K-12 Pedagogies for Geosciences: Improving Student Learning about Topographic Maps and Landscapes using Hands-on Play and Drones

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Introduction

Although challenging given myriad teaching methods and diverse learners, recent studies emphasize the importance of active instructional approaches to engage students in learning [1,2]. Hands-on activities such as use of Play-Doh®, LEGO®, sand, and/or common household items have been utilized to support teaching and learning about landforms and concepts in physical geography more broadly [3,4]. Most recently, drones have provided hands-on learning opportunities for young (i.e. K-12) students [5].

Objective: ***Determine if and to what extent the learning of basic geographic concepts can be enhanced through hands-on play and geospatial technologies.***

Data and Methods

The study was conducted at Comstock Public Schools in Michigan from Sept. 2019 through Mar. 2020 (stopped abruptly due to COVID-19 pandemic). The project team included a classroom teacher and two university faculty.

Activities and planning

- Materials acquisition and prework
  - Play-Doh®, LEGO®, and FlyBrix drone kits
  - Drone aerial image data capture at a local park
- Lesson plans
  - Collaborative development of pedagogical approach
  - e.g., mental mapping exercise: draw a map of Comstock we discuss the process(es) of mapping
  - e.g., water boxes activity to draw a contour map
  - Schedule of content covered [Table A]

Table A. Project schedule of activities.

Meetings	Content	Hands-on activities

September 2019	• Introduction to the project
	• Expectations of participants
	• Geography basics
	  • What is geography?
	  • Global grid
		Participant pretest assessment
		• Mental mapping drawing exercise and discussion
		• Introduction to topographic mapping and contour lines using water boxes

October 2019	• Introduction to drones and physics of flight • Introduction to drones for mapping (show local park data)	• Construct Flybrix drone and fly • Demonstrate high-end mapping drone for data collection
November 2019	• Introduction to contour lines • How to read a topographic map • Basic landscape features	• Topographic map activity • Constructing a landscape using Play-Doh® (2D to 3D)
December 2019	• Introduction to research project	• Constructing a landscape with LEGO®
January 2020	• Discussion of research project	• Constructing landscape of project study area (local park) with Play-Doh®
February 2020	• Continue research project	• Group-based sustainable local park exercise with discussion
March 2020*	• Work on presentation of project results (to be presented to township board)	***Participant post-test assessment***
April 2020*	• Synthesis of all project content	• Park day with food, play, and activities and in conjunction with Earth Day celebration

*Canceled due to COVID-19 pandemic.

Assessment

- 8-question assessment developed about basics of global grid and topographic maps
  - Pretest conducted before instruction began and post-test administered toward the end of the project period

Data Analyses

- Quantitative analysis (pre- vs. post-tests)
  - Statistically compared overall test scores using Wilcoxon signed-rank test for paired samples
  - Examined aggregated results by question
- Qualitative analysis
  - Students' written reflections after each meeting were collected along with overall thoughts of teacher
  - Quotations representative of the group as a whole were selected and reported

Results

Classroom instruction

Selected photos showcase our efforts in the classroom with the students from traditional lecture-style approaches [Fig. 1] to hands-on activities with Play-Doh® [Fig. 2], LEGO® [Fig. 3], and building and operating FlyBrix drones [Fig. 4]. Students also completed group-based discussion activities about local parks and sustainability, creating drawings to summarize thoughts [Fig. 5].

Figure 1. Classroom instruction of global grid basics. (1)

Figure 2. Creating 3D landscapes using Play-Doh® from a topographic map. (2)

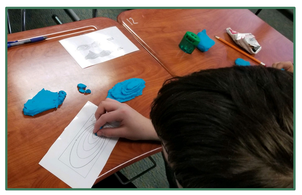

Figure 3. Creating 3D landscapes with LEGO®. (3)

Figure 4. Test flight of built FlyBrix drone. (4)

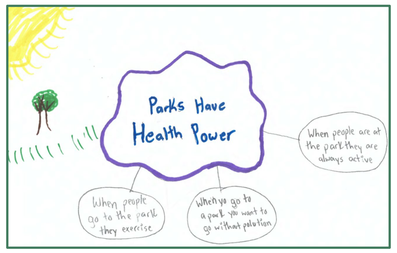

Figure 5. Example groupwork result from brainstorming the importance of parks in local communities. (5)

Quantitative findings

36 of the 92 students (39%) completed both the pre- and post-test assessments. In comparing the two, the Wilcoxon signed-rank test confirmed a statistically significant difference (W = 79.5, p=0.005) with a pretest mean score of 46% (standard deviation of 20.3) and a post-test mean score of 60% (standard deviation of 18.4) [Fig. 6]. Examination by question revealed improved scores for nearly all questions [Table B].

