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Design strategies to integrate creative learning in elementary school curricula through computer programming activities

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ABSTRACT

Cultivating children's creativity and imagination is fundamental to preparing them for an increasingly complex and uncertain future. Engaging in creative learning enables children to think independently and critically, work cooperatively, and take risks while actively engaged in meaningful projects. While current trends in education, such as maker movements and computer science education, are dramatically expanding children's opportunities for engagement in creative learning, comparatively few empirical studies explore how creative learning can be integrated into elementary school curricula. In this paper, we investigated five key design strategies for integrating creative learning in school curricula through computer programming activities. The five design strategies, drawn from design meetings with in-service teachers and two pilot studies, comprise (1) prepare an object-to-think-with for specific curricular ideas, (2) find a context that provokes a leap of ideas within a disciplinary framework, (3) facilitate tinkering through disciplinary inquiry, (4) pair students and establishing developer and researcher roles, and (5) provide feedback to connect computer programming projects to disciplinary ideas. Implementing these strategies with mixed-method analysis indicated positive support for the efficacy of these design strategies. We also provide insights into difficulties with integrating creative learning into school curricula.

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Creative learning; constructionism; computer programming education; curriculum integration; elementary education; coding education

1. Introduction

1.1. Creative learning

Cultivating children's creativity and imagination is essential to prepare them for an increasingly complex, uncertain future. To nurture creativity, it is important that children engage with a learning environment that allows them to think independently and critically, while engaging with a variety of materials and conditions which activate divergent thinking (Cropley, 1997). Resnick (2017), who calls this process "creative learning," posits that learning environments nurturing creative thinking have the following characteristics:

(1) Projects: The learning experience involves opportunities to work on projects that generate an end product to share as a central activity.
(2) Passion: The learning experience supports working on what learners are interested in or what is relevant to them.

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(3) Peers: The learning experience involves opportunities for learners to learn from one another while asking questions, exchanging feedback, and building on each other's ideas.
(4) Play: The learning experience involves opportunities to experiment, try out unfamiliar actions, take risks, make mistakes, and iterate on ideas in order to complete their projects.

While current trends in education, such as the maker movement and computer science education, are dramatically expanding the opportunities for children to engage in creative learning experiences (Blikstein & Krannich, 2013; Grover & Pea, 2013; Israel & Lash, 2020), school environments are often considered incompatible with children's creative exploration (Beghetto, 2010). One reason is that traditional teaching is often convergent (transmitting predetermined facts to the students) as opposed to divergent (encouraging students to explore different ways of understanding), which is key to creative thinking (Guilford, 1950). As well, a practical constraint is that schools lack the time to cover all the required activities and lessons, resulting in highly prescribed instruction that minimizes opportunities for students to explore divergent ideas. Additionally, most schools must meet externally imposed curriculum standards established by national and/or regional governments and have little to no time to cover anything else. And finally, teachers who are most comfortable with traditional instructor-driven pedagogy tend to be dismissive of, or anxious about, changing their teaching practices.

1.2. Computer programming as a pathway into creative learning in school environments

Increasingly integrated globally into school curricula, computer programming has reported to be able to open up opportunities to creative learning (Resnick & Rusk, 2020). Integrating computer programming into school contexts primarily aims for development of computational thinking (Wing, 2008). In addition to coding skills, advocates of computational thinking emphasize how learning to program can help learners develop systematic and critical thinking skills while also engaging in social and iterative learning processes (Grover & Pea, 2013). This social and iterative aspect of the programming process has much commonality with creative learning processes. Papert (1980) who developed LOGO – the first programming language for children – supports this view, arguing that computers can support children's creative endeavors by engaging them in active and iterative learning processes through programming.

Computer programming is also known to facilitate students' knowledge construction in general, allowing them to develop their own understanding through physically interacting with computational artifacts as representations of fundamental concepts and ideas about the world (Harel & Papert, 1990). Such interaction often lead to children's engagement in interdisciplinary ideas and practices (Wing, 2008). In other words, computer programming can support not only creative exploration but also disciplinary learning, which has been a major challenge for integration. While computer programming is certainly not the only approach to creative learning (Bevan et al., 2014), its iterative, collaborative nature – enabling children to express ideas in a variety of formats such as images, animation, or interactive artifacts – dramatically expands possibilities for personally meaningful, project-based, peer-oriented, and playful learning experiences.

However, integrating computer programming in school curricula has its challenges. While a number of studies have shown educational benefits of programming activities besides learning how to code in STEM fields (e.g. Lee et al., 2020; Sengupta et al., 2013; Weintrop et al., 2016) as well as in non-STEM subjects such as social sciences and language arts (Barr & Stephenson, 2011), there are a limited number of empirical studies on pedagogical strategies that support the simultaneous development of creative and disciplinary thinking (Beghetto, 2010; Bevan, 2017; Gajda et al., 2017). With recent technological advancements introducing new tools, materials, and opportunities for creative learning, the time is right for researchers to examine how creative thinking can be integrated into disciplinary curricula using recent computer programming technologies.

