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Exploring Family Engagement with Photo-Taking to Support Observation During an Outdoor MAR Experience about Pollinators

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Abstract: Mobile technologies that include photo-taking elements help to support children's observation and exploration of the natural world; however, how families engage with digital photo-taking features has not been fully explored. We investigated how 22 families engage with digital photo-taking features of a MAR app that prompts place-based observation of the outdoors. Families' interactions with the app were qualitative coded and then two vignettes from different place-based micro-learning locations were developed to understand learning practices related to photo-taking. Findings show that families were deliberate in taking photos that recorded their observations of the outdoors; however, the environment and features within the app impacted families' observational talk and excitement levels during the photo taking activities themselves. These findings contribute to the understanding of the importance of photo-taking activities during MAR experiences.

Introduction

People use photographs to document the natural world, capturing their observations for later reflection. Scientific photo-taking, along with other tools, supports record-taking and encourages children to develop scientific observation skills (Eberbach & Crowley, 2009). Photo-taking features in mobile technologies, while providing an activity that appeals to children, have been shown to help people learn to observe and identify the nature around them (Land & Zimmerman, 2015; Kawas et al., 2019). Mobile augmented reality (MAR) technologies support families' exploration and observation of place-based experiences by virtually augmenting digital features onto local science phenomena (Zimmerman, Land, Faimon & Chiu, 2022; Yun et al., 2022). When designing an MAR experience, small design decisions can impact learners' interactions with and movement through the environment. However, there is a lack of research exploring how families interact with photo-taking activities to encourage scientific observation within MAR. This study explores: *how do families engage with digital photo-taking features of a MAR app that prompts place-based observation of the outdoors?*

Conceptual framework

Our research was designed with the concepts of learning-on-the-move (LOTM) (Marin, 2020; Silvis et al., 2018) and sensory observation and engagement (Eberbach & Crowley, 2009). LOTM emphasizes how people learn collaboratively as they move within spaces where their learning is grounded, such as learner's experiences and relationships with nature and family (Marin, 2020), and how multi-site, multi-modal technologies are used as learning tools (Silvis et al., 2018). Learning experiences are anchored within and influenced by the environment and place that learners move through. In designing for LOTM we encouraged families to explore the needs of pollinators and build knowledge by moving within and engaging with native pollinator's habitats through observation, prompts, and other activities grounded in place.

Mobile technologies encourage families and youth's engagement toward nature and science in outdoor spaces through observation, science talk and discussion, and tactile investigation of nature (Land & Zimmerman, 2015; McClain & Zimmerman, 2016; Kawas et al., 2019; Yun et al., 2022). Learning experiences that are situated in a specific outdoor place help to support families' observations and knowledge building of the world around them (Marin & Bang, 2018). Tactile and visual sensory engagement help support children's scientific observation, encouraging them to use their everyday observation skills as connected to disciplinary knowledge brought in by a family member or tool (Eberbach & Crowley, 2009). Additionally, scaffolding parents' and families' conversational techniques can aid in supporting joint attention and talk as families make observations of the natural world (Eberbach & Crowley, 2017). Children observe their world every day, but supporting scientific observation requires more structured activities or family support (Eberbach & Crowley, 2017), such as encouraging record-taking of children's observations (Eberbach & Crowley, 2009) through taking photos of the natural world in the structure of a scientific observation activity (Kawas et al., 2019). Previous work (Land & Zimmerman, 2015; Zimmerman et al., 2022) has demonstrated how photo-taking as part of an analysis, scientific classification, or field journal framework can encourage scientific talk. Building on this work, we explore how families engaged with the photo taking activities throughout the app as a tool designed to support scientific observation and structured recording of observations and science content.

Methods

This analysis is situated within a larger Design-Based Research (Sandoval & Bell, 2004) study, SPACES, to create MAR applications for outdoor science education for rural families. This analysis focuses on the second iteration of an app about pollinators designed for Shaver's Creek Environmental Center (SCEC), a 7,000 acres (28 km^2) outdoor learning center associated with Penn State University, for use on walking trails around the main building.

Nature center, app, and photo taking app features

The study was held at SCEC which serves approximately 100,000 visitors annually. Our team of learning scientists collaboratively designed our MAR app on pollinators with pollinator researchers and SCEC staff. The app took families on an outdoor tour around the main educational building focusing on pollinator gardens and other environmental features that a pollinator would need to survive in meadows and forested areas.

