Remediating Fraction Arithmetic Misconceptions with a Game-based Intelligent Learning Environment

Obedoza, Jarl Brent Y.[1a], Sison, Raymund C.[1b]
[1]De La Salle University, 2401 Taft Ave., Malate, Manila 1004 Metro Manila, Philippines
[a]jarl_brent_obedoza@dlsu.edu.ph, [b]raymund.sison@delasalle.ph

INTRODUCTION

Fraction arithmetic is difficult for Grade 5 students (Lortie-Forgues et al., 2015, pp. 14-23) because of:

1. Fraction Notation
2. Accessibility of Fraction Magnitudes
3. Opaqueness of Standard Fraction Arithmetic Procedures
4. Complex Relations between Rational and Whole Numbers Arithmetic Procedures
5. Sheer Number of Distinct Procedures

This results in errors and misconceptions, such as adding numerators and denominators across (Aksoy & Yazlik, 2017, pp. 224-225, 231; Fazio & Siegler, 2011, p. 16; Mohyuddin & Khalil, 2016, p. 144).

GAP

Existing systems (Cyr et al., 2019; Beal et al., 2010) and previous work (Espulgar et al., 2018) either use the usual classroom pedagogies where the difficulty is found or…

$$\frac{2}{3}+\frac{3}{4}$$
$$=(\frac{2}{3}*1)+(\frac{3}{4}*1)$$
$$=(\frac{2}{3}*\frac{4}{4})+(\frac{3}{4}*\frac{3}{3})$$
$$=\frac{8}{12}+\frac{9}{12}$$
$$=\frac{17}{12}$$

simply do not let the players handle the arithmetic process where the problem lies.

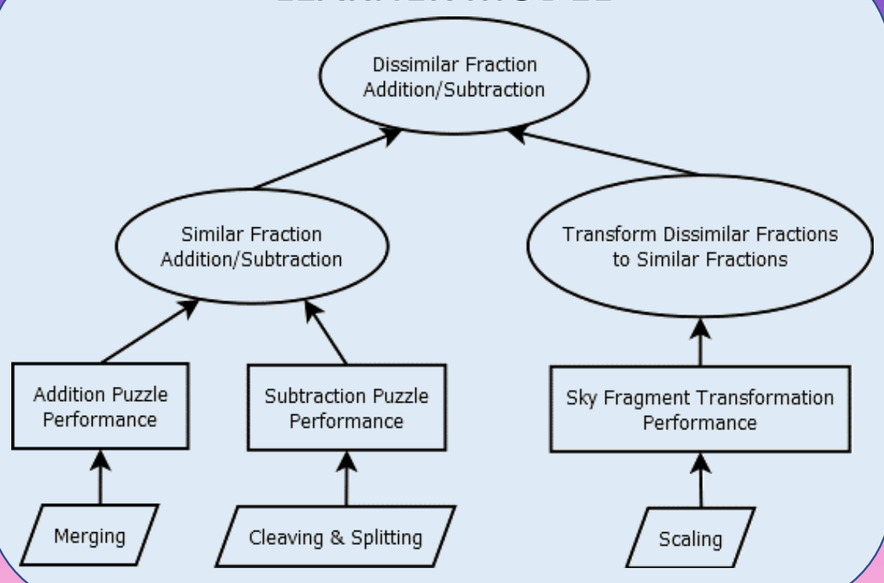
LEARNING OUTCOMES (LOs)

- Add/Subtract similar fractions
- Transform dissimilar fractions to similar fractions
- Add/Subtract dissimilar fractions

Designed to impart

Approximates mastery of

LEARNER MODEL



Models user actions in the

PEDAGOGICAL COMPONENT

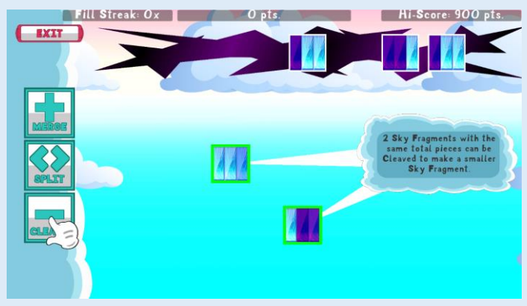
- Controls puzzle generation and progression decision to ensure misconception troubleshooting and achieving LOs.
- Sets up misconception traps by disabling Sky Fragments or Rifts to force player into either using Sky Fragments or solving Rifts with values that entice the use of misconception.

