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The Counterproductive Effects on Learning Achievement and Intrinsic Motivation for Ludicization as an Online Learning Pedagogy Involving Game Elements

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ABSTRACT

This study investigated the actual efficiency of ludicization, a game-related pedagogy that integrates game elements with online learning based on ludic metaphorization of educational contexts, by identifying whether it exerts counterproductive effects on learning achievement and intrinsic motivation. This study involved adapted versions of CET-6 (College English Test-6) and Harter's intrinsic motivation scale to assess learning achievement and intrinsic motivation, respectively. ANCOVA revealed that ludicization showed counterproductive effects on posttest scores (N = 36, M = 62.910, SD = .865) compared with the control group (N = 36, M = 63.937, SD = .865). ANOVA suggested that ludicization exerted counterproductive and insignificant effects on intrinsic motivation-related subscales: challenge, curiosity, and independent mastery. The main conclusion was that ludicization would exert insignificant or even counterproductive effects on learning achievement and intrinsic motivation. These findings implied that we should not take positive effects of game-related pedagogies for granted.

KEYWORDS

Counterproductive Effects, Empirical Study, Intrinsic Motivation, Learning Achievement, Ludicization

INTRODUCTION

Online learning is an educational instruction that enables educators to perform completely asynchronous or partly synchronous pedagogical procedures based on online technologies (Broadbent, 2017). Online learning allows learners to participate in pedagogical practice beyond the limitations of face-to-face time and location (Luo, Lin, & Yang, 2021). Especially after the breakout of COVID-19, educators have been increasingly implementing online learning (Schneller & Holmberg, 2014; Seaman, Allen, & Seaman, 2018). Based on the accessible and flexible designs in online learning, educators and

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learners can enjoy more inclusive experiences, customized procedures, and student-centered activities (Huang, Liu, Tlili, Yang, & Wang, 2020; Zuo, Ma, Hu, & Luo, 2020).

Online learning has created various activities compatible with the accessible and flexible online techniques. For instance, online discussion forums, with their interactive functions, are the extensively-utilized activities in blended online learning (Payne, 2020; Saeed & Ghazali, 2017). Influenced by the reciprocal community involving text-based communications, learners could achieve timely self-reflection, critical thinking, self-awareness (Saeed & Ghazali, 2017), knowledge construction at the social level, and constant contributions of input and output (Bailey, Almisharraf, & Hatcher, 2021). In other words, immersive and interactive experiences could encourage learners to achieve particular goals and reinforce expected outcomes.

Compatible with the flexible and interactive features of online learning, games involve a series of interesting and meaningful choice designs allowing participants to achieve precise and compelling goals based on specific mechanism (Kim, Song, Lockee, & Burton, 2018). Games in the education context could be implemented in the form of digital games with the intention of learning, training, or health care (Loh, Sheng, & Ifenthaler, 2015). Defined by rules, participants in the game systems would engage themselves in an artificial conflict for quantifiable outcomes (Salen & Zimmerman, 2004). The increasingly accessible and flexible online learning techniques enabled educators to implement game or game-related elements in pedagogical practices (Chans & Castro, 2021; Hassan, Habbiba, & Majeed, 2021; Kim et al., 2018).

These implementations have contributed to numerous game-related pedagogies aiming to enhance learners' enjoyment and effectiveness of instruction (Kim et al., 2018; Yamani, 2021). Ludicization is one of the game-related pedagogies in the online learning context and it involves game elements integrated with online learning. The concept "ludicization" is mainly mentioned and discussed from the study Sanchez, Young, & Jouneau-Sion, 2016. Ludicization stands for the process of transforming the original reference contexts into enjoyable, ludic, and playful situations rather than just making a game (Sanchez, Young, & Jouneau-Sion, 2016). We defined and summarized the features of ludicization in the section 2.1.