The Pollinator Explorers App is focused on a specific type of native pollinator—solitary bees—and what they need to thrive in a forest and meadow habitat. Families in our study used the app to explore six different GPS-triggered micro-learning locations around the outside perimeter of the nature center and collected evidence (through photos) of what these native bees need to live and thrive in this habitat. Our app was built with the ten design conjectures in Table 1, as guides for the development of the Pollinator Explorers App, with this analysis focusing on design conjectures five and six.

Table 1

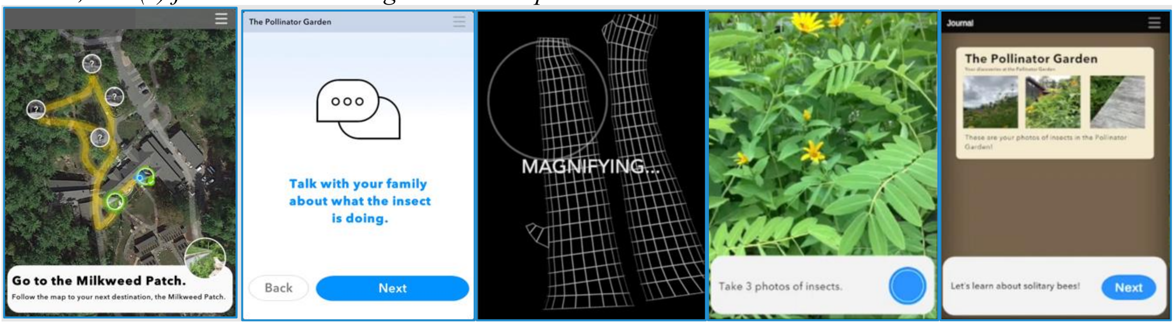
The ten design conjectures guiding the development of the Pollinator Explorers App; our analysis here focuses on conjectures 5 and 6 (bolded)

Overarching Design Conjectures	Features in the MAR app
1. Visualize 'seeing the unseen' scientific phenomena in digital simulations and animations.	After scanning a flower, a magnified view of a pollen grain is shown.
2. Place-based photographs, line-art, and text-based descriptions of the science concepts that connect to families' communities in the present day.	At all microlearning locations, content is given and then families engage in an observational activity to find real-world examples of the phenomena shown.
3. Immersion through AR filters and digital storytelling allows learners to imagine that they are in a new place or time.	A log is scanned and then the visitors can imagine the inside of a typical nest for a solitary, native bee is shown.
4. Use of movement across a space to represent unfolding storyline, aspects of a concept, or changes across time, space, or season.	A wayfinding map allows visitors to emphasize four critical ecological phenomena that come together to support how bees survive.
5. Sensory engagement via tactile and visual observation of objects or specimens on-site to support scientific noticing.	**At the log microlearning location, families use content provided to count and collect data on downed trees.**
6. Channel attention to key scientific phenomena through the families' photo-taking activities.	**The families use the content provided to identify pollen in the center of flower.**
7. Integrate on-site observations with digitally presented science content by creating a scientific journal.	The learners' photographs and bee observation checklist (of yes or no answers) are populated in a journal that they can review after the visit.
8. Discussion prompts or place-based activities that support sense-making and knowledge integration via focusing conversation on scientific phenomena and big ideas.	Families are encouraged to answer questions about the evidence of bees or other pollinators, talk about what they notice, the difference between a pollinator and human tongue, and what bees need in a habitat.
9. Discussion prompts support personalizing the experience via focusing conversation on prior experiences of the families.	Families are encouraged to connect their prior experiences with flowers, bees, and beehives/nests with the new content presented.
10. Discussion prompts, content, and digital activities to support environmental stewardship, personal connections, or community awareness.	Families discuss they humans could help maintain healthy bee habitats (e.g., by planting flowers that bloom at different points in the season).