1.3. Purpose of this study

This study addresses the research question: What are the key design strategies to integrate creative learning in elementary school curricula? By carefully identifying and trying out these strategies with students and teachers, this study aims to contribute evidence-based approaches that educators can employ to integrate creative learning into their curricula through computer programming. In the following sections, we describe the design strategies and how they were generated. We then share the findings from the implementation of a unit designed using the design strategies in a classroom to show how each design strategy may have played a role in achieving the goals of the social studies unit, in this case for the unit on the role of ICT in the agricultural industry. Finally, we conclude with several insights about integrating creative learning in school curricula.

2. Identifying the design strategies

2.1. Methodology

To generate our key design strategies, we conducted a series of design discussions with a group of teachers for two pilot studies in a classroom setting. Eight teachers (*F*=1, *M*=7) were recruited from a teacher professional development event on computer programming education. This group comprised one middle school teacher, five elementary school teachers, and two elementary school coaches. As with most school districts in Japan, the elementary school teachers were responsible for teaching all subject areas while the middle school teacher specialized in technology education. All teachers had more than eight years of teaching experience and had been implementing programming lessons at their school districts. The design meetings with these teachers included two 2-hour in-person brainstorming sessions and three online meetings, as well as observations during two pilot studies and post-pilot discussions. In each research meeting, about half of the teachers voluntarily participated.

The pilot studies took place at an elementary school in rural Japan as a weekend workshop. While the lesson unit was intended to be conducted across six weeks, one period per week (i.e. 45 minutes), all six periods were conducted as a single one-day workshop for the pilot studies because of the researchers' and school's scheduling constraints. Participants took a break between each period to mirror the condition the lesson was designed for.

A group of 6th-grade students voluntarily participated in the first pilot study and a group of 5th-grade students in the second study. Each session was conducted only with students who were usually in the same class to create a social environment close to their normal classrooms. The researchers collected screen and audio recordings from each laptop, video recordings of the whole classroom, and worksheets and post-it notes produced by participants during the lessons. The screen and audio recordings provided information on how the students collaborated and worked on the project. The classroom recordings captured the students' interactions, such as walking around in the classroom or stopping by at other groups' desks. As a means of analyzing the data, the researchers developed a rubric. The researchers also examined the meeting notes from the teacher debrief meeting. The notes from the meetings with teachers helped to determine teachers' opinions and questions regarding things that worked or did not work. The researchers conducted a close reading of the data and discussed to identify ways of refining the strategies.

2.2. Rubric for creative learning integration

Based on the design strategies we designed the lessons, and subsequently developed a rubric to examine how each lesson fulfills the expectations for a social studies unit and a creative learning activity. The rubric had six criteria: five for creative learning experiences and one for the social studies. All criteria had levels of 3 (the highest level), 2, and 1 (the lowest level). The wording of the criteria was slightly modified after the first pilot for clarity. The criteria for creative learning were based on Resnick's original creative learning principles (2017). One of Resnick's principles, *Projects*, was turned into the criterion "Purpose" to capture how students identified their goals and strived to achieve them. While creative learning is usually an exploratory process and does not require a clear goal from the beginning, creative learning environments should allow learners to discover what they want to do and learn to accomplish it. We compared learners' initial ideas with the final projects to see how successful they were at achieving their goal. Since *Projects* also enable learners to achieve their goals using time, materials, and resources wisely, we added another criterion: "Process." This criterion examined the behavior of each student before and after the presentation required in the middle of the lesson to see if each student was able to make progress.

To reflect the second principle, *Passion*, we used the criterion "Remixing" to look at how students added their own ideas or interests to ideas introduced by the instructor. To determine how each student explored their own ideas, we compared each final project and the examples presented at the beginning of the class from three perspectives: appearance – character or background of the Scratch project, structure – structure of the code, and approach – the problem-solving strategy.

For the third principle, *Peers*, we used the criterion "Peer support" to determine how student worked with others. We examined how many times students interacted with other students through actions such as explaining their project, asking questions, and giving feedback. The interactions were counted by a set of conversations rather than by individual interactions.

We selected the criterion "Tinkering" to reflect the fourth principle, *Play*. Tinkering is often defined as "fooling around directly with phenomena, tools, and materials" (Wilkinson & Petrich, 2013), emphasizing an exploratory engagement with objects to build a multi-dimensional understanding of them. In this study, we decided to evaluate how much tinkering occurred based on the number of iterations each student conducted to achieve their project goal. We counted an iteration as the combination of trying out and modifying based on the outcome they received from the trial.