Confronted with the popularity of online education, researchers tend to concentrate on the effectiveness of online teaching and learning (Shire, Worthman, Shih, & Kasari, 2020). Game-related pedagogies might be associated with the hypothesized promising influences on instruction and learning (Kim et al., 2018; Sailer & Homner, 2020). However, game-related pedagogies pedagogies might produce side effects opposed to the desired outcomes, i.e., counterproductive effects (Diefenbach & Müssig, 2019). Counterproductive effects of game-related pedagogies would appear when the pedagogies do not motivate learners to make progress but lead to dysfunction of pedagogical practices e.g., to motivate negative behaviors and demotivate positive behaviors (Diefenbach & Müssig, 2019). Game-related pedagogies would not be regarded as the "panacea" (Diefenbach & Müssig, 2019). Thus, this study reflected on the actual efficiency of ludicization as a game-related pedagogy and investigated whether ludicization exerted insignificant, unstable, or even counterproductive effects on specific dimensions.

We chose learning achievement and intrinsic motivation as the dimensions to quantitatively assess efficiency of ludicization. Motivation, with its association with learning performance, is a central concept for teaching and learning (Li, Luo, Lei, Xu, & Chen, 2022; Pintrich & Schunk, 1996). Past researches have demonstrated the positive influences of game-related approaches on higher-order thinking skills and test performance (Asigigan & Samur, 2021; Cao, Gong, Wang, Cheng, & Wang, 2022; Chans & Castro, 2021; Johnson, Urazovm & Zanoli, 2022; Lei, Chiu, D. Y. Wang, C. X. Wang, & Xie, 2022; Ortiz-Martines, Santos-Jaen, & Palacios-Manzano, 2022; Tahir, Mitrovic, & Sotardi, 2022).

Apart from the proved effects on learning achievement, game-related pedagogies are proved to exert positive impacts on motivation (Candel & Colmenero, 2022; Ortiz-Martines et al., 2022), cognitive load (Asigigan & Samur, 2021), attention, relevance, confidence, satisfaction (H.-C. K. Lin,

Y.-H. Lin, Wang, Su, & Huang, 2021), cooperation, and interaction (Hassan et al., 2021). Intrinsic motivation, as the motivational instantiation of human beings' proactive and growth-oriented nature, reflects the volitionary need based on which individuals achieve engagement in particular activities (Vansteenkiste, Lens, & Deci, 2006; Deci, 1975). Thus, we chose intrinsic motivation as the second dimension to evaluate the efficiency of ludicization. The section 2.2 describes the theoretical association among ludicization, learning achievement, and intrinsic motivation.

The current study is developed in the following sequence. The literature review section (2.1-2.2) presents the definitions and features of ludicization theoretically associated with learning achievement and intrinsic motivation, based on which we raised the research hypotheses. The methodology section describes research participants (3.1), instruments (3.2), procedures (3.3), and statistical approaches (3.4) for the experiment as the quantitative method of the current study. The results section (4.1-4.2) reports the findings from the meta-analyses to test the hypotheses. The section of discussion (5.1-5.2) demonstrated the potential reasons for the research phenomena. The section of conclusion presented brief summaries of findings for answers to the hypotheses (6.1) and insights for future research based on the limitations of this study (6.2).

LITERATURE REVIEW

This section provided the theoretical background for us to raise the hypotheses.

Ludicization and its Features

Ludicization is concerned with playful experiences acceptable for potential players. As educators have increasingly employed digital technologies in educational areas, ludicization could indicate the process of designing learning situations that combine educational purposes and ludic characteristics (Sanchez et al., 2016). Since players have the intentions from which their desires for involvement in ludic experiences come, they do not need to necessarily find ludic elements from the materiality of objects or the factuality of gestures to maintain playful procedures (Henriot, 1989). Indeed, ludicization encourages players to develop desired behaviors based on autonomy (Sanchez et al., 2016).

Ludicization has three core features as follows. First, ludicization could transform the reference situations, i.e., the target situations, into immersive playful experiences (Sanchez et al., 2016). Rather than introducing game elements to create fun and real educational contexts, ludicization transforms the behavioral situations and the meaning of players' behaviors into immersive imaginary experiences (Sanchez et al., 2016). The transformation enables learners to easily decode hosts' expectations based on the explicit game mechanics (Sanchez et al., 2016). Players also have avatars as the emblematic figures or items projecting identities, rewards, or punishments, allowing them to explicitly consider their decisions or behaviors (Sanchez et al., 2016).

