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ARTICLE

Comparisons of creativity performance and learning effects through digital game-based creativity learning between elementary school children in rural and urban areas

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Abstract

Background: Creativity is an important ability for problem-solving in both personal life and academic learning. Few creativity studies have investigated the development of children's creativity in disadvantaged rural areas or compared the rural–urban differences through digital game-based creativity learning. Understanding such differences can help provide resources for promoting learning equality in creativity.

Aims: This study aimed to compare the rural–urban difference in elementary school children's creativity performance and their learning effect through digital game-based creativity learning.

Sample: Participants were 261 3rd and 4th graders and 194 5th and 6th graders from 6 elementary schools.

Method: Two digital game-based creativity learning systems were employed to conduct a five-class experimental instruction. A creativity test and a questionnaire were also used.

Results and Conclusions: The results indicate that the urban middle graders, but not the upper graders, outperformed their rural counterparts in the creativity test before game-based learning. Nevertheless, all children got a higher score on the creativity test after the game-based learning, suggesting the employed creativity learning systems could be vehicles for improving elementary school children's creativity. However, the rural children gained less from the learning than the urban children, which may be due to weaker competencies in self-regulated learning. Further studies can employ an inventory to verify this and also consider providing more scaffolding of self-regulated learning to more disadvantaged students during digital game-based creativity learning.

Additionally, the results of this study reflect the importance of self-determination and rewards in learning motivation. Appropriate rewards may encourage persistence in taking on challenges.

KEYWORDS
creativity, game-based learning, rewards, rural area, self-determination, self-regulation

INTRODUCTION

Creativity is defined as the process of generating contextually or culturally original and valuable products (Yeh, 2017). It is an important ability for coping with problems in personal life and a crucial competence for self-actualization in the 21st century (Plucker et al., 2015; Yeh et al., 2020). In the last decade, although many studies have investigated children's creativity, only a few of them have investigated the development of children's creativity in rural areas that have a lower socioeconomic status (SES) and fewer learning resources, or have compared the rural–urban differences in creativity. It has been found that, in general, urban children had a higher level of creativity performance than rural children (Xu & Pang, 2019; Yeh, 2004). Understanding such a rural–urban gap can help provide resources for promoting learning equality in creativity.

Moreover, it has been found that digital game-based learning can be an effective vehicle for enhancing creativity (e.g., Stolaki & Economides, 2018; Ting & Yeh, 2023; Yeh et al., 2020; Yeh, Chang, et al., 2019; Yeh et al., 2022; Yeh et al., 2023). Digital game-based learning refers to learning that integrates digital games into a learning environment, by which learners can experience a joyful learning process as well as achieve learning goals (Liao et al., 2019; Wang et al., 2016; Yang & Chen, 2020). Whether rural children and urban children can benefit equally from digital game-based creativity learning is worth exploring. In short, this is a two-phase study. The first phase investigated the performance of creativity among rural and urban children. The second phase explored whether digital game-based creativity learning had different influences on rural and urban children's creativity.

LEARNING EFFECTS AND INDIVIDUAL DIFFERENCES IN CREATIVITY DIGITAL GAMES

The rural–urban difference in creativity development

According to the Ecological Systems Model of Creativity Development (Yeh et al., 2014; Yeh, 2017), the mesosystem that involves school and family experience directly influences children's creative potential throughout their childhood and teens. A great deal of empirical evidence has supported the significant effects of mesosystem on individuals' development of creativity (Beghetto & Kaufman, 2014; Deng et al., 2016; Jankowska & Karwowski, 2019; Rubenstein et al., 2018), which may explain the rural–urban difference in creativity development.

Regarding family influences, extensive studies have demonstrated that socioeconomic status (SES) (Runco, 2014; Yang et al., 2020; Zhang et al., 2018), parenting style (Mehrinejad et al., 2015; Moltafet et al., 2018; Si et al., 2018), parental values (Deng et al., 2016; Pugsley & Acar, 2020), parental involvement (Kim & Hill, 2015; Liu et al., 2013; Robinson et al., 2013) and family structure (Pang et al., 2020) have a great impact on creativity development. For example, in a study of elementary school children, it was found that family SES and parent–child relationships were significantly correlated with social creativity (Zhang et al., 2018).

As for school influences, it was found that most teachers described environmental factors, individuals' influences, societal norms, materials, resources and external inspiration as the main influences on the development of creativity (Rubenstein et al., 2018). Moreover, teacher beliefs and pedagogies towards creativity have a great influence on children's development of creativity (Gutshall, 2013, 2014; Rubenstein et al., 2013). In a study that compared rural–urban differences, Huang et al. (2019) reported that teachers from urban schools were more sensitive to student expectations regardless of behavioural intention. Overall, urban children may have more advantages from school education or experiences that help develop creativity. However, it was found that in areas with great academic pressure, the school sacrificed independent intellectual inquiry, which led to a general decline in creativity among students in upper grades in elementary school (Yi et al., 2013).