The social studies rubric consisted of a single criterion with three levels of achievement, reflecting the extent to which a student demonstrated understanding of the use of ICT in relation to the agricultural industry's development. This rubric was created with reference to Japanese standards of study for elementary school 5th-grade Social Studies, which states in part that,

> consideration should be given so that students can form their own views on the development of industry and the improvement of people's lives in line with the progress of information technology from a multifaceted perspective from the standpoint of industry and people. (Ministry of Education Culture, Sports, Science, and Technology, 2017)

2.3. Key design strategies

As a result of the design meetings and two pilot studies, we identified and refined five design strategies to integrate creative learning in an elementary school curriculum through computer programming activities. We formed these strategies to be discipline-agnostic. Table 1 presents the list of strategies:

Table 1. Proposed key design strategies for creative learning integration.

	Strategy	Creative learning framework related to this strategy
1	Prepare an object-to-think-with for specific curricular ideas	Play
2	Find a context that provokes a leap of ideas within disciplinary framework	Play, Passion
3	Facilitate tinkering through disciplinary inquiry	Play
4	Pair students and establish a developer and researcher role	Peers
5	Provide feedback to connect computer programming projects to disciplinary ideas	Project

2.3.1. Prepare an object-to-think-with for specific curricular ideas
One major question was how to make sure all students engage with curricular ideas while ensuring they have enough space to explore, experiment, and construct their own understanding by creating artifacts. These two goals are often seen as contradictory: the first tends to emphasize structure whereas the second emphasizes more freedom for students. However, we noticed in the two pilot studies that the materials for construction, in this case programming blocks, can work as a structure to help students engage in a certain way of thinking. For example, conditional blocks (i.e. IF and THEN blocks) that trigger different events depending on distinct conditions facilitate thinking about relationships between elements or incidents. Indeed, Papert (1980) suggests that programming can be an object-to-think-with for students to take an objective view on their understanding and help them to "think about thinking." If a certain object-to-think-with is associated with a certain way of thinking, we may be able to scaffold students' disciplinary thinking by selecting a specific object for making.

2.3.2. Find a context that provokes a leap of ideas within disciplinary framework
In a creative learning process, it is important that learners work on a topic or issue that matters to them (Resnick, 2017). Engaging students' interests creates ongoing tension for school-based learning, which has fixed curriculum goals all students need to meet regardless of their interests or background. For educators who lead creative learning in classrooms, designing a learning activity that satisfies both the curriculum goals for the class and each student's personal interest is one of the most critical challenges.

This tension came to our attention during our initial pilot study. We provided three example projects that varied in complexity, ideas, and the type of programs being used; our goal was to scaffold students' idea generation while guiding them through the social studies curriculum. However, these examples led to apparent lack of diversity in the projects created by the students, essentially over-restricting their ideas (see Figure 1). The students seemed to have viewed these examples as directives rather than suggestions.

The lack of idea explorations in the pilot study led us to the second design strategy: choosing an open-ended theme that invites unconventional ideas and free exploration while providing a minimal structure to help students focus on disciplinary ideas. A strategy that provides students with initial scaffolding while creating a space for them to explore their own ideas may be a key design consideration for integrating creative learning in curricula.

2.3.3. Facilitate tinkering through disciplinary inquiry
Another challenge was the lack of depth in engagement with social studies learning goals. Our analysis of the first pilot study exactly indicated this problem. One teacher who observed and

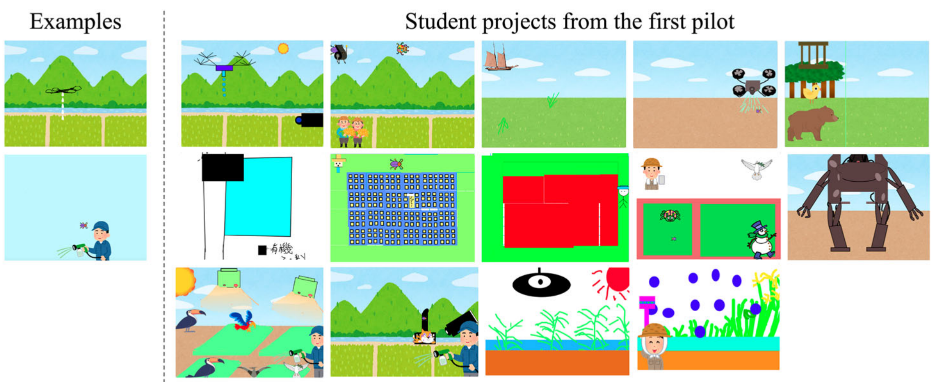

Figure 1. Student projects in comparison to the examples from the first pilot study.

participated in the post-pilot meeting described the unit as "a Scratch class 'flavored' with social studies," implying that the unit touched upon a social studies topic, but its contribution to the students' understanding was minimal. In a normal social studies class, a teacher would ask a follow-up question to encourage students to think critically about the topic. In creative learning environments, on the other hand, there were limited opportunities for teachers to invite students in such inquiry because students are often immersed in a highly complex, non-linear process with their peers, and also because the students' thinking process is less visible for teachers.