Besides, ludicization provides metaphors reflecting analogical relation between elements related to the playful experiences and procedure or organization in the reference situations (Sanchez et al., 2016). Since metaphors reflect the essential procedures or sections of the reference situation, ludicization contributes ontological significance to behavioral guides or organizations in practical contexts (Sanchez et al., 2016). Ludicization transforms educational goals into motivating goals in ludic contexts, and players could associate progress with points, rewards, and competitions (Sanchez et al., 2016). The reward or punishment system allows the hosts to transfer learners' responsibility of performing acceptable and expected behaviors into earning points or rewards.

Moreover, reflexive space in ludicization reflects the congruency between metaphors and reference situations. The environments involving continuously generated feedback guiding future behaviors of players based on their previous behaviors are the reflexive space, the critical concept of ludicization (Sanchez et al., 2016). Reflexive feedback environments ensure players' relatively sufficient liberty in making decisions and taking actions, contributing to their feeling of competency (Sanchez et al., 2016). Based on feedback embodied in the metaphorical forms, players could promote their autonomy

by practicing their liberty of decisions and behaviors consistent with the objectives of the reference situations (Sanchez et al., 2016). Even if players have lost some metaphorized elements, e.g., points or rewards, they would perceive these punishments as less severe consequences due to ludic contexts (Sanchez et al., 2016). Thus, metaphorical feedback from ludic contexts could encourage players to make progress associated with their competency for the target objectives, reflecting the consistency between the metaphors and the requirements of the reference situations.

Overall, the three core features of ludicization are the transformation in imaginary experiences, metaphorization of the target reference situation, and congruency between metaphors and reference situations. The transformation from the reference situation into imaginary playful experiences could ensure players' immersion. Metaphors associate essential parts in the reference situation with elements in the playful experiences. Metaphorization contributes ontological significance to players' interests in performing the desired behaviors or reaching the objectives. The consistency between metaphors and reference situations suggests that players gain much motivation for better mastery as the ludic activities progress and continuously produce feedback tailored to their behaviors.

Theoretical Association Among Ludicization, Learning Achievement, and Intrinsic Motivation

Autonomy-supportive contexts enable individuals to make decisions, provide timely feedback, and limit the use of pressure to promote particular behaviors (Vansteenkiste et al., 2006). Autonomy-supportive contexts were positively correlated with intrinsic motivation (Vansteenkiste et al., 2006). Intrinsic motivation is the reachable state and the premise of learning and development (Vansteenkiste et al., 2006). Individuals' physiological needs for competence and autonomy could contribute to intrinsically motivated behaviors (Nuttin, 1973). Internalization refers to internalizing the initially external regulation of the behaviors and plays a central role in the process of socialization (Deci & Ryan, 2000). Individuals' psychological needs for competence, autonomy, and relatedness contribute to internalization (Vansteenkiste et al., 2006). Competence indicates the ability to finish something successfully and efficiently. Autonomy stands for independence and freedom from coercive control or influence. Relatedness means the state of being related to others and involved in groups or social communities (Deci & Ryan, 2000).

Thus, autonomy-supportive contexts could satisfy individuals' needs of competence, autonomy, and relatedness. These satisfied needs were positively associated with intrinsic and could enhance learning achievement (Vansteenkiste et al., 2006). Game-related pedagogies could thus fulfill these needs to provide autonomy-supportive contexts and guarantee learning achievement.

Ludicization could fulfill the demands of competence, autonomy, and relatedness associated with intrinsic motivation and learning achievement. Reflexive space in ludicization could provide players with relatively sufficient liberty in actions or decisions, contributing to players' autonomy (Sanchez et al., 2016). Users' liberty in actions and timely metaphorical feedback could cultivate individuals' sense of belonging and orient them to make progress (Sanchez et al., 2016), reflecting an increase in competency and relatedness. Thus, ludicization is associated with intrinsic motivation and learning achievement at the theoretical level.