To date, only a limited number of studies have been conducted to analyse rural–urban differences in creativity. In a big-sample sequential longitudinal study (N = 1790 in the first year and 1839 in the second year) held in Taiwan, Yeh (2004) found different developmental trajectories of scientific creativity between the rural children (with lower SES and fewer school resources) and urban children (with higher SES and more school resources); she found urban 6th graders' scientific creativity decreased due to the academic pressure, but the urban 4th graders outperformed their rural counterparts, which may due to their superior family and school resources. Notably, she found creative personality was positively related to family factors (rs = .60–.85) and school factors (rs = .55–.78). More recent studies (Anwar et al., 2012; Hernández-Torrano, 2018; Shi et al., 2012) have also found that urban students outperformed rural students in a divergent-thinking test. Such a rural–urban gap could be potentially explained by the influence of school learning experiences and family socioeconomic factors because these contextual factors may influence an individual's learning motivation, as the theory of Ecological Systems Model of Creativity Development (Yeh et al., 2014) suggested. To conclude, the aforementioned findings suggest rural–urban differences in creativity development. Whether such difference also exists in digital game-based creativity learning is also our concern in this study.

Instructional design and individual differences in digital game-based creativity learning

Digital game-based learning can effectively improve students' learning motivation, and properly integrating learning strategies into digital games can significantly improve students' attention, motivation and learning achievement (Partovi & Razavi, 2019; Yang & Chen, 2021). Recent studies regarding digital game-based learning are increasing, and many such studies have been conducted to train creativity through game-based learning (e.g. Behnamnia et al., 2020; Celume et al., 2019; Stolaki & Economides, 2018; Yeh et al., 2020; Yeh, Chang, et al., 2019; Yeh, Chen, et al., 2019). The findings of these studies have suggested that digital game-based learning affected students' ability to develop creative skills, knowledge transfer, acquisition of skills in digital experience, a positive attitude towards learning and insightful learning (Behnamnia et al., 2020).

Research findings suggest that learning and pedagogical aspects are the most essential attributes for the design of digital games (Tahir & Wang, 2019). This study, in addition to creativity skill and disposition training, incorporated the concepts of self-determination, scaffolding, rewards and self-regulation to enhance learning motivation and creativity. It has been suggested that self-determination is critical to the effectiveness of game-based learning (Millsa et al., 2018; Rogers, 2017; Yeh et al., 2020). Self-determination theory emphasizes the basic psychological needs of autonomy, competence and relatedness (González-Cutre et al., 2014; Ryan & Deci, 2000). In individual learning systems, autonomy and competence needs are especially important for achieving personal growth and optimal functioning. During game-based learning, autonomy can be achieved through personal control over one's game playing; feelings of competence can be seen in the willingness to take on challenges (Oliver et al., 2016; Rogers, 2017; Yeh et al., 2020). In addition, scaffolding in the game-based learning environment can facilitate learners' engagement to produce the desired learning (Chen & Law, 2016; Haataja et al., 2019).

Providing points (Werbach & Hunter, 2012), challenges, stories, feedback and rewards are also important elements in game-based learning (Hamari et al., 2016). Incorporating these elements for game-based learning, we developed two versions of a digital creativity program (the Digital Game-based Learning of Creativity with an emphasis on Self-Determination-A [DGLC-SD-A] and the Digital Game-based Learning of Creativity with an emphasis on Self-Determination-B [DGLC-SD-B]) for middle and upper graders in elementary schools. A previous study that employed the DGLC-SD-A (Yeh et al., 2020) indicated that the DGLC-SD-A is an effective vehicle for improving elementary school children's learning of creativity and self-determination and that it has a great impact on mastery experience during game-based creativity learning.

To date, few studies have compared the learning effect of creativity through digital game-based learning between rural and urban children. Digital game-based learning allows students to engage in challenging tasks and achieve a goal in a short time. By playing the creativity games, learners can enhance their creative thinking through repeated practice of creative skills, discovering mistakes, correcting mistakes, sharpening their thought processes and efficiently achieving the desired goal. Although digital game-based learning can attract learners' attention and enhance learning (Brezovszky et al., 2019; Gil-Doménech & Berbegal-Mirabent, 2019; Khowaja & Salim, 2019), learners with varied motivation in learning and ability in adjusting their learning during the process may have different levels of learning outcomes. Notably, Kraus et al. (2012) discovered that individuals from high SES backgrounds, with considerable resources, tend to perceive themselves in more agentic ways and concentrate on their internal state and goals, which is related to self-regulation in learning. Self-regulation refers to the process by which learners personally activate and sustain cognition, affect and behaviour that is systematically oriented towards the achievement of learning goals (Zimmerman & Schunk, 2008). It is found that self-regulated learning behaviours such as goal setting and monitoring were crucial to success in computer-based learning environments (Chen & Hsu, 2020). Similarly, Sabourin et al. (2013) found that self-regulated learners made good use of in-game curricular resources and were deliberate in their actions; as a result, self-regulated learners demonstrated significantly higher learning gains than their counterparts. In other words, compared with students from low SES areas, students from high SES areas may be more motivated and self-regulated during digital game-based learning, which leads to better learning outcomes.