This realization led us to our third design strategy: support creative exploration using questions aligned with disciplinary ideas. Such support should inspire students to articulate their understanding as they iterative work on their projects.

2.3.4. Pair students and establish a developer and researcher role

While learning from peers is one of the four characteristics of creative learning (Resnick, 2017), students often struggle to find a productive way to work with their peers when peer learning is not part of their everyday norms. In the initial pilot study, after individually getting used to Scratch, we encouraged students to work in teams. However, we witnessed no students actively trying to work with other students. The students were not used to working collaboratively and needed support to begin working together.

In the second pilot, we paired up the students from the beginning and made them work together on one project to encourage peer activities. Employing Lewis' (2011) pair-programming framework, we assigned one student a "navigator" role (i.e. a person in charge of deciding what to do without touching a computer) and the other student a "driver" role (i.e. a person in charge of manipulating a computer based on the navigator's suggestions). This format did encourage students to work together, but classroom observation and video analysis revealed uneven distribution of work between the students who were sitting at the desk handling computers ("driver") and the students who were supposed to help their peers by providing suggestions ("navigator"). The teachers pointed out that many students must have assumed that a driver makes the major contribution and a navigator was a mere supporter.

Based on these insights, we decided to include a design strategy to highlight the importance of peer work and to introduce roles in the creative process more familiar to students. By switching names to "developer" and "researcher," the strategy attempts to even out the responsibility between two students and also encourage more material research, which should help the students better ground their work in the Social Studies context.

2.3.5. Provide feedback to connect computer programming projects to disciplinary ideas

Other issues raised by teachers during the debrief meetings for the pilot studies was that students did not complete the unit with subject-related takeaways. In normal disciplinary units, teachers often wrap up the unit by overviewing important takeaways or by having students take an exit quiz to revisit what they have learned. Indeed, the pilot studies did not appear to encourage the students to "go back" to the content knowledge frequently enough. Since students tend to work on unique projects in creative learning, it is difficult for an instructor to provide a single conclusion that summarizes all learning that occurred in the room.

This observation led us to realize that instead of providing a uniform conclusion applying to all students, the instructor needs to find opportunities to show how each of their ideas apply to disciplinary idea. One strategy we devised was to use the sharing opportunities during and at the end of the unit to provide feedback from the instructor on the connection between students' projects and disciplinary.

3. Implementation

3.1. Methodology

To evaluate the efficacy of the design strategies, we implemented a lesson unit that was carefully designed using our design strategies in a classroom setting with students. Ten 5th-grade students (*F*=5, *M*=5) from the same elementary school as the two pilot studies voluntarily participated in the implementation. Similar to the pilot studies, the unit was conducted as a one-day workshop.

3.2. A lesson unit based on the proposed key design strategies

To examine each design strategy in a real classroom setting, we designed a lesson unit consisting of six periods (see Figure 2).

Each participant received a Chromebook and used an online visual programming platform called Scratch (Maloney et al., 2010) to conduct the computer programming activities. Many of the participants had no Scratch before the study. To limit the relational bias, one researcher who had never met the participants taught the whole lesson, assisted by another researcher specialized in social studies education, who provided insights from a subject-matter expert. We applied the five design strategies that we generated from the pilot studies as indicated in Table 2.

The first period was for participants to familiarize themselves with the Scratch platform. Students were given a basic introduction to the platform and introduced to five basic blocks before starting to create a practice project. The functions introduced here were carefully selected: covering both general basic functions (such as the layout of the editors, how to add and delete spites, movement blocks, etc.) and a function that was specific to the type of projects students were going to create ("broadcast" blocks), thus incorporating the first design strategy. The broadcast blocks were intended to help students to program one event to happen after another, guiding them to examine chronological relationships between phenomena such as the aging society and the decreased production of rice: one of the fundamental "way[s] of thinking" included in the social studies curriculum (Ministry of Education Culture, Sports, Science, and Technology, 2017).

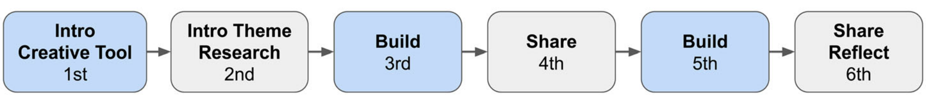

Figure 2. Activities assigned for each period.

Table 2. Strategies and the methods of application.

