the children and their parents who were involved in the photo-elicitation process. A total of 20 children and their parents took part in both the video-recordings and photo-elicitation conversations, while 15 of these mothers/carers were available for the parent interview 7 weeks after the program. Only one child chose not to engage with the photobooks at the 1-week conversation (Dyad 1.4—refers to Playgroup one, child/parent four), and so her data has not been included in analysing the photobooks. However, her mother did provide information at the 7-weeks interview and this data has been included. One grandmother attending as carer was interviewed in lieu of the mother at the 7-weeks interview (Dyad 4.2).

## Data Analysis

Children's transcripts were read and interpreted in the context of the photographs taken from the video-recordings. Children were classified as knowing what they did if they correctly described their actions at 50% or more of the exhibits in which they engaged. Similarly, children were classified as understanding how the exhibits worked if they correctly explained or modeled the working of 50% or more of the exhibits. Some children were initially shy and did not answer, but then warmed

up to the task and provided explanations, and these were also classified as understanding.

Data analysis was conducted using an inductive approach through thematic analysis (Merriam and Tisdell, 2015). All photobook analyses were completed by the first author who was familiar with each child through conducting and transcribing the conversations. Three rounds of coding were used to identify the themes relating to how the photobooks assisted the children in demonstrating their understanding of how the science exhibits worked. Initially, a description of each child was written that summarized how the photographs provided a context, the forms of communication being utilised by the child, and what the child understood, along with identifying relevant examples. This process was mostly driven by the data itself, although the literature did inform initial themes. The second round of coding further described the emerging themes of context, competence, and communication for each child, while adding the theme of participation. The final round of coding related to the cross-case analysis and how the themes were distributed across the children. The original video-recordings of the children's interactions with the exhibits and audio-recordings from the conversations were referenced to clarify any aspects.

To determine how the photobooks had been used over time, the parents' 7-weeks interview transcripts were read. The first author developed the initial themes, which were then discussed with the second author. After two rounds of coding, parents' comments were categorised in relation to how the child had shared the photobook, cognitive aspects (the child had used the photobooks to talk about what they did, the child had used the photobooks to explain how the activity worked) and affective aspects (the child had displayed enjoyment in showing the photobook to others). Examples of these themes are provided, relating back to the children's participation in the photobook conversation where possible.

## Trustworthiness

The quality of this research was enhanced by addressing two components of trustworthiness: credibility and transferability. Credibility provides confidence that the findings of the research are accurate and reflect the perspectives of the participants (Creswell and Poth, 2018). Credibility in this research was established using multiple participants and multiple methods of data collection, where triangulation of the findings was enhanced. Transferability is the extent to which the results can be applied to other similar contexts (Creswell and Poth, 2018). Through detailed descriptions of the methodology, along with a range of multiple and diverse descriptive vignettes, readers can assess the transferability of the research findings to their related situations.

## RESULTS

The findings are presented in two sections. The first section describes how the children demonstrated their science understanding using the photobooks. The second section describes how the photobooks were used to home.

## How the Photobooks Assisted Children to Demonstrate Their Science Understanding

Four major themes were identified relating to how the photobooks assisted the children in demonstrating their understanding of how the science exhibits worked: providing a context, demonstrating competence, multiple forms of communication, and participation on children's own terms. The first three themes are presented in **Table 3**, highlighting their occurrence across the dyads, and then described in the following sections. The fourth theme is described below.

### Providing a Context for Conversation

The photobooks provided the children with a focus for conversation and a context for the questions they were being asked. All 19 children found the photobooks provided them with a visual reminder of the Outreach program and how they had participated in that program. By looking at a concrete representation of themselves interacting with an activity, the children were able to respond to open-ended questions, such as "What are you doing here?" and "How did you make it work?" When turning the pages of her book, one girl confidently stated, "I can remember what we were doing here" (Dyad 5.4), highlighting how the photographs served as a memory aid for what she did in the Outreach program.