Families navigated between micro-learning locations using a GPS map that tracked their location (Figure 1a) All micro-learning locations included text, photographs, and line art to support observations related what a bee needs to survive (I.e., food for self and young, water, diverse landscape, nesting locations) (Figure 1b). Micro-learning locations included digital augmented reality elements of science phenomena (i.e., bee nests inside of logs, microscopic pollen grain) layered over real-world objects to further families' observations and immerse them in more deeply understanding bee needs and habitats (Figure 1b). At the end of each micro-learning location, families took photographs that recorded what they learned and observed based on specific photo taking prompts (Figure 1d), which were then saved in their journal (Figure 1e). The first five micro-learning locations focused on a specific aspect of what a bee needs to survive in habitats like meadows and forests, while the sixth micro-learning location included discussion questions and activities that helped families bring what they had learned together and make connections across stops and the environment. For this analysis, we focus on the first five micro-learning locations where families were asked to take photographs.

Figure 1

Pollination MAR App Features: (a) family discussion prompt, (b) AR log scan, (c) GPS map, (d) photo taking screen, and (e) journal summarizing content and photos taken



(a) (b) (c) (d) (e)

Participants

Through our partnership with SCEC, the Center sent out Twitter, Instagram, and Facebook messages announcing the days and times that our team would be on-site conducting a research study. An article was included in the Center's member newsletter as well. Study recruitment bookmarks were placed at local libraries and a science center as well. Families had to have one child between the ages of 5-12 to participate and at least one of the adults who was present had to be the legal guardian or parent for all participating children. Families also had to be willing to be audio- and video-recorded; however, a legal guardian/parent had to opt-in to having their families' images shown in research-oriented publications such as this one. Families received one US $20 gift card for completing all study protocols.

Our team recruited 29 families on-site at the nature center; however, seven families were excluded from this analysis due to partial data. After written consent and children's assent was obtained, families borrowed an iPad™ mini pre-loaded with the app, which also screen-recorded the family's tour experiences. At least one family member wore a GoPro mounted on a baseball hat to collect data from the learner's perspective. From the 22 families, there were 34 adults and 37 children. Of these families, their self-reported racial affiliation included White (77%), Hispanic or Latinx (6%), Asian (6%) and Other (1%). Children (male: 51%, female: 46%, nonbinary: 0%) were primarily 5-12 years old (78%; ages 0-4: 14%, ages 5-8: 49%, ages 9-12: 30%, ages 12+: 8%). Two families (7%) homeschooled their children. 68% of families had previously visited the nature center. All 22 families completed the MAR experience with just their consented family present and had full screen recording and GoPro — without interruptions of their recording due to battery, memory card, inadvertent shutting off screen recordings, or other common malfunctions.

Data sources and analysis

Data consisted of 14 hours of merged video data from 22 families. Post-visit interviews were conducted on-site and included questions about what families learned about pollinators as well as questions that asked families to reflect on their experience with the app to support further redesign. The families' screen recordings of the visit and GoPro videos were merged into side-by-side video files for researchers to consider both the outdoor environment and technological environment in the analysis. Post-visit interview files were created as well. The merged video files and post-visit interviews were transcribed professionally and checked by research team members for accuracy.

The merged data files were analyzed qualitatively by the first and second author. Researchers used a binary coding framework (I.e., yes/no questions) in Table 2 to analyze the recordings regarding if a) children were engaged during the photo taking activity, b) any family member made observations or connected to app content, and c) families or children expressed excitement during the photo taking activity for each GPS-triggered micro-learning location. Building on "blitzcoding" (Callanan, 2012), we used this binary coding scheme to quickly identify key learning locations throughout the data that could shed light on how families engaged with the digital photo taking features throughout the app experience. Prior to coding, the first and second author jointly viewed one video as a training session, and then independently coded five videos with 91% agreement. The coders worked through disagreement about discrepancies, and the code book was expanded and solidified. Next, the two researchers separately coded the rest of the videos with a shared understanding of the coding framework. We used the results from the coding to identify patterns across the families' interactions in the micro-learning locations. This coding analysis was then used to inform our selection of exemplar vignettes from two families at the different micro-learning locations. These vignettes served to expand upon the patterns in the coding analysis and to explore differences in family engagement and observations when taking photos with the MAR app. Post-experience interview videos were also reviewed to see how many families mentioned the photo-taking feature when asked for feedback about the app.