	Strategy	Lesson unit	Methods of application in the lesson unit
1	Prepare an object-to-think-with for specific curricular ideas	1st period	Introduced a set of blocks that help students to integrate chronological causal relationships (i.e. Broadcast Message blocks).
2	Find a context that provokes a leap of ideas within disciplinary framework	2nd period	Provided a theme situating the students as "inventors came from the future" that develop "tools to solve the problem facing rice farmers."
3	Facilitate tinkering through disciplinary inquiry	3rd and 5th period	Provided a worksheet with questions and issues that help students reflect on specific aspects of their projects while they are iterating their projects.
4	Pair students and establish a developer and researcher role	3rd to 6th period	Paired students and assigned each student either a developer or researcher role, and switched them several times during the workshop.
5	Provide feedback to connect computer programming projects to disciplinary ideas	4th and 6th period	The instructor provided feedback during the whole-group sharing, commenting on how their ideas may be connected to social studies ideas and how they might strengthen that.

During the second period, students were introduced to the theme of the unit: the information and communication technologies and their impact on rice farming industry. The instructor used slides to introduce a couple of statistics and three typical problems facing rice farmers in the form of stories about three farmers. Students broke into pairs, selected one of the issues they were most interested in, and conducted further research about the issue. Each pair received two pages of resources relevant to their chosen issue and additional resources the instructor had prepared at back of the room.

The instructor then asked the students to create animation using Scratch that introduces their ideas of an invention to support rice farmers in dealing with their challenges. Here we incorporated the second design strategy: i.e. find a context that provokes a leap of ideas. By calling the project "invention" while also setting up the situation in the future, we tried to invite students to imagine ideas beyond what already exists in the real world.

Students in pairs then brainstormed potential solutions to the problems facing rice farmers. Using another blank worksheet (Figure 3) as thinking prompts, the pairs chose one idea and further explore as the solution.

This worksheet was the scaffolding added based on the third design strategy, i.e. facilitation of tinkering through disciplinary inquiry. The prompts on the worksheet were designed to invite students to articulate and refine their ideas while also helping them to consider elements of the project aligned with the disciplinary ideas.

The third period was dedicated to the development of the project. Using the pair-programming technique (Lewis, 2011), one student took the role of a developer and the other as a researcher, applying the third strategy. The instructor cued them to switch roles several times during the workshop.

The fourth period was a mid-point sharing opportunity for students to share their project and ask for help if they encountered any challenges. Each student stood in front of the class and talked through how they are trying to solve the rice farmers' problem using the invention, what they are going to do next, and challenges they are working on. These questions reflect the fifth design

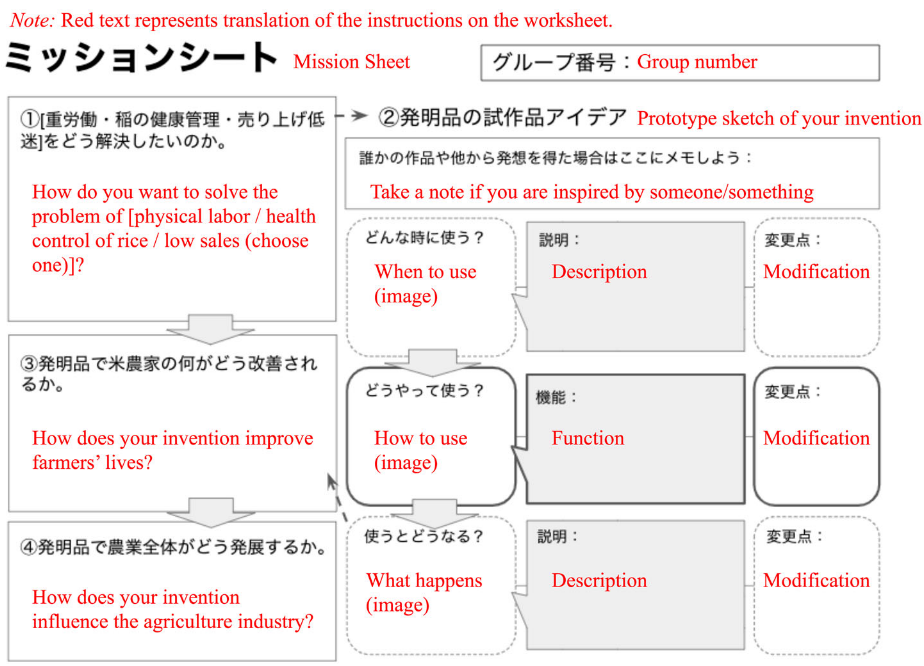

Figure 3. Modified worksheet after the second pilot study.

strategy: i.e. to give feedback about connecting bridge computer programming projects to disciplinary ideas during the project. Other students also provided feedback to each group using comment cards detailing things they liked and questions they wanted to ask.

The students continued to build their projects through the fifth period. The instructor encouraged students to revisit the worksheet and modify the details as their ideas developed. During this time, using the worksheet, the students also prepared for their final share-out planned for the sixth period.

The sixth and final period was focused on presentation and reflection. Each pair demonstrated their Scratch projects at the front of the class, sharing details of their inventions and how they may solve ongoing problems. The instructor acknowledged an aspect of each group's project connected with the ideas in social studies, thus encouraging students to revisit the curricular topics. This process is reflective of the fifth design strategy: i.e. feedback for bridging projects with disciplinary ideas.