Bases its decisions on the

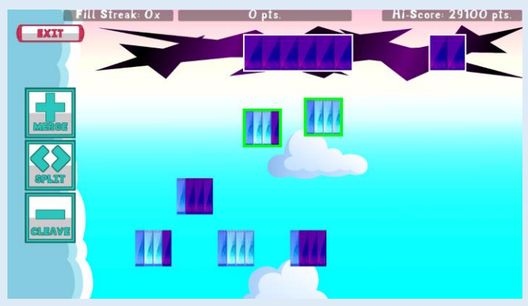
Adjusts puzzles in

GAME COMPONENT

Component that the user interacts with. Starts out easy and simple before gradually introducing the fraction notation and dissimilar fractions. Difficulties in fraction arithmetic (Lortie-Forgues et al., 2015, pp. 14-23) were addressed via learning principles in games (Gee, 2004) and game design.

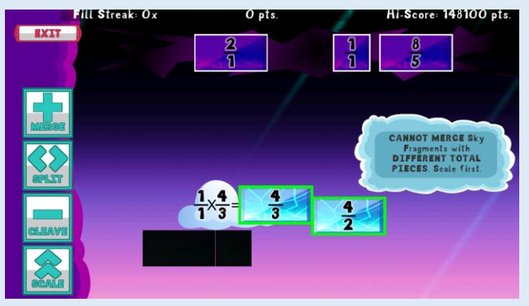


Stage 0



Stage 1

Stage 2



Stage 3

METHODOLOGY

The GILE's capability to remediate fraction addition/subtraction misconceptions was investigated, so comparison was made between a version with the intelligent components and one without. It was developed following Sison et al. (2018)'s Outcome-based Game Design Framework. Different from the previous work (Espulgar et al., 2018) which was about introducing the GILE, this work focused on using the GILE to address a specific problem in a domain where a research gap is present as well as extending its component functionalities and fine graining the design to better achieve learning outcomes.

Participants were heterogeneously grouped according to math performance by their math teachers so both groups had a balance of high performers and average performers. Quasi-experiment short quizzes were gathered from 23 convenience-sampled playtesters (13 experimental, 10 control) that were having their online fraction arithmetic math lessons to test this, lasting for 4 days with 1-hour synchronous sessions each day. Only 6 of the 23 were able to progress far into Stage 3 which contains misconception traps.

RESULTS

Some playtesters (C2, C3, and C10) exhibited misconceptions in short quizzes.

Playtester	Pre-test Misconceptions	Post-test Misconceptions
E9	0	0
E13	0	0
C2	4	-
C3	4	4
C4	0	0
C10	3	-

Table below shows that misconceptions of C2, C3, and C10, as defined in the GILE, were eradicated while playing the GILE.

Playtester	Adding Across Attempts	Adding Across Traps	Subtracting Across Attempts	Subtracting Across Traps
E9	0	5	0	5
E13	0	0	0	1
C2	0	1	0	2
C3	0	2	0	5
C4	1	7	0	10
C10	0	4	0	1

However, C3's misconceptions still appeared in the post-test. (C2 and C10 failed to do the post-test.)

CONCLUSIONS

Remediation of misconceptions in the GILE was possible but transfer of improvement to standard fraction arithmetic short quizzes did not always occur. This may be due to difficulties in supervising the gameplay of participants during a pandemic. Despite this, a GILE was presented to fill the research gap.

Further improvements to the GILE could be to develop assessment mechanics on top of the learning outcome mechanics. Assessment as well as learning outcome mechanics are further discussed in (Sison et al., 2018). Knowledge transfer from in-game context to formal classroom contexts (e.g. short quizzes) could be further investigated. To do so in the midst of a pandemic might entail the development of protocols for effective distance assessment.