Table 2
Codebook for how families interacted with the photo taking app at each micro-learning location

Yes/No Questions	Description
Different photos?	The family takes three different photos (Ex: photos of three different flowers, photos of a log from three different angles)
Deliberate photos?	The family takes at least one picture that represents the photo taking prompt
Children engaged?	Engagement of at least one child in the photo taking activity. This could include taking photos, making observation, talk or non-verbal excitement or interest connected to the micro-learning location or photos during the activity
Scientific observation or talk?	At least one family member remarks about the app content or nature observed (Ex: "this one where there's a bug on it, that's the common milkweed.")
Children express excitement?	The children expressed excitement (Ex: running to find a flower, "Ooh, a bee!")
Other family excitement?	Other family members expressed excitement (Ex: pointing to a flower, "Ooh, a bee!")

Results

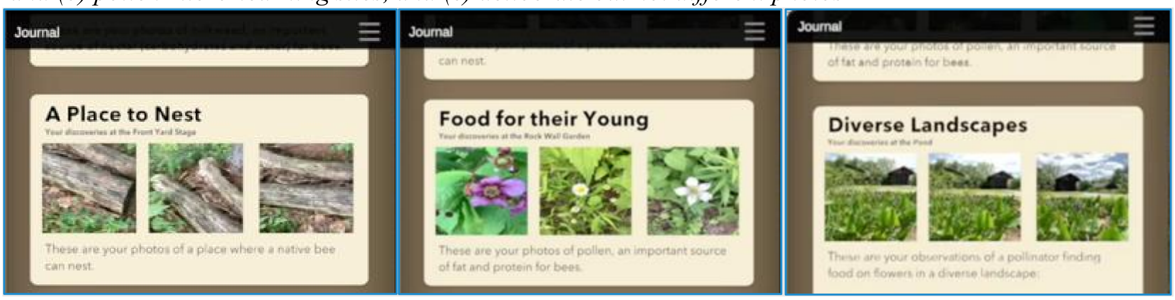
Overall, families enjoyed the ability to take photos, and the majority of families (55%) mentioned the photo taking activities as something that stood out to them when asked for feedback about the app. Throughout the MAR experience, families engaged with the photo-taking activities (Table 3) by taking the time to take different photos of aspects of nature they observed and make scientific observations or connections to the app content. While each micro-learning location included a similar photo-taking activity prompt around the selected ecological concept (Figure 1d, I.e., "take three photos of ___"), they all had different family discussion prompts and other activities that influenced families' interactions.

Table 3
Percentage of families that engaged with the photo-taking activity at each micro-learning location

Form of engagement	*Pollinators*	*Nectar*	*Nesting in Logs*	*Pollen*	*Diverse Habitat*
Different photos?	100%	100%	95%	100%	91%
Deliberate photos?	100%	100%	100%	100%	91%
Children engaged?	100%	95%	86%	100%	95%
Scientific observation/talk?	95%	86%	50%	95%	91%
Children's excitement?	73%	41%	27%	41%	73%
Other family excitement?	73%	41%	18%	55%	55%

The app asked families to take three photos but did not specify that those photos had to be of different things or at different angles (Figure 1d). Despite this all families did this at three of the micro-learning sites, and most did at the other two sites (95% at nesting in logs, 91% at diverse habitat). While families could have assumed that they were supposed to take three different photos, this practice could have also been driven by a desire to document different things that they had observed. At the other two micro-learning sites a small percentage of families did not take different photos, either because of an adult taking the same photo to get through that part of the app while the child was disengaged or because families were trying to capture one specific aspect of the location. All families also took "deliberate photos" or photos that represented the photo taking prompt at the first four micro-learning sites (Figure 2a, b, d), with two families not taking deliberate photos at the final micro-learning site. While one family was not engaged with the app at all, the other family was highly observant and engaged with the micro-learning location and photo taking prompt but was unable to find any pollinators to take photos of and just took pictures of the pond in general. Therefore, their photos did not fit our definition of "deliberate photos" despite the family spending a relatively long time trying to find a pollinator and making scientific observations about the location. Families with children that did not engage with the photo taking activity still could have one adult taking different or deliberate photos as a form of "rule following" but the children would be completely disengaged from the app. For example, one father took 3 different and deliberate photos at the nesting in logs micro-learning location but no one in the family spoke and their 8-year-old daughter was looking at something or watching her father take photos without engaging. Families could also have children that were engaged but did not take different photos. This only happened at the diverse habitat micro-learning location with two families while one of the children was attempting to take a close-up photo of the same pollinator that they had been observing (Figure 2c). Overall, 97% of families with children that were engaged with the photo taking activity also took different photos and/or deliberately took photos.