4. Evaluation

4.1. Data

We collected the same set of data as the pilot studies to examine the experiment: screen and audio recordings of each laptop, video recordings of the whole classroom, and worksheets and post-it notes produced by students during the experiment. The researchers also examined the meeting notes from the teacher debrief meeting after the experiment.

4.2. Analysis

Using the same rubric that we developed for the pilot studies, we examined whether the lesson we developed based on the design strategies fulfilled criteria as a social studies unit and a creative learning activity. Two researchers examined the data collected during the activities (i.e. screen, audio, video recordings and students' written notes) using the rubrics and discussed until they reached an agreement on the analysis. The researchers repeatedly read the observation notes and meeting notes from the discussion with teachers to triangulate the results based on the rubric. Figure 4 summarizes the relationship between the design strategies and the rubric criteria that we used to evaluate the strategies.

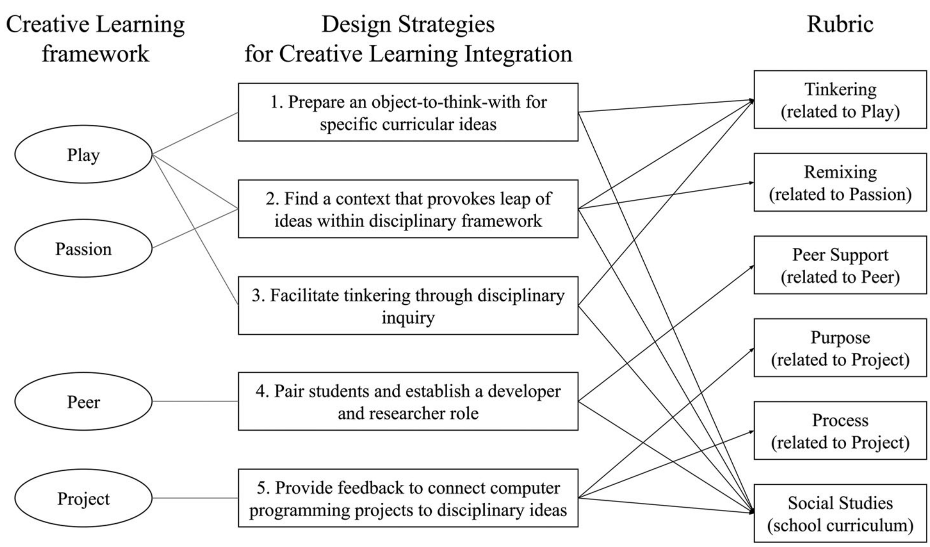

Figure 4. Rubric categories in relation to design strategies.

The two then had several discussions to examine the implications about integration of creative learning in classroom environments.

4.3. Results

As shown in Table 3, the rubric scoring on creative learning and social studies criteria indicated that almost all students received the highest score (Max=3.0, Min=1.0).

The first strategy, *prepare an object-to-think-with for specific curricular ideas*, aimed to provide an opportunity for students to engage with curricular ideas while deeply involved in creative learning processes. In the experiment, we introduced "broadcast" blocks that enable users to chronologically trigger one event after another. Several groups made use of this idea by organizing a chain of events in their projects. For example, one group that created a machine that turns rice into fuel made use of broadcast blocks to describe how rice transforms into fuel (Figure 5).

Contemplating how the use of information technology will affect agriculture is a practice deeply associated with the social studies "way of thinking" (Ministry of Education Culture, Sports, Science, and Technology, 2017). By introducing carefully chosen blocks as building blocks for tinkering, we were able to create an environment that students can engage with such disciplinary thinking mechanisms effectively, which Papert (1980) calls "microworlds."

The second strategy, *find a context that provokes a leap of ideas within disciplinary framework*, was implemented to better support students' playful exploration as well as the social studies thinking process. During the experiment, we observed a wide variety of appearances, structures, and approaches in student projects (Figure 6).

Table 3. Median and standard deviations of each student's score on the rubrics.

	Creative Learning					Subject
N=10	Purpose	Process	Remixing	Peer Support	Tinkering	Social Studies
Score (Max=3.0, Min=1.0)	2.6(*SD*=0.5)	3.0(*SD*=0.0)	3.0(*SD*=0.0)	3.0(*SD*=0.0)	3.0(*SD*=0.0)	3.0(*SD*=0.0)