Hypotheses of this study

In this study, we first investigated the rural–urban differences in creativity performance. Then, we examined whether the digital game-based creativity learning systems (DGLC-SD-A and DGLC-SD-B) would have varied influences on rural and urban elementary school children's creativity. The following hypotheses were proposed: (1) There would be rural–urban differences in creativity performance because of the differences in school and family factors. (2) Digital game-based creativity learning would have positive influences on children's creativity learning. However, urban children who generally have a high SES would benefit more from digital game-based learning than rural children who generally have a lower SES because of a higher level of self-regulation ability.

METHOD

Participants

Participants were 261 3rd and 4th graders (middle graders) and 194 5th and 6th graders (upper graders) selected from 6 elementary schools in Taiwan. We sampled three schools from the capital city to represent the urban sample and three schools from an island to represent the rural area. The average income per family in 2019 for the sample urban areas was about 47,414 USD, and that for the sampled rural area was about 28,925 USD. The age range for the 3rd and 4th graders was 9–10 years, and that for the 5th and

6th was 11–12 years. The participants were composed of 241 boys (53.0%) and 214 girls (47.0%). 211 of were urban children (46.4%), and 244 were rural children (53.6%). This study was approved by the Institutional Review Board of the university where the research was conducted. Written informed consent was obtained from all participants' parents, and each participant was rewarded with a gift of their choice valued at about 10 USD.

Instruments

Digital game-based learning system for creativity

The DGLC-SD-A developed for middle graders (Yeh et al., 2020), and the DGLC-SD-B developed for the upper graders at elementary school (Yeh, Chen, et al., 2019), were employed to investigate the effects of creative learning on participants. The DGLC-SD-B is a revised version of the DGLC-B (Yeh, Chen, et al., 2019). The differences between the two versions of the game-based learning system are as follows: (1) Creativity training embedded in different story contexts: The games in the DGLC-SD-A are connected through the story "Searching for the Clown's Color Balls," whereas those in the DGLC-SD-B are connected through the story "Searching for Lost Treasures"; and (2) Creativity tasks differ in their level of challenge: With the same format, some of the practice tasks are more difficult in the DGLC-SD-B than in the DGLC-SD-A. However, both learning systems consist of nine games for enhancing dispositions and skills of creativity, with each game ranging from 10 to 15 min.

Based on previous results (Yeh et al., 2020), we included nine games in the DGLC-SD-A and DGLC-SD-B, which covered the following four parts of creativity training:

1. 3D product design (game 1): This game was a self-test of creativity through designing a secret base. The software of Unity for 3D design was employed. Participants could choose different colours, materials, objects, etc. to design a secret base. The size and direction of an object could also be changed.
2. Enhancement of creativity dispositions (game 2 and game 3): These games were employed to enhance positive thinking and attitude when encountering frustrations and thinking outside the box during problem-solving. In these games, a question followed a short story presented through amination.
3. Facilitation of creativity skills (game 4 to game 8): These games included practices of sensitivity in observation (10 test items), divergent thinking in creating products through moving geometric objects, convergent thinking in moving geometric objects to match given figures, lateral thinking in problem-solving (10 situated-based test items) and SCAMPER (substitution, combination, adaptation, modification, putting to other uses, elimination and reversing) in inventing a product. The practice of divergent thinking, convergent thinking and SCAMPER are all conducted through Unity.
4. 3D product design and peer evaluation (game 9): This game included a self-test of creativity through designing a secret base and facilitation of observational learning. Participants were requested to rate their classmates' designs of a secret base in game 1 and game 9, by which we hoped their imagination and creativity could be stimulated through appreciation of others' creative designs.

In short, these creativity strategies were practiced through 3-D drawing, animations, short stories, open-ended questions, observations, product creation and problem-solving (see Figure 1 for exemplifying screens).

Creativity test

The Product-based Figural Creativity Test (PB-FCT) (Yeh et al., 2013; Yeh, Hsu, et al., 2019) was employed to measure the participants' creativity. The PB-FCT included three subtests (with figures of C, ⊓ or ⨯ in each subtest) in which participants were instructed to draw as many original and functional products