Figure 2
Families' photos in the journal showing examples of: different and deliberate photos at the (a) nesting in logs and (b) pollen micro-learning sites, and (c) deliberate but not different photos



(a) *(b)* *(c)*

Individual micro-learning location analysis

The first micro-learning location about pollinators showed the highest levels of all coded aspects of engagement. This could have been because of the open-endedness of the photo taking prompt ("take three photos of insects"), the previous observation activity, or because it was the first part of a new learning experience. On the other hand, the solitary pollinators nesting in logs micro-learning location had the lowest levels of observation talk (50%), engagement (86%) and excitement (27% of children, 18% other family members). While families showed high levels of engagement during the rest of the activities at this micro-learning location, including an observation activity and an AR scan of the log, the photo taking activity did not elicit this response. This could have been because the families were still focused on the AR scan, or that the static nature of the photo taking prompt ("take three photos of logs") made this activity lackluster in relation to the other dynamic activities during this micro-learning location. The last photo taking location, covering diverse habitats at the pond, showed high levels of excitement (73% of children, 55% of other family members) and continued high levels of scientific observation and content comments (91%) but also showed a dip in taking different and deliberate photos (91%). These trends could have been influenced by this activity taking place late in the app experience (the fifth micro-learning location), children being excited to look at the other wildlife around the pond (frogs and turtles), or the two observation activities (family discussion and observation checklist) that preceded the photo taking activity at this micro-learning location. These trends demonstrate how families' experiences, talk, and engagement with the photo-taking as an observational recording tool differed based on app structure, environment, and family interactions at each micro-learning location. To investigate how families experienced the photo-taking activity, we analyzed vignettes from two families at different micro-learning locations in the tour.

Vignette 1: Photo-taking supporting observing flowers and pollinators on milkweed

At the nectar micro-learning experience (the second micro-learning location), families are introduced to two different forms of milkweed, common and swamp, that are planted locally as nectar for pollinators. The family of David (Father) and Amelia (6-year-old-girl) demonstrate how families used the photo-taking activity to continue their observations of pollinators that they did at the first find-a-pollinator location while adding in new content about milkweed and identification of flowers from the MAR app (Figure 3).

David:	Milkweed ((points at the swamp milkweed))
Amelia:	Okay. So, we'll first take a picture of the orange one with the bee on it. Got it. ((takes picture))
David:	So that was the swamp milkweed, and then this one where there's a bug on it ((points to pink milkweed)), that's the common milkweed.
Amelia:	All right. ((takes picture)) Now it said three photos. One more photo to do. Let's take a picture of two of them together. ((backs up to take a photo of the milkweed patch))

This family's interactions showed one way in which families engaged with the digital photo-taking features of a MAR app: supporting scientific observation by applying the content in the app with the specimens on-site. For instance, David brought together the content from the *MAR_app* with the local landscape during the photo-taking activity, referencing both types of milkweed plants (common and swamp) shown in the app when his family took pictures. While taking photographs, David and Amelia engaged in observations of the colors and types of milkweed flowers, as Amelia tried to take three different photos that captured what she observed. Their observations of pollinators on the flowers also influenced Amelia's choice of which orange milkweed to take a picture of, as she deliberately chooses the "one with the bee on it". In reviewing the photos, Amelia took in their journal, David remarked "those are great milkweed pictures", encouraging her photo taking and observation skills. In this way, the *MAR_app* supported families' sensory observation related to new science content such as the types of milkweed present on-site.

Figure 3
(a) iPad screen showing milkweed at the micro-learning location, (b) iPad screen of Amelia taking photos of the milkweed and pollinator, (c) David pointing out the milkweed, (d) journal showing their photos

(a) *(b)* *(c)* *(d)*

Vignette 2: Photo-taking supporting identifying pollen on native flowers

During the photo taking activity at the pollen micro-learning location, families used visual observational practices to identify flowers containing pollen like those presented within the app. John (Father) helped his children, Maxwell (12-year-old boy) and Sean (6-year-old-boy) engage in these observations (Figure 4a, b). Both children showed excitement while photographing flowers containing pollen for their digital field journal.