Ideally, ludicization would positively influence intrinsic motivation and thus enhance learning achievement. However, as the Introduction section presented, ludicization as a game-related pedagogy might not necessarily motivate participants' positive behaviors consistent with the intended effects and demotivate their negative behaviors not compliant with the intended effects (Diefenbach & Müssig, 2019). However, the positive effects of game-related experiences have been taken for granted, blurring whether playful experiences can promote intended behaviors in real-world contexts (Diefenbach & Müssig, 2019).

Since ludicization is associated with learning achievement and intrinsic motivation, we have raised the following hypotheses to investigate whether ludicization would exert counterproductive effects on these two dimensions.

H1: Ludicization exerts counterproductive effects on learning achievement.
H2: Ludicization exerts counterproductive effects on intrinsic motivation.

Then we designed the experiment as the qualitative method to prove these hypotheses.

METHODOLOGY

We conducted an experiment as the quantitative method for our research design. This section describes the elements for the empirical experiment: participants, instruments, procedures, and statistical approaches, for this quantitative study.

Research Participants

The experiment involved 72 senior undergraduates, including 41 female participants and 31 male participants, from Chinese universities as the participants. The participants attended the courses of English for general purposes to enhance their English proficiency. We randomly divided these participants into two classes similar in scales and homogeneity. The experimental group adopting ludicization involved 36 participants, including 20 female participants and 16 male participants. The control group adopting the traditional didactic pedagogy involved 36 participants, including 21 female and 15 male participants.

Research Instruments

We employed English proficiency tests and the questionnaire concerned with motivation to quantify learning achievement and intrinsic motivation.

Adapted CET-6 as the Assessment of Learning Achievement

Considering the instrument assessing participants' learning achievement in the College English course, we adapted the questions in College English Test-6 (CET-6). Since CET-6 is the authorized tests to assess participants' English proficiency in China, CET-6 questions can provide relatively reliable results about participants' learning achievement in the College English course.

We conducted a pretest and posttest involving the adapted CET-6 questions. The total score of both pretest and posttest is 100. Each test contains ten cloze questions, 10 paragraph matching questions, ten multiple-choice questions, one Chinese to English translation task, and one writing task from CET-6.

Adapted Version of Intrinsic Motivation Scales as the Assessment of Intrinsic Motivation

For quantified assessment of participants' intrinsic motivation, we employed the questionnaire based on Harter's (1981) intrinsic motivation scale involving three dimensions: challenge, curiosity, and independent mastery. The adapted questionnaire consists of 15 questions scored with a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree) (see Table 1).

The "challenge" dimension described participants' preferences for challenging or effortless assignments (Lepper, Corpus, & Iyengar, 2005). The "curiosity" dimension described the extent to which participants perform specific behaviors due to their internal curiosity or external rewards (Lepper et al., 2005). The "independent mastery" dimension described how participants are long to achieve mastery independently or dependent on instructors' guidance (Lepper et al., 2005).

Habitica as the Platform for Ludicization

We selected Habitica (https://habitica.com) that fulfills the conditions of ludicization. Habitica creates battlefields where participants could defeat the monsters, embodiments of learning tasks or habit items, to level up and gain rewards (Diefenfach & Müssig, 2019), reflecting transforming the current learning

Table 1. Items description and factor loadings for Harter's (1981) intrinsic motivation scale

Item description		Factor loading	
		1	2
Challenge	Q1.1 I like hard work because it's a challenge.	.641	
	Q1.2 I like to learn as much as I can in class.	.666	
	Q1.3 I like the topics that make me think pretty hard and figure things out.	.737	
	Q1.4 I like difficult problems because I enjoy trying to figure them out.	.736	
	Q1.5 I like difficult assignments because I find it more interesting.	.693	
Curiosity	Q2.1 I do extra projects because I can learn about things that interest me.	.506	
	Q2.2 I read things because I am interested in the subject.	.506	
	Q2.3 I do my assignments to find out about a lot of things I've been wanting to know.	.695	
	Q2.4 I work really hard because I really like to learn new things.	.715	
	Q2.5 I work on problems to learn how to solve them.	.694	
Independent mastery	Q3.1 I like to try to figure out how to do assignments on my own.		.859
	Q3.2 When I don't understand something right away, I like to try to figure it out by myself.		.773
	Q3.3 When I make a mistake, I like to figure out the right answer by myself.		.688
	Q3.4 If I get stuck on a problem, I keep trying to figure out the problem on my own.		.712
	Q3.5 I like to do my assignments without help		.723