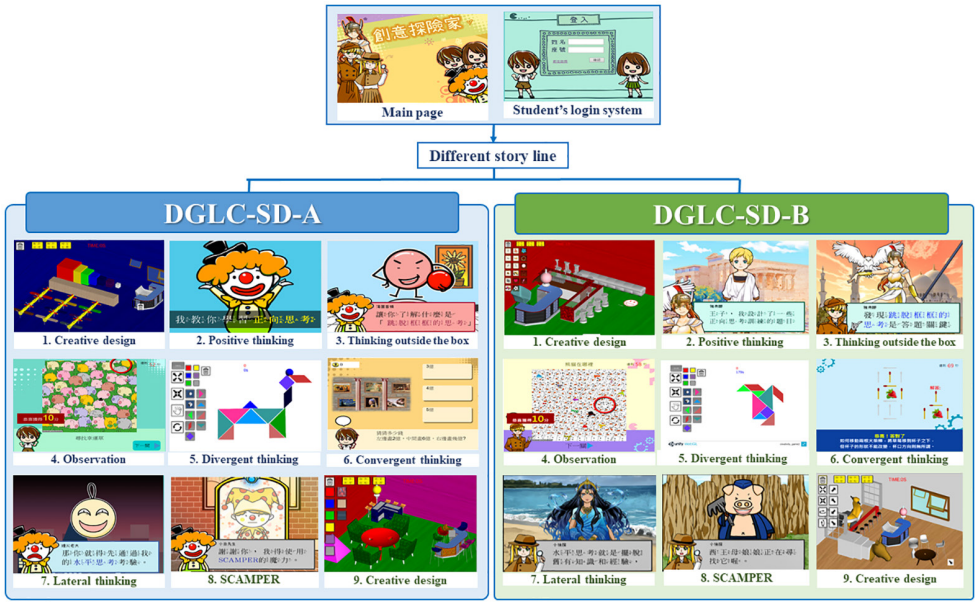

FIGURE 1 Exemplifying screens for the digital game-based learning systems.

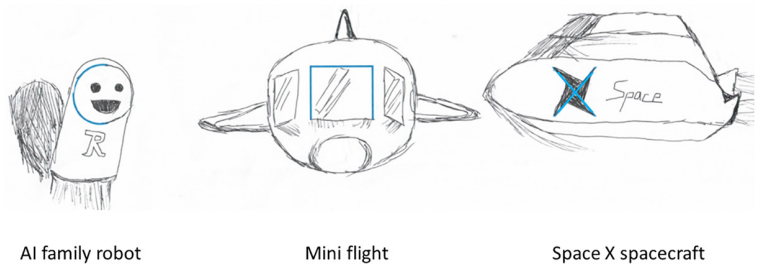

FIGURE 2 Examples of children's drawing in the PB-FCT.

as they could be based on the given figures (see Figure 2 for examples of student performance). No examples were given so as not to limit creative thinking. The test time for each subtest was 5 min. Two indices were measured in the PB-FCT: originality and valuableness. The creativity score of each designed product was the score of originality (0–4 points) × valuableness (0–3 points). Originality is the sum of "rarity" of a response (0 points: ≥ 5%; 1 point: ≥ 2% and <5%; 2 points: ≥ 1% and <2%; and 3 points: <1%) and specialness of modelling (0 points: with simple structure; 1 point: with creative and elaborative design). "Valuableness" was scored by the number of different functions of response (0 points: not valid; 1 point: has only one function; 2 points: has two different functions; and 3 points: has three or more different functions). The total score of creativity was the sum of each score of the drawn products. Taking the AI family robot (see Figure 2) for example, only two participants among the 455 participants drew a robot in task C. Then, the product was scored as follows: rarity = 3 points (the percentage for this response was 2/455 = .004 which is lower than 1%); specialness of modelling = 1 point; valuableness = 1 point (the participant did not indicate it as a multi-functional robot). Therefore, the total score of the AI family robot was [3 (rarity) +1 (specialness of modelling)] × 1 (valuableness) = 4 points. Notably, the degree of similarity between the product a student drew and how it would look in reality was not considered. The products could be something that had never been invented. The correlations between originality and valuableness for C, ⊓ and ⨯ were .755, .822 and .785, *p*s < .001 (Yeh et al., 2013).

Two trained raters conducted the rating of creativity tests. To ensure the inter-rater reliability, they were requested to rate 30 creativity tests together to get consensus before they started to rate the tests

separately. During the rating, discussions were conducted to reach a consensus whenever there were difficulties in deciding a score.

Reflection questionnaire

A 7-item reflection questionnaire was employed to understand participants' attitudes towards game-based learning. Each question was scored from 1 point to 6 points, representing "strongly disagree" to "strongly agree." The 7 items are displayed in the Results session.

Experimental design and procedures

A pretest–posttest design was employed for both the rural and the urban groups. The participants and their parents completed their consent forms before they participated in the experiment. During the experiment, the participants first completed the pretest of creativity. Then, the participants completed their game-based learning in the computer laboratory at their schools during a flexible learning time or a computer class with the help of the computer science teacher and the home-room teacher of each class. To ensure fidelity under such a condition, we gave the teachers a clear introduction to the game-based learning and a list of standardized procedures for conducting the game-based learning. During gameplay, the teachers only needed to keep an eye on whether the students were focused on the learning because all detailed instructions for participants were embedded in the game-based learning system. After the game-based learning, the participants completed the posttest. All the participants completed the game-based learning experiment in five classes throughout one week (see Figure 3 for procedures). Notably, the content of the employed game-based learning was not related to any content taught in regular classrooms.

During the game-based learning, the middle graders took the DGLC-SD-A, and the upper graders took the DGLC-SD-B. Notably, for class 2, class 3 and class 4, participants were allowed to decide the order of game playing within each class to enhance their self-determination by elevating their sense of autonomy and competence. In addition, an extra reward of 5 USD was given after the experiment if the total game score or secret base design was in the top three in the participant's class; the obtained score in each game was shown at the end of the game. Additionally, whenever the participant got a right or appropriate answer, the screen would pop out different encouraging words. Furthermore, from game 2 to game 8, participants received their scores at the end of each game. These designs were employed to encourage self-regulation through a goal setting of achieving great performance and self-monitoring of learning.