Twelve of the children (63%) identified themselves, family, or friends interacting with the exhibits or identified the room in the photobooks. Two examples demonstrate this:

"That's you and me, Mummy. That's me and Mummy."  
(Dyad 3.2)

"That was me in this room." "That was me in that [pink] top."  
(Dyad 4.2)

This self-identification reinforced that the book was about them and assisted in connecting the children with their experiences of the program.

Ten of the children (53%) also pointed to specific parts of the photographs to reinforce what they were saying or what was happening. The following example demonstrates how a child used pointing in his explanations.

Looking at the photograph of himself playing with the cogs, child in Dyad 3.2 states "You take them off and put them there" (pointing to the photograph). Researcher replies, "You remember taking some of the cogs off and putting them in different places."

Additionally, some children chose to point at objects in the photographs rather than respond verbally.

Researcher: So, you are racing the cars down the ramp.  
Can you remember which ramp was the fastest? [Name]  
is pointing to the red ramp. (Dyad 2.2)

These examples demonstrate how the photobooks provided a context to stimulate the children's thinking.

**TABLE 3 |** Occurrence of common themes across dyads in relation to how the photobooks assisted the children in demonstrating their understanding of how the science exhibits worked.

Dyad number*	Providing a context for conversations			Demonstrating competence		Multiple forms of communication		
	Visual reminder of content	Identifying self, family and friends	Pointing to highlight aspects	What did you do?	How did it work?	Verbal	Non-verbal	Through parent
Dyad 1.1	✓	✓	✓	✓	✓	✓	✓	
Dyad 1.2	✓			✓		✓	✓	✓
Dyad 1.3	✓			✓	✓	✓	✓	✓
Dyad 1.5	✓	✓		✓	✓	✓	✓	✓
Dyad 2.1	✓			✓	✓	✓		
Dyad 2.2	✓		✓	✓	✓	✓	✓	✓
Dyad 2.3	✓	✓		✓	✓	✓		
Dyad 2.4	✓	✓	✓	✓	✓	✓	✓	
Dyad 3.1	✓			✓	✓	✓	✓	
Dyad 3.2	✓	✓		✓		✓	✓	✓
Dyad 3.3	✓	✓	✓	✓		✓	✓	✓
Dyad 3.4	✓			✓		✓	✓	✓
Dyad 4.1	✓	✓	✓			✓	✓	✓
Dyad 4.2	✓	✓	✓	✓	✓	✓	✓	✓
Dyad 4.3	✓	✓	✓	✓		✓	✓	✓
Dyad 5.1	✓		✓	✓	✓	✓	✓	✓
Dyad 5.2	✓	✓	✓	✓	✓	✓	✓	
Dyad 5.3	✓	✓	✓	✓	✓	✓	✓	✓
Dyad 5.4	✓	✓		✓	✓	✓		✓
Total	19	12	10	18	13	19	16	13

\*Dyad number refers to playground and child/parent dyad. Child in Dyad 1.4 chose not to participate in the conversation, so the total number of children is 19.

### Demonstrating Competence

The photobooks allowed the children to demonstrate their understanding of the science associated with various exhibits of the Outreach program. All but one of the children described what they were doing in the majority of the photographs, with 10 of the children describing what they were doing in all the exhibits. In relation to understanding, 13 of the 19 children (68%) could explain how the majority of the exhibits worked, with three children explaining all the exhibits in which they participated.

When asked what they were doing, most children provided a description. Some children provided detailed descriptions such as “That was me playing with the dogs” (Dyad 3.3) and “I put that one in and I picked that one up. It was floating it was, in the water. If you look closer, see it does sink ‘cause it’s very big” (Dyad 4.2). Other children used simple descriptions, such as “Looking” (Dyad 1.2) and “Smelling” (Dyad 3.4). The one child who did not describe what she was doing (Dyad 4.1) was quiet and chose to reply “I don’t know” to all but one question through her mother.

Many children did not have the scientific language to explain how an exhibit worked. However, through using their own language and body actions in conjunction with the photographs, they were still able to give an explanation that demonstrated understanding. Even when some children used one or two word answers they could demonstrate an understanding of how the exhibit worked. A range of examples are presented below to highlight children’s explanations of how exhibits worked.