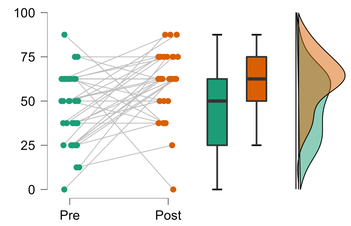

Figure 6. Raincloud plot comparing student performance between pre- and post-tests. (6)

Table B. Pre-/post-test comparisons by question.. (B)

Question	Pretest (percent correct)	Post-test (percent correct)	Difference
Q1 – 0°	67%	89%	**+22%**
Q2 – Point B	53%	75%	**+22%**
Q3 – Point F	56%	69%	**+13%**
Q4 – Vegetation color	61%	78%	**+17%**
Q5 – Contour interval	34%	40%	**+6%**
Q6 – Elevation at A	32%	31%	**–1%**
Q7 – Elevation at B	31%	39%	**+8%**
Q8 – Steepest slope	37%	61%	**+24%**

Qualitative findings

Students

- "I learned about making contour maps, and enjoyed the play-dough activities about making them."
- "What I learned about contour maps is that they are easy to use when learning how steep a mountain or hill is."

Teacher

- "This project allowed students to engage in a variety of hands-on activities that deepened their knowledge of spatial thinking. The contour mapping instruction helped to illustrate concepts that often were too abstract for students to understand when taught in a conventional method. I watched students move from a very novice understanding, to being able to create a 3D landform out of Play-Doh® or LEGO® based on a 2D contour map. Not only were students fully engaged, but they were conversing in a manner that showed deeper understanding of the process."

Discussion

Students positively reacted to the activities introduced. Results are consistent with similar studies. Pre- and post-test results are encouraging, but we recognize our small sample size (limited due to parental/guardian consent).

- **Suggestions:** (i) engage students consistently with hands-on activities, (ii) use a variety of activities (e.g., LEGO®, Play-Doh®, FlyBrix), and (iii) work with experienced teachers to effectively manage the classroom (due to high levels of excitement and to blend in activities with regularly scheduled class content).
- **Future work:** (i) develop and share modules for broader adoption, (ii) test method with more students (at a variety of grade levels), (iii) collect additional qualitative data for more comprehensive evaluation, and (iv) integrate these efforts into community-based work (as planned in our project originally but dropped due to the COVID-19 shutdown in March 2020).

Conclusion

Findings confirm statistically significant improvement in student performance through pre- and post-tests. Results reinforce findings of similar studies that report that hands-on play, student-centered activities along with geospatial technology can enhance student learning.

Acknowledgments

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iii. Human subjects research protocol was approved by the Western Michigan University Institutional Review Board in Oct. 2019 (#19-09-43).

References

1. Spronken-Smith, R., et al. 2008. Where might sand dunes be on Mars? Engaging students through inquiry-based learning in geography. *Journal of Geography in Higher Education* 32 (1): 71–86.
2. Schlemper, M.B., et al. 2019. Teaching spatial thinking and geospatial technologies through citizen mapping and problem-based inquiry in grades 7–12. *Journal of Geography* 118 (1): 21–34.
3. Rule, A.C., et al. 2006. Learning Landform vocabulary through different methods: Object boxes, sand and dough creations, or puppet plays. *Journal of Geoscience Education* 54 (4): 515–25.
4. Carnahan, L., et al. 2014. Teaching physical geography with toys, household items, and food. *The Geography Teacher* 11 (3): 93–107.
5. Joyce, K.E., et al. 2020. Using minidrones to teach geospatial technology fundamentals. *Drones* 4 (3): 57.

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