situation in imaginary experiences (Sanchez et al., 2016). Habitica provides analogical relations between game elements, e.g., experiences, rewards, leaderboards, and the target situation, i.e., learning organization and habit development, satisfying the demand of metaphorization in ludicization (Sanchez et al., 2016). Participants' behaviors congruent with their intentions would produce experience and gold as the rewards (Diefenfach & Müssig, 2019). Habitica changes the meaning of establishing learning habits for better learning outcomes originally in the reference situation, consistent with the demand of the consistency between metaphors and the reference situation (Sanchez et al., 2016).

Experiment Procedures

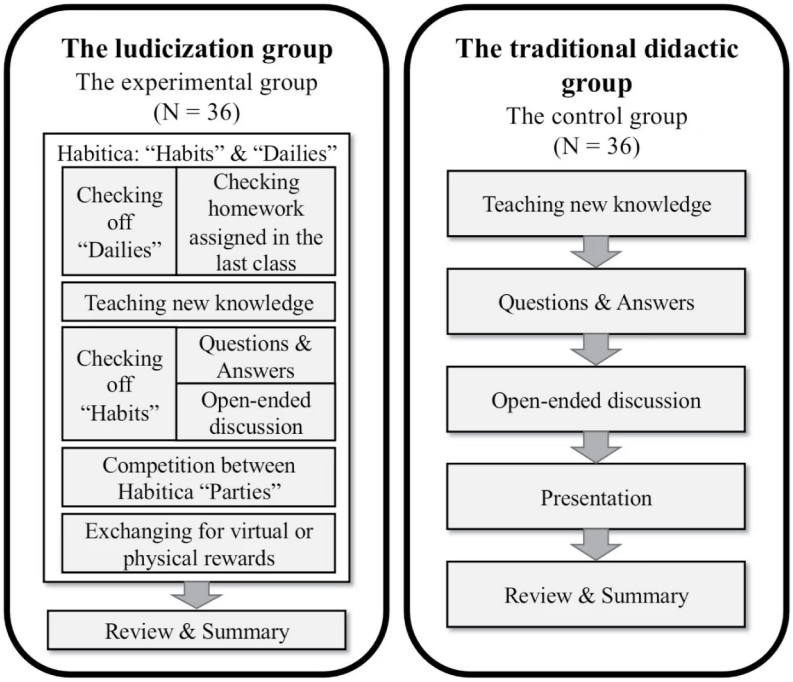
The experiment procedure (see Figure 1) lasted six weeks (from November 1st, 2021, to December 3rd, 2021). The participants attended the English course five times a week. Each course lasts about 100 minutes. Two English teachers parallelly taught the two treatment groups. They were also the raters of the CET-6 pre- and posttest.

Basic Empirical Procedures

Before the course began, the participants took an English pretest. We recorded participants' pretest scores reflecting their English foundation. Having finished the pretest, participants began to take courses. The teacher employed Habitica in the experimental group, while the teacher adopted the traditional didactic approach in the control group.

Once the participants finished the 6-week courses, they took a posttest to assess their English proficiency in terms of test performance, reflecting learning achievement. They also took a post-course questionnaire based on Harter's intrinsic motivation scale, reflecting their quantified intrinsic motivation.

Figure 1. The empirical procedures investigating the effects of ludicization on learning achievement and intrinsic motivation



Pedagogical Practices in the Ludicization Group

Before the first course began, the teacher asked participants to make preparations for ludicization. Participants were asked to set "answer questions in class" and "actively participate in in-class discussion" as the goals in "Habits" of Habitica. For extracurricular tasks, participants were also asked to set "finish assignments" as the "Dailies" goals in Habitica. The teacher randomly divided the whole class into four groups and formed four "parties" in Habitica.