The following conversation relates to the car ramp:

Child in Dyad 2.4: You put car there (pointing). It goes really fast if you go there (pointing to red metal ramp).

It goes a little bit slow (pointing to other ramps). That one is the fastest (pointing to the red ramp again).

Researcher: Why was that the fastest?

Child in Dyad 2.4: It’s nice and smooth. They’re bumpy (pointing to the other ramp surfaces).

This child has provided a clear explanation of how the ramps work, using terminology of “smooth” and “bumpy” and pointing to aspects of the photographs to highlight his comments.

The following conversation relates to the cogs:

Researcher: Can you remember playing with the cogs and the steering wheel?

Child in Dyad 1.1: You turn this one (steering wheel) and it turns these, and they turn each other. They just help, they help.

Researcher: They help each other to turn.

This child talks about how turning the steering wheel results in the other cogs turning. He uses the terminology of “they help” to explain how interlocking cog wheels work.

A third example is a conversation between a mother and child about the balance scales:

Child in Dyad 4.2: We take one and put it in, and those balancing, and those on the other side and the other one goes on the other way.

Mother: What were the scales doing?

Child in Dyad 4.2: Balancing.

Mother: How did you make them balance?

Child in Dyad 4.2: Put two apples in that one and put two apples in there and it makes it balance.

Mother: What happens if it didn't balance?

Child in Dyad 4.2: (points to picture on page showing not balanced): One up, one down.

In this example the mother is encouraging the child by asking a range of questions. Not only has the child described a balancing situation, she has also identified a situation that is not balanced in the photographs.

Two children engaged in fantasy play (Rennie and Howitt, 2020) when playing with plastic insects (Dyad 1.2 and Dyad 3.2). Both children provided a detailed description of what they were doing. The child in Dyad 1.2 was pretending the insects were Grandma and Grandpa who went shopping and then were having a cup of tea in their holiday house, while the other was making a home for a grasshopper. There was no science explained in relation to the designated activity. The child in Dyad 3.2 demonstrated his previous experience with how insects move and their habitats. He demonstrated how grasshoppers jump and he commented that to make a home for the grasshopper you need "some leaves and some rocks." Further, when asked if the log was the grasshopper's home, he replied confidently "No, it doesn't live in logs. Different animals live in logs."

Those children who did not explain how the exhibits worked tended to give short or one-word answers that described what they were doing rather than providing an explanation. Some children stated, "I don't know". Such answers could reflect that they did not understand how the activity worked, did not understand the question, or simply chose not to provide an answer.

### Multiple Forms of Communication

Using the photobooks allowed the children to demonstrate their knowledge through multiple modes of communication: verbal, non-verbal and through their parent. All children described what they were doing using words, although in many cases it was in language familiar to the child. Sixteen of the children (84%) used nonverbal means to communicate, such as gross motor actions to describe how an activity worked, nodding/shaking of head to indicate agreement/disagreement and pointing to emphasize a specific aspect. Thirteen of the children also communicated through their parent. This could be through the parent asking the child a specific question to encourage a response, the parent encouraging a response or the parent interpreting the child's words for the researcher.

This first example highlights a mother questioning her daughter to provide additional information, the use of language appropriate to the child to describe the surface of the mirror ("slimy slopey") and the use of body movement to help describe what is happening (opening the mouth). The researcher, child and mother (Dyad 1.3) were looking at mirror photographs.

Researcher: I really like these [three] pictures here as it is you and your Mum really looking and trying to work out what is happening in these mirrors.

Mother: Do you remember the shape of the mirror?

Child in Dyad 1.3: Yeah.

Mother: Do you remember we were touching it to work out the shape of the mirror? Was it a straight mirror or was it a bit different?

Child in Dyad 1.3: A bit different.

Mother: What did it feel like?

Child in Dyad 1.3: It was slimy slopey.

Researcher: Slimy slopey. That is a really good description.

Child in Dyad 1.3: I liked the one with the funny heads . . . and I had a face like 'aaah' (mouth open).

This example highlights the importance of allowing children to use their own language to describe what is happening.