To sum up, scaffoldings were embedded in the creativity learning system to guide the practice of creative strategies and challenging tasks. Constructive and immediate feedback for answers, free choices of game order, verbal encouragement, rewards and peer evaluation for creative design were incorporated

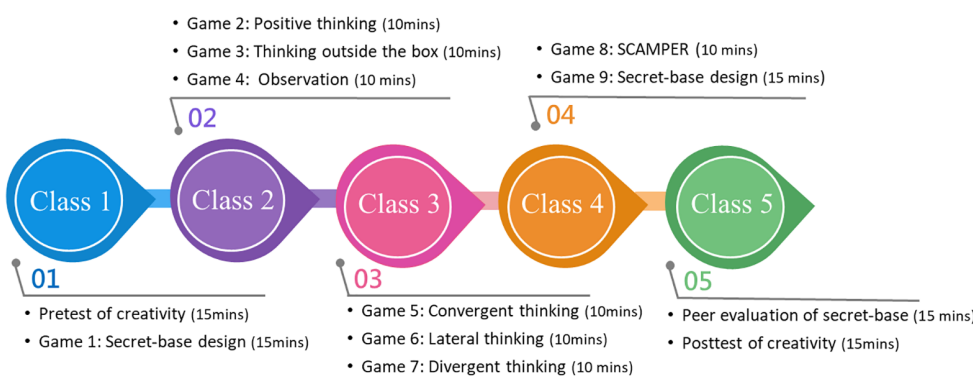

FIGURE 3 Content and procedures of the game-based learning systems.

during game-based learning to enhance their learning motivation, self-determination, self-regulation and creativity.

RESULTS

Preliminary analysis

We first employed Chi-Square (χ^2) test to examine whether the rural and the urban students were different in some background information and experience, including playing general digital games (0 h vs. .1 to 1.5 h vs. above 1.5 h), playing creative digital games (0 h vs. .1 to 1.5 h vs. above 1.5 h), father's educational degree and mother's educational degree (elementary school to senior high school vs. college vs. graduate school). The results showed that students in different areas did not vary in the experience of playing general digital games through computers or smartphones ($\chi^2 = 3.381$, $p = .184$), nor in playing creative digital games ($\chi^2 = .648$, $p = .723$) (See Table 1).

However, as expected, more fathers and mothers in urban areas possessed a higher educational degree, whereas more fathers and mothers in rural areas possessed a lower educational degree. χ^2 for father = .93.773, $p < .001$; χ^2 for mother = .93.954, $p < .001$ (See Table 1).

Rural–urban differences in creativity performance

Using the pretest score of creativity as the dependent variable and using Area (rural vs. urban) and Group (middle graders vs. upper graders) as the independent variables, we conducted a 2 × 2 analysis of variance (ANOVA) to examine the creativity development of rural and urban children (See Figure 4 for *M*s and *SD*s). Levene's test of homogeneity of variance indicated that the error variance of the dependent variable was equal across groups (*p*s > .05).

The results yielded a main effect of Area, $F(1, 440) = 4.005$, $p = .046$, $\eta^2_p = .009$, as well as an interaction effect of Group × Area, $F(1, 440) = 440$, $p = .018$, $\eta^2_p = .018$ (see Table 2). Overall, the urban

TABLE 1 The distribution of game-playing time and parents' educational degrees in rural and urban areas.

	Rural		Urban			
	n	%	*n*	%	χ^2	*p*
Playing general digital games						
0 h	21	8.8	23	11.8	3.381	.184
0.1–1.5 h	160	66.7	137	70.3		
Above 1.5 h	59	39.2	35	17.9		
Playing creative digital games						
0 h	125	64.1	104	43.3	.648	.723
0.1–1.5 h	94	48.2	78	32.5		
Above 1.5 h	21	10.8	13	5.4		
Father's educational degree						
Elementary to senior high school	93	68.9	15	14.3	93.773	.000
College	37	27.4	37	35.2		
Graduate school	5	3.7	53	50.5		
Mother's educational degree						
Elementary to senior high school	94	65.3	17	15.2	73.954	.000
College	40	27.8	50	44.6		
Graduate school	10	6.9	45	40.2		

Note: 215 students did not know their father's educational degree. 199 students did not know their mother's educational degree.

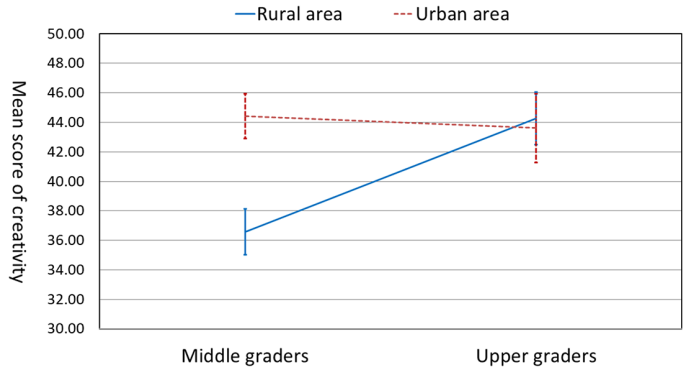

FIGURE 4 *M*s and *SD*s of creativity scores for the rural and urban children.