John:	Sean, are there any flowers over there, ready to find? Anything we can take pictures of? Sean, can you go over and see any flowers on that side?
Sean:	I see purple! ((points to the flowers))
Maxwell:	Oh, cool! ((excitement))
Sean:	I want that one.
John:	Okay, you got to take a picture of that. Good job, bud.

While helping the children select flowers that they could photograph, John shared prior knowledge in identifying the local flowers at the pollen micro-learning location. Through their visual observations, the children took photos of these flowers based on their interest and identification of pollen as seen across each flower.

John: There's some more flowers right here. Did you see these ones?
Sean: Oh yeah, I did.
John: Those are daisies, maybe? ((points to the flowers))
Maxwell: These are cool ones. I see a lot of pollen on these.
John: That's right.

While reviewing their photos in the journal (Figure 4c) Maxwell showed excitement while saying "cool, right?" as he scrolled through the various photos that the family had taken up to that point in their MAR experience.

This family's interactions showed another way in which families engaged with digital photo-taking features of a MAR app: supporting scientific observation through prior knowledge and personal interests. Sean, for instance, focused on observing flowers that were a color he was interested in (i.e., I see purple!) and John was able to focus his family's second observation on daisies, something that Maxwell expressed interest in (i.e., These are cool ones.). By allowing the families to take multiple photographs, they connected the new content on pollen to each siblings' specific interests on-site.

Figure 4
(a) John pointing out flowers (b) iPad Screen of Maxwell taking photos, and (c) journal with their photos

(a) *(b)* *(c)*

Discussion

These findings demonstrate that throughout the MAR experience families were deliberate in taking photos that recorded their observations and the content of the app. Trends in across the micro-learning locations demonstrated how both the nature center environment and the features within the app impacted how families engaged with observations during the photo taking activities — especially the families' observational talk and excitement levels. As the two vignettes explored above demonstrate, families were able to use the MAR app's photo taking prompts to encourage observations of the environment and record-taking of those observations through the journal. In the first vignette, the photo-taking allowed Amelia and her father David to take photos that applied new scientific content of nectar and milkweed plants through their observations. In the second vignette, the photo-taking allowed siblings Maxwell and Sean and their father John to integrate their prior knowledge or personal interests with the new science content of pollen. These findings help to shed light on how families interact with photo taking, as a common design element in mobile technologies, within the broader MAR experience.

Returning to our orienting theory, the prior work has shown the importance of movement in outdoor education and science learning (Marin, 2020; Marin & Bang, 2008). Adding to this literature, this study's findings show that by designing for families to learn-on-the-move together, families could use digital photography to capture their observations of scientific phenomena. Table 3 showed that as family members moved through the gardens, all families took different and/or distinct photographs that captured their observations throughout the MAR experiences, moving through the space to take purposeful photographs that applied new scientific content.

Movement and sensory observations were important parts of the learning process as illustrated by John, Sean, and David pointing at flowers to orient family members observation. Families had to move around to capture different plants or pollinators, as shown by Amelia backing up to photograph both types of milkweed plants, and Maxwell moving around the pollen micro-learning location to photograph flowers in different locations. Other LOTM literature shows the importance of technologies such as GPS and mapping software (Silvis, et al., 2008; Taylor, 2017), as our work adds digital photography to the list of technologies that can help learners as they explore the outdoor places in their communities. While some prior work has shown the LOTM technologies can support interest (i.e., Kawas, et al, 2019), our work illustrates that having the opportunity to take multiple unique photographs may support families with siblings with different interests or ages (e.g., Maxwell and Sean), and that having directed photo-taking prompts may encourage families to look closer at their environment to connect content (e.g., Amelia), helping them stay engaged and focused on scientific observational tasks and ecological learning outcomes.

Our work has practical implications to informal science education. While AR and other related technologies have shown to support family learning (Kawas, et al, 2019; Yun, et al., 2022), our work demonstrates how an MAR technology including photo-taking, integrated into a specific location's walking trails, can support both science practices (i.e., observation) and science content (i.e., pollen and nectar as key food sources for native bees) learning outcomes.

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