Although quietly spoken, the boy in the following example demonstrated his understanding of how the car ramp worked through multiple forms of communication. His mother repeated various questions to encourage a reply. Answers tended to be short (especially at the start of the conversation) and included nodding and pointing throughout.

Researcher: Did you like playing with the ramps:

Child in Dyad 2.2: (Nods.)

Researcher: What were you doing here?

Child in Dyad 2.2: Racing the cars down the ramp.

Researcher: Which ramp was the fastest?

Child in Dyad 2.2: (Points to the red smooth ramp.)

Researcher: Why was that the fastest ramp?

Child in Dyad 2.2: Because it is more flatter.

Researcher: Do you know which ramp is the slowest?

Child in Dyad 2.2: (Nods.)

Researcher: Do you want to point to the slowest one?

Child in Dyad 2.2: (points to the other three ramps.)

Researcher: Why were they the slowest ones?

Child in Dyad 2.2: Because they were bumpier than that one (pointing to the red smooth ramp).

There is a clear explanation of how the ramps worked, supported by the body language of nodding and pointing.

### Participation on Children's Own Terms

The photobook allowed the children to participate in the conversation on their own terms. Notably, by asking the children if they wanted to turn the page, all children were able to move at their pace or withdraw when they were no longer interested in participating. Four examples demonstrate this.

Once they had started with the photobook and understood the process involved, both children in Dyad 3.3 and Dyad 3.4 turned the pages of the book when they were ready to move on rather



**TABLE 4** | Classification of parents' description of how their children had used the photobooks at home.

Dyad number*	Child has shared the photobook	Cognitive		Affective
		Child talked about what they did	Child explained how the exhibit worked	Child's enjoyment in showing the photobook
Dyad 1.1	✓	✓		✓
Dyad 1.2	✓	✓		✓
Dyad 1.3	✓			
Dyad 1.4	✓	✓		✓
Dyad 1.5**				
Dyad 2.1	✓	✓	✓	✓
Dyad 2.2	✓			✓
Dyad 2.3**				
Dyad 2.4**				
Dyad 3.1	✓	✓	✓	
Dyad 3.2***				
Dyad 3.3***				
Dyad 3.4**				
Dyad 4.1	✓	✓		✓
Dyad 4.2	✓	✓	✓	✓
Dyad 4.3	✓			✓
Dyad 5.1	✓			
Dyad 5.2	✓	✓	✓	
Dyad 5.3	✓	✓	✓	✓
Dyad 5.4**				
Total	13	9	5	9

\*Dyad number refers to playgroup and child/parent dyad.

\*\*Parent absent from playgroup on day of interview.

\*\*\*Parent provided limited comments due to children's demands on her time.

than waiting to be asked to turn the pages. Thus, they kept the conversation moving at their pace.

In contrast, two children chose to stop the interview. On the last of nine pages in his photobook, the child from Dyad 1.1 stated, "Okay, I am going to go", and promptly got up and left. Similarly, on page 8 of 16 pages the following conversation occurred with the child from Dyad 4.3:

Researcher: Should we turn the page again?

Child in Dyad 4.3: No.

Researcher: No. Have you had enough?

Child in Dyad 4.3: Yeah.

Researcher: Yes. That's perfectly alright. We will stop our conversation now. This [photo]book is for you to take home.

Notably, the child in Dyad 4.3 was described as quiet (see **Table 1**) yet still felt empowered to stop the conversation. These examples highlight how the use of photobooks can allow children more control over the photo-elicitation process as they have the power when turning the pages.

## Extended Use of the Photobooks at Home

**Table 4** provides a summary across the dyads of the number of parents who, during their interview 7 weeks after the Outreach program, mentioned cognitive aspects (the child had used the photobooks to talk about what they did, the child had used the photobooks to explain how the activity worked) or an affective aspect (the child had displayed enjoyment in showing the

photobook to others) when discussing how their children had used the photobooks at home.

Of the 15 parents who were interviewed at 7 weeks, 13 referred to their children's cognitive and/or affective use of the photobooks at home. Cognitive themes include the child talking about what they were doing (9 of 13) and explaining how the exhibits worked (5 of 13). The affective theme relates to the children's enjoyment of both the Outreach program and showing the photobook to others (9 of 13). Various parent's comments relating to how their children interacted with the photobook at home are presented below.