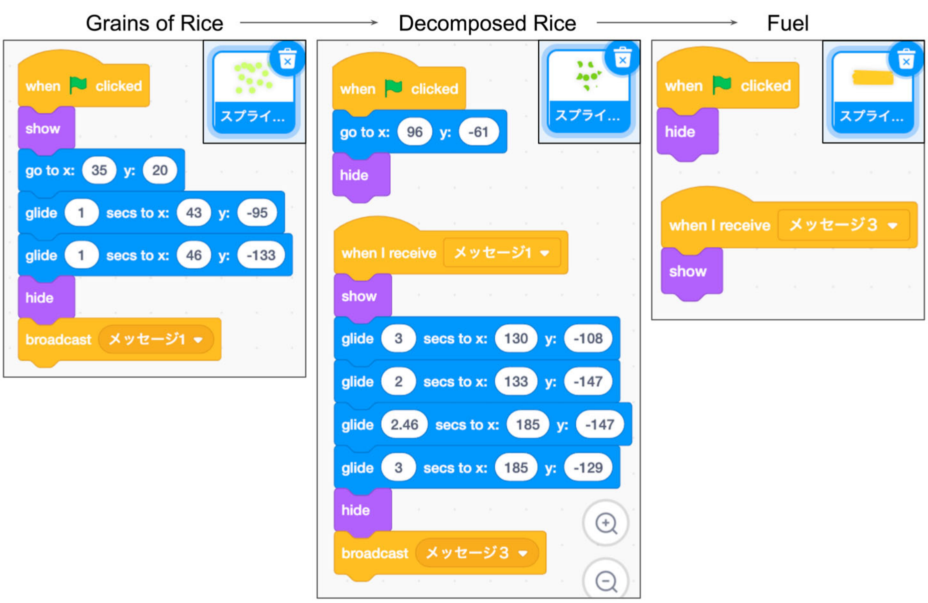

Figure 5. Programs created by a pair that includes a chain of transformation from rice to fuel using broadcast blocks.

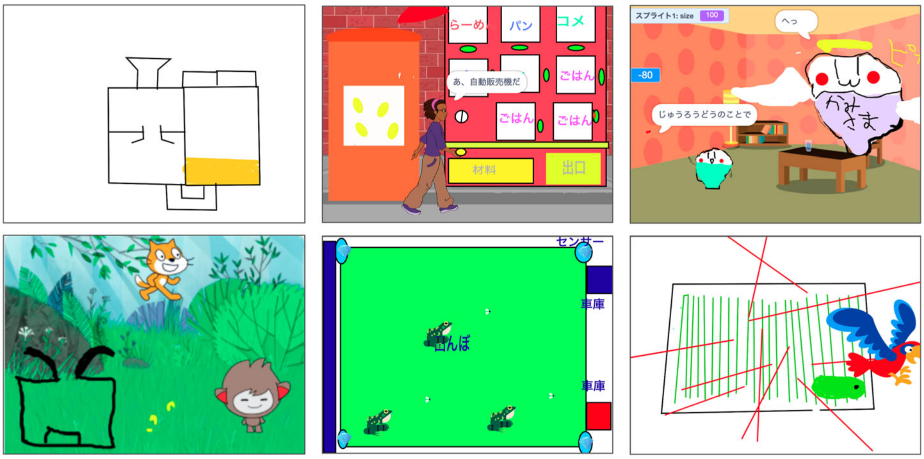

Figure 6. A variety of projects from the experiment.

For example, one group shared a robot that provides moral support to farmers who suffer from physically and mentally demanding field labor. Another group came up with a machine that turns rice into attractive alternatives for modern consumers, such as noodles or bread. These diverse projects not only indicate increased tinkering and remixing in the participants' learning process, but also better engagement with social studies ideas.

The third strategy, *facilitate tinkering through disciplinary inquiry*, aimed to support curricular thinking without restricting, but rather inspiring more tinkering. As seen in Figure 7, the worksheet provided questions and elements of the project to reflect upon the issues facing rice farmers, which is one of the curriculum goals of this unit.

The worksheet helped students in articulating design rationale in accordance with curricular ideas. In addition, by artiuclating why they made certain design decisions, students often received feedback