TABLE 2 The effects of Grade group and Area on creativity.

	ANOVA				
Source	***MS***	***F***	***p***	η^2_p	**Post-hoc test**
Group	1231.838	3.713	.055	.008	
Area	1328.788	4.005*	.046	.009	A2 > A1
Group × Area	1874.494	5.649*	.018	.013	G1: A2 > A1; A1: G2:>G1

Note: Group: G1, middle graders; G2, upper graders. Area: A1, rural area; A2, urban area.

children outperformed the rural children. Analysis of simple main effect revealed that the upper children outperformed the middle children in the rural areas, $F(1, 240) = 10.957$, $p = .001$, $\eta^2_p = .044$. Moreover, the urban middle children outperformed the rural middle children, $F(1, 253) = 12.982$, $p < .001$, $\eta^2_p = .049$.

Participants' opinions about the game-based learning system

Seven questions were employed to understand the participants' feelings towards game-based learning. The *M*s and *SD*s are shown in Table 3. To examine the rural–urban differences, we conducted t-tests for the middle graders and the upper graders separately. The results showed that only questions 6 and 7 yielded significant differences in the upper grader group, $t = -4.984$ ($p = .001$) and $t = -3.114$ ($p = .005$). Compared with the urban children, the rural upper graders were motivated by the extra awards for best secret base design and top game scores.

Effects of an area on the improvement of creativity

Using Test (pretest score of creativity vs. posttest score of creativity) as the dependent variable and using Area (rural vs. urban) as the independent variable, we conducted repeated measure ANOVA to examine the effects of Area on the improvement of creativity (See Figure 5 for *M*s and *SD*s). Before conducting repeated measure ANOVA, we employed the Kolmogorov–Smirnov test to evaluate the distribution of creativity improvement (Posttest minus Pretest). Levene's test of homogeneity of variance indicated that the error variance of the dependent variable was equal across groups (ps > .05).

For middle graders, significant differences were found on Test: $F(1, 229) = 60.611$, $p < .001$, $\eta^2_p = .209$, on Test × Area: $F(1, 229) = 6.161$, $p = .014$, $\eta^2_p = .026$, and on Area: $F(1, 229) = 25.729$, $p < .001$, $\eta^2_p = .101$ (see Table 4). Analysis of simple main effect revealed that children in both the urban and the rural areas improved their creativity performance, $F(1, 106) = 43.669$, $p < .001$, $\eta^2_p = .292$ and $F(1, 123) = 18.695$, $p < .001$, $\eta^2_p = .132$. Moreover, the urban children outperformed the rural children in the pretest, $F(1, 253) = 12.982$, $p < .001$, $\eta^2_p = .049$, and in the posttest, $F(1, 229) = 27.793$, $p < .001$, $\eta^2_p = .108$, respectively.

TABLE 3 *M*s and *SD*s for the middle and upper graders in the questionnaire.

Items	Middle graders		Upper graders	
	Urban	Rural	Urban	Rural
1. I felt that this creativity game was interesting.	5.24 (1.30)	5.29 (1.24)	5.08 (1.45)	5.01 (1.46)
2. This creativity game increased my creativity.	5.04 (1.36)	5.31 (1.23)	5.07 (1.45)	4.91 (1.39)
3. The encouraging feedback given during the game playing made me feel more confident.	5.16 (1.32)	5.25 (1.24)	5.00 (1.45)	4.87 (1.40)
4. The chance to receive a gift for earning a high score motivated me to try harder.	5.15 (1.37)	4.99 (1.54)	5.12 (1.44)	4.95 (1.36)
5. Being able to decide the game order by myself made the game more interesting, and it motivated me to move on to the next game.	5.12 (1.32)	5.06 (1.31)	4.97 (1.53)	4.95 (1.45)
6. The reward for the best design motivated me to design the secret base seriously.	5.16 (1.39)	4.89 (1.35)	3.27 (1.58)	4.67 (1.12)
7. The extra reward for the top scores encouraged me to try harder to complete the games.	5.32 (1.24)	5.15 (1.27)	3.91 (1.51)	4.96 (1.04)

Note: The numbers in parentheses are standard deviations.

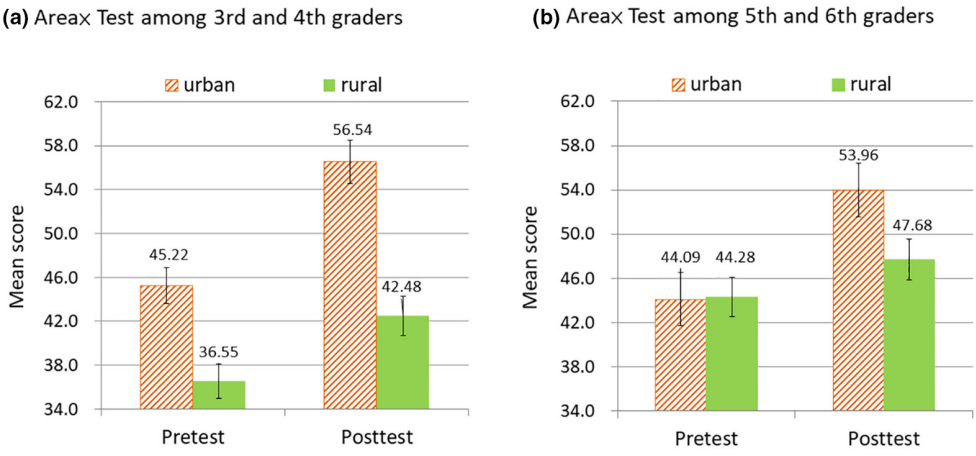

FIGURE 5 Means and standard errors of creativity scores for the urban and the rural groups.