Nine parents noted that children talked about what they were doing in the photos, with some children going through every page of the album.

He showed all his grandparents. "Look at my photos, this is what Mummy and I did during [science Outreach program] coming to playgroup." He loved it and went through every single page; this is what we did here, and this is what we did here. (Parent in Dyad 5.3)

He showed it to his Nonna and Nonno. He showed them the photos and explained that he was interviewed and what he was doing. He showed it to anyone who was happy to see it. All the grandparents made a very big deal of him being in this special book. (Parent in Dyad 1.2)

Both these quotes demonstrate how the children 'owned' the photobook and became the narrator of their story. The significance of the second quote is that it related to a quiet

boy who had engaged in fantasy play through most of the program and had spoken in short sentences with the researcher during the photo-elicitation conversation. At home, this child appeared happy and confident to discuss the content of the photobook with his grandparents and his role in the research project.

Five parents also commented on how the children used the photobook to explain how the exhibits worked.

[Grandparents] are visiting at the moment. So, he's taken it out and shown it to them. He's talked through a lot of things, in particular . . . the one with the feather in the bottle and how that worked . . . and how they were putting the fruit in the weighing thing [scales] and how that worked. (Parent in Dyad 2.1)

I remember sitting at the table and we did actually talk about what she did, with the photos. As a little 3-year-old, their explanations are amazing. How they explain and how they see it through their eyes. (Carer in Dyad 4.2)

These quotes demonstrate how children's confidence as they share their explanations of how the exhibits worked and how they used them, suggests they are developing a science identity. The second quote highlights how the child's explanation of how the exhibits worked has led to a shift in the grandparent's perception of the capability of the child (in this case, the mother was not available for interview).

Nine parent comments related to their child's enjoyment of both the Outreach program and the showing of the album.

He tells me what he was doing [in the picture]. He really enjoys looking at himself while he is playing. He remembers that it was fun, and it brought joy to him. (Parent in Dyad 1.1)

She made a point of [it] when her grandmother came over. "Omnia, Omnia, have a look." We have a few little photo books at home that we have put her holiday photos in that she has chosen that she likes in her bedroom. She has this [Outreach program photobook] in her bedroom as well. (Parent in Dyad 1.4)

The second quote is significant as it related to the child who did not engage with the photobook at all during the photo-elicitation conversation. In a more familiar context, she was eager to share the book with family and it had pride of place in her bedroom.

## DISCUSSION

The purpose of this paper was to describe how individualised photobooks were used to support 3- and 4-year-old children in demonstrating their science learning and developing their science identity through participation in a science outreach program. The use of the individual printed photobooks provided the children

with a context for conversation, and allowed them to show their competence, use multiple modes of communication, and to participate in the research on their own terms. At home, the photobooks were used to support children's recollection of their outreach experience in a cognitive and affective manner.

Similar to findings reported by Pyle (2013) and Stephenson (2009), the photobooks in this research provided a context for conversations by focusing the children's attention and reminding them of what they did in the Outreach program. By seeing themselves and their family members in the photographs, the children knew the book was about them and this encouraged conversations. The visual reminder of the Outreach program allowed the children to share and explain what they knew about the science exhibits and how they worked, thus demonstrating their competence. This was evidenced both in the photo-elicitation conversations and at home. Some children who were quiet during the photo-elicitation conversations with the researcher, or did not wish to interact with the researcher, readily shared the content of the photobook with family members when at home.

Young children who are still developing their communication skills may not possess the necessary language to adequately express their understandings (Howitt et al., 2017). The individualized photobooks used in this research allowed the children to utilise different modes of communication: verbal, nonverbal (gestures such as nodding or pointing) and through their parents. Most children used both verbal and nonverbal communication to explain the exhibits in the Outreach program. Notably, children used their own language in the verbal communication, such as the term 'slimy slopey' to describe the concave slope of a mirror. Howitt et al. (2017) have previously noted the importance of accepting children's language and allowing them to provide an answer that makes sense to them. This approach acknowledges children's competence and developing skills. Similarly, Clark (2011, p. 328) recognized young children as "meaning makers" and "skillful communicators" when provided with a range of ways to demonstrate their knowledge.