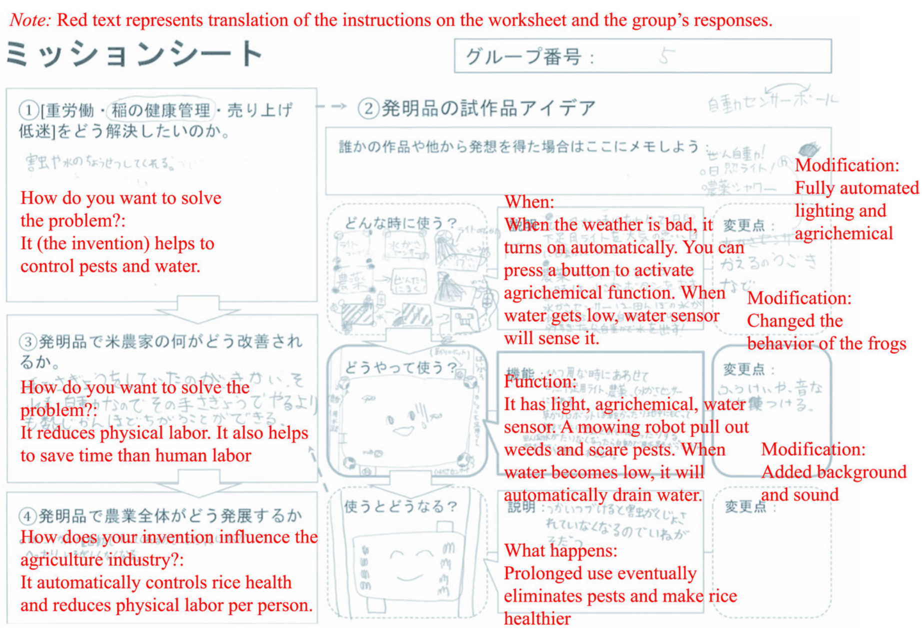

Figure 7. Worksheet filled out by a pair of students with signs of iterations.

from their peers or the instructor and were able to iterate on the very aspect of the project. For example, a group that was creating a project about an automatic water channel system (Figure 7) made use of the prompts on the worksheet to envision functionalities to detail beyond what they can articulate in Scratch, and iteratively adjusted the ideas based on the feedback they received.

The fourth strategy, *pair students and establish a developer and researcher role,* was intended to strengthen peer learning experience in the unit. In the experiment, we were able to observe many students standing up and conducting their own research, looking up tutorials for Scratch, and looking up relevant resources that we placed at the back of the room. As a result of the role assignment, most students were able to find something to contribute for their projects while closely communicating with one another to achieve the shared goals.

The fifth strategy, *provide feedback to connect computer programming projects to disciplinary ideas,* was designed to help ensure students achieved disciplinary goals while also supporting the development process of the project. By receiving guidance instead of direct instruction as feedback on their project presentations, students were able to incorporate the feedback in their iterations for the latter half of the project. The participating teachers also strongly acknowledged the strength of this approach.

5. Discussion

This study has examined strategies to integrate creative thinking in elementary school curricula through computer programming activities comprising design meetings with teachers, two pilot studies, and one implementation. The implementation in a classroom showed that a lesson unit incorporating the five design strategies was mostly successful in supporting the elements of creative learning – projects, passion, peers, and play – while engaging students in the unit goal for social studies.

The consideration of design strategies highlighted difficulties of integrating the elements of play in school environments. Playful exploration is often considered to require time for students to explore different materials and ideas (Gutwill et al., 2015), which is often not available in classroom settings. Classroom instruction has a set of disciplinary goals that all students must meet, which sometimes contradicts the exploratory and divergent nature of creative processes. However, this study showed that by embedding disciplinary inquiries as part of development processes – for example, in the form of an ideation worksheet, framework for a share out, or structure of feedback – play can be incorporated in classroom instruction.

This study also broadened our understanding of the ways in which computational practices can be incorporated into school curricula. A number of studies have explored how to integrate computational thinking in school curricula for the purpose of expanding mathematics and sciences or other STEM related areas (Bevan, 2017; Israel & Lash, 2020). However, fewer studies have shown how humanities and social science concepts can be learned through computational practices. This study provided some evidence to show how social studies concepts and practices can be strategically learned through computer programming activities.

Finally, this study has highlighted the role of computer programming as an effective tool to integrate creative learning into other curriculum areas. Computer programming environments not only provide expanded creative freedom but also work as a sandbox for students to take risks, make mistakes, iterate, and improve (Maloney et al., 2010). Such divergent environments are crucial for the development of creative thinking (Cropley, 1997). Our experiment showed the diversity of ideas students could generate while grounding their inquiries in a shared disciplinary goal.

6. Conclusion

This study identified and examined five design strategies to integrate creative learning in elementary school curricula. We used strategies drawn from literature and design meetings with in-service teachers as well as from two pilot studies to design and successfully implemented a lesson unit.

There are several limitations to this study to be explored further in the future. First, we implemented the curriculum unit in a group of 10 students in order to focus on an activity design, but a normal classroom size is usually larger than the class we worked with (normally 20–30 students). More logistical issues or challenges might be found if we tested the strategies in more typical classroom settings. Second, due to scheduling restrictions, we conducted both pilot studies and the experiment in one day instead of spacing the lessons out over six weeks. Having these sessions once a week may reveal other challenges that we could not see in this study, such as allowing time for students to recall the material. Third, while we tried to identify universal strategies that can be applied to any classroom setting, some elements may not be applicable to other cultural contexts since our study was deeply grounded in the empirical data collected in Japanese classroom settings.

There are also several questions remain for future studies. This study intentionally focused on the unit design strategies, thus eliminating other factors that could impact the classroom experience such as instructor facilitation. Furthermore, this study showed how cognitive development with regard to disciplinary knowledge and skills in creative learning processes are not as visible as in traditional teacher-centered classrooms. Thus, in future studies, it is crucial that researchers explore assessment to elicit and capture student learning specifically in creative learning activities.

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