For upper graders, significant differences were found on Test: $F(1, 181) = 25.707$, $p < .001$, $\eta^2_p = .124$ and on Test × Area: $F(1, 181) = 7.533$, $p = .007$, $\eta^2_p = .40$. However, no significant Area effect was found. Analysis of simple main effect revealed that children in both the urban and the rural areas improved their creativity performance, $F(1, 65) = 22.828$, $p < .001$, $\eta^2_p = .260$ and $F(1, 116) = 6.529$, $p = .012$, $\eta^2_p = .053$. Moreover, the urban children outperformed the rural children in the posttest, $F(1, 181) = 4.218$, $p = .041$, $\eta^2_p = .023$. However, the urban children did not outperform the rural children in the pretest, $F(1, 184) = .053$, $p = .818$, $\eta^2_p = .000$ respectively.

DISCUSSION

Performance of creativity

This study aimed to compare the rural–urban differences in creativity performance and creativity learning through game-based learning. We found that while the rural children's creativity seemed to have a steady developmental trend, the urban children's creativity seemed to stop developing in upper grades, which

TABLE 4 The effects of Area on creativity improvement.

	ANOVA				
Source	***MS***	***F***	***p***	η^2_p	**Post-hoc test**
Middle grade					
Test	8213.645	60.611	.000	.209	T2 > T1
Test × Area	834.837	6.161	.014	.026	A1: T2 > T1; A2: T2 > T1 T1: A1 > A2; T2: A1 > A2
Area	7415.352	25.729	.000	.101	1 > 2
Upper grade					
Test	3006.560	25.707	.000	.124	T2 > T1
Test × Area	880.994	7.533	.007	.040	A1: T2 > T1; A2: T2 > T1 T2: A1 > A2
Area	389.919	1.199	.275	.007	

Note: Area: A1, urban area; A2, rural area; T1, pretest; T2, posttest.

led to no area differences in creativity performance in upper grades. In Taiwan, it is generally accepted that upper grade students' academic pressure in the capital city is much greater than that in the sampled island. The results here are in accordance with the previous finding that urban children's creativity started to decrease in the 6th grade due to academic pressure (Yeh, 2004) and that the decline of upper graders' creativity may result from increased emphasis on standardized testing and drill exercises (Kim, 2011). In addition, according to the *Ecological Development Theory of Creativity* (Yeh, 2017; Yeh et al., 2014), young children's creativity is greatly impacted by the family and school environment and resources, and such a direct influence gradually decreases and transforms into an indirect influence as children grow up. This may also explain why the advantages of urban children disappeared in the upper grades.

However, middle-grade children in urban areas had higher levels of creativity performance than their peers in rural areas. Such an urban–rural gap supports the great influences of school education and resources (Deng et al., 2016; Huang et al., 2019; Rubenstein et al., 2018), as well as family factors, such as SES, parenting style, parental values, parental involvement and family environment (e.g., Deng et al., 2016; Moltafet et al., 2018; Pang et al., 2020; Pugsley & Acar, 2020; Yang et al., 2020; Zhang et al., 2018) in younger children in elementary schools. In this study, the urban parents' SES is much higher than that of the rural parents. The result supports the finding that there is a positive relationship between family SES, diversity of life experience, and different indices of creativity; moreover, diversity of life experience works as a mediating variable through which family SES influences creativity performance (Xu & Pang, 2019). The result of this study also supports that high-SES parents tend to respect children's pace of development and exploration (Pugsley & Acar, 2020) and such family factors are highly interactive with school factors (Yeh, 2004).

Game-based learning, self-determination, rewards, self-regulation and creativity learning

To compare the rural–urban differences in digital game-based creative learning, we employed the DGLC-SD-A and DGLC-SD-B for the middle and the upper grades in elementary schools, by which we investigated whether the learning systems would effectively improve the children's creativity in both areas as well as whether rural–urban differences exist in such learning. Although no control group was employed, the results of the opinion questionnaire and those of the creativity test showed a trend that children in both areas and grade levels enhanced their creativity within the context of game-based learning; however, the urban middle and upper graders' creativity improved more than that of their rural counterparts. The findings suggest that the digital game-based creativity learning systems may help inspire

the 3rd to 6th graders' learning motivation and therefore enhance their creative thinking. The positive responses to questions 1 to 3 in the reflection questionnaire (all above 5.00 points) also support such an argument (see Table 3 means). All participants responded that the game was interesting, the game increased their creativity, and the encouraging feedback given during the game playing made them feel more confident when playing the game.