The use of individualized photobooks allowed the children to participate in the research process on their own terms. By asking the children if they wanted to turn the page, they were able to either move at their own pace or withdraw when they were no longer interested in participating. This embraces a rights-based participatory approach to early childhood research where young children's opinions, agency and ability to make decisions are taken seriously, and they are given opportunities to accept or decline their involvement in the research process (Mayne and Howitt, 2015).

The individualized photobooks provided a mechanism to support young children in retelling their story at home, demonstrating their knowledge of the exhibits and sharing their enjoyment of being involved in the Outreach program. Here, the child was the narrator as there were no words in the photobook. This placed the child in a position of power, with the adult having to listen or ask questions. As the story was the child's own and told with his or her own choice of words or actions, ownership was encouraged. Multiple readings of the book at

home provided opportunities and time for children to demonstrate their understanding, share their enjoyment, and re-live their science-related experiences. Katz (2011) also noted the enthusiasm of children at home revisiting their photobooks, engaging in conversations and building on existing relationships in the process. Individualised photobooks taken home provide ongoing opportunities for children to reinforce their cognitive and affective links with the program.

In terms of science identity, the use of individualised photobooks was found to contribute to the development of the children's identity and increase their agency in science and the parent's perceptions of their children as young scientists. Children saw themselves in the photographs and these became the center of the photo-elicitation and home conversations. Through explaining what they were doing and how the activity worked, children could see themselves as capable science learners, thereby reinforcing their science identity. Parents also perceived their children as young scientists, capable of describing and explaining what they were doing in the photographs. This can further reinforce children's science identity. Additionally, multiple readings of the photobook can assist children to internalise their science identity (Katz, 2011). While the photo-elicitation conversation allowed the children to demonstrate their science identity, conversations at home around the individualised photobooks proved a powerful mechanism to enhance that science identity. This has implications for photo-elicitation research around individualized photobooks and consideration of incorporating a "take-home" element into data collection.

This research is limited by the small sample of child/parent dyads who chose to participate and being in only one Australian state, albeit five varied locations. It is worth noting that research into children's interactions in playgroups is complicated by the nature of the environment. Although there may have been about 20 children in each playgroup, space logistics meant that it would not be possible to video-record sufficient data for more than 3–5 children during the period of exhibit interaction. A further limitation is that the information gathered in the 7-week parent interviews is restricted by what the parents could remember about how the photobooks were used at home. The photobooks could have been used at home in other ways not noticed by the parents and therefore have not been reported here. Finally, only mothers participated in this research. Fathers may have interacted differently with their children during the Outreach program and noticed different things at home when the children were sharing their photobooks.

It is worth noting also that science identity is a construct, not a visible characteristic of the child. By observing what children do, listening to them talk, hearing about parent's thoughts and their interpretations of their child's behaviors, we have inferred that participation in the science outreach program, supported by the photobooks used in our research process, has provided effective opportunities for children to develop their science identity. On this basis we conclude that our research has highlighted how the use of take-home individualized photobooks that capture

children interacting with various exhibits from an Outreach program has assisted in developing children's identity and increasing their agency in science and the parent's perceptions of their children as young scientists. The question of whether the photobooks should have words or not is interesting but moot. With words present, there can be a shift from the child telling the story to the adult telling the story, and thus the ownership of the story is no longer with the child. While the addition of words may be powerful in providing information about the photographs, we suggest that ownership of their story can assist children in creating a science identity. The photobooks present a valuable approach to extending the 'shelf-life' of outreach programs because they allow children to continue their science conversations at home and rehearse their science-related experiences.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Human Research Ethics Committee, The University of Western Australia. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

## AUTHOR CONTRIBUTIONS

CH and LR conceived and designed the project of which this study is part. CH prepared the photobooks and analysed the children's data. LR analysed the parent data. CH wrote the first draft of the manuscript. CH and LR both contributed to manuscript extension and revisions, read and approved the submitted manuscript.

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**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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