Notably, the children's positive responses in the questionnaire may reflect the importance of self-determination (see question 5 in Table 3) and reward (see questions 4, 6, and 7 in Table 3) in positive learning motivation and learning outcomes. It has been suggested that experiences that satisfy the need for self-determination are more likely to bring about the intrinsic motivation of engagement in activities and positive outcomes (Millsa et al., 2018). In this study, we provided chances for the participants to decide the game order to enhance their performance during game playing; great performance would be rewarded with an extra gift. The experience of choosing conveys a sense of autonomy and volition (Ryan & Deci, 2000). The results of this study suggest that the freedom of making choices may bring a positive impact on children's creativity learning. Moreover, the findings suggest that appropriate rewards may be important for fortifying elementary school children's internal motivation, especially for middle graders and rural upper graders. This finding is supported by the higher scores on related reflection questions and suggests that a good combination of external motivation and internal motivation may boost the learning of creativity. Notably, we found that rural upper graders seemed to care more about winning the extrinsic rewards and perceived that creativity digital games as a competition; a competitive environment can be detrimental to the learning of creativity.

In addition, urban children at both the middle and upper levels improved more in creativity performance than their rural counterparts. The mean scores in the reflection questions 4 and 5 suggest that the urban students may have stronger motivation to play the game than the urban students. Past findings suggest that individuals with high SES backgrounds tend to perceive themselves in more agentic ways and concentrate on their internal state and goals (Kraus et al., 2012); moreover, self-regulated learners not only have a sufficient set of learning strategies but also have the motivational control to put forth the essential effort to engage in these cognitive processes (Pintrich, 2000). Accordingly, the urban students who have a higher SES in this study may have stronger motivation and better competencies in using self-regulation strategies such as goal-setting and self-monitoring than the rural students. However, this requires further verification.

CONCLUSIONS AND IMPLICATIONS

Few studies have compared the rural–urban difference in elementary school students' creativity development or their creativity learning through digital game-based learning. This study, therefore, employed two learning systems to explore such issues. The integration of creative performance and feedback from the reflection questionnaire indicates that the development of creativity was different between rural and urban children. Nevertheless, they all seem to benefit from the employed game-based learning, suggesting that the creativity learning systems we developed can be effective vehicles for improving elementary school children's creativity. However, the urban children gained more during the learning than the rural children, which may be due to their motivation and competencies in self-regulation learning. Because creativity has been regarded as an important future skill for 2030 by the Organization for Economic Cooperation and Development (OECD) (OECD, 2019), and because digital games have become an essential part of life for the young generation, taking advantage of such a digital instrument to promote potential development and learning equality has become important. The findings of this study shed light on such issues.

Limitations and implications

Owing to the tight schedule of the school curriculum in our sampled schools, we could not have longer experimental instruction to optimize the learning outcomes. Future studies can replicate our research

design and extend the experimental instruction period by cooperating with schools that can provide more sufficient time for the experiment. In addition, this is a cross-sectional study. Further studies, if the sampled schools are willing to cooperate, can conduct a longitudinal study to further understand children's developmental trajectory of creativity in both the rural and urban areas. This would provide insights into school education. Additionally, because the sampled rural schools are in remote areas and had limited students, some of them just had one class for each grade. Therefore, it is impossible to include a class as a control group at the same school. To compensate for this limitation, we included a questionnaire to verify the students' feelings towards our design in the employed digital game-based learning, by which we infer the possible reasons for positive learning outcomes. These evidenced speculations, nevertheless, need further verification. Another limitation of this study is that we provided a participation reward and an in-game performance reward. Although the results of reflection questions (items 4, 6, & 7) showed that the in-game rewards had a great impact on their learning motivation, we do not know which types of rewards had a greater influence on the learning outcomes. Identifying the influence of different types of rewards on creativity learning can provide more concrete suggestions for further game design or related instruction. Finally, the results suggest that the incorporation of rewards, self-determination and self-regulation contributes to the learning of creativity; which element is most beneficial to participants can be examined in further studies.

Despite the limitations of this study, the findings of this study provide several implications for curriculum design and instruction for both classroom teaching and digital game-based learning of creativity in elementary schools. First, chances for strengthening self-determination (e.g., chances to decide how to play the game) and verbal persuasion to enhance performance should be incorporated into lessons to enhance students' self-confidence and motivation when they are coming up with creative ideas or taking challenges. Second, appropriate rewards help encourage persistence in taking challenges and problem solving among elementary school children. However, they should be used with care; too much emphasis on rewards can be detrimental to creativity performance. Finally, future studies may consider observing the self-regulation strategies such as goal-setting and self-monitoring during digital game-based learning.

AUTHOR CONTRIBUTIONS

Yu-chu Yeh: Conceptualization; data curation; formal analysis; funding acquisition; methodology; project administration; resources; supervision; validation; visualization; writing – original draft; writing – review and editing. **Yu-Shan Ting:** Data curation; formal analysis; investigation; writing – original draft.

CONFLICT OF INTEREST STATEMENT

None to declare.

DATA AVAILABILITY STATEMENT

The data is not available for the authors are still accumulating data for further analyses.

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