After teaching new knowledge, the teacher started the question-and-answer and open-ended discussion sections. Volunteer participants who actively answered the questions or joined the discussion could check the habits and earn health points, experience, and golds as rewards. Meanwhile, participants' behaviors influenced the progress of the "parties" because any member's failure to reach the goals would lead to the loss of all the members' health points as a punishment. Participants could use golds to purchase virtual goods to equip and upgrade their avatar in Habitica. They could also exchange 20 golds in Habitica for real-world rewards, e.g., prepared stationery stuffs.

At the end of each course, the teacher assigned the extracurricular tasks to consolidate participants' mastery of knowledge. Once participants finished the assignments after class, they could check off the daily goal. The teacher checked participants' assignments at the beginning of the next class to avoid cheating. If someone failed to finish the assignments, this participant would mark the daily goal unfinished, leading to losing health points, experience, and gold in Habitica. Then the teacher repeated the cycle of the courses for the ludicization class.

Pedagogical Practices in the Traditional Didactic Group

The teacher arranged the same syllabus in the control group without implementing any playful experiences. The teacher taught the course contents using traditional slides, during which the teacher

asked the participants and listened to participants' responses. Having learned all the new knowledge, participants gained an open-ended question and had a discussion.

Before the end of class, the teacher picked some volunteers to present their answers to the question, based on which the teacher summarized the key concepts and resolved the understanding. The teacher repeated this cycle of the courses for the traditional didactic class.

Supplementary Materials and Approaches of Statistical Analyses

This part introduced how we statistically analyze the data collected from the empirical experiment. We employed IBM® SPSS® Statistics 26 to perform statistical analyses. Data for H1 involve the participants' pre- and posttest scores in different pedagogies. The variable group "Pedagogy" demonstrated which pedagogical approach participants received in the empirical process (1 = Ludicization, 2 = Traditional didactic). The variable groups "Pretest" and "Posttest" demonstrated participants' performance of CET-6 (College English-6) pre- and posttest in the adapted versions. The variable group "Gender" demonstrated participants' genders (1 = Female, 2 = Male).

To analyze participants' learning achievement, we compared participants' posttest scores (the variable group "Posttest") in the two "Pedagogy" groups to investigate the efficiency of game-related pedagogies. However, participants' English foundation would inevitably influence the results of comparisons. Since participants' English foundation was an uncontrollable factor positively associated with the pretest scores (the variable group "Pretest"), we implemented ANCOVA (Analysis of Covariance) to exclude the impacts of pretest scores on the experiment results (Aldrich & Cunningham, 2015, pp. 204).

Data for H2 involve participants' feedback of the questionnaire on intrinsic motivation in different pedagogies. The variable group "Pedagogy" demonstrated which pedagogical approach participants received in the empirical process (1 = Ludicization, 2 = Traditional didactic). The variable groups from "Q1.1" to "Q3.5" demonstrated participants' scores of the 5-Likert questions on intrinsic motivation-related subscales, i.e., challenge ("Q1.1-Q1.5"), curiosity ("Q2.1-Q2.5"), and independent mastery ("Q3.1-3.5"), in Harter's intrinsic motivation scale.

For quantitative measurement of intrinsic motivation, we investigated whether participants in different pedagogy groups gave significantly different feedback of intrinsic motivation. Based on the reliability and validity of the questionnaire, we performed ANOVA (Analysis of Variance) to identify the differences between the two groups in learning motivation rating (Aldrich & Cunningham, 2015, pp. 161).

RESULTS

This section reported the statistical findings to test the research hypotheses.

Does Ludicization Exert Counterproductive Effects on Learning Achievement?

We first whether the data on learning achievement fulfilled the requisites for ANCOVA.

Requisites for ANCOVA

The first requisite was that the variable data should be normally distributed. We performed the one-sample Kolmogorov-Smimov (K-S) test to investigate the normality of the "Pretest" and "Posttest" variable groups. The results suggested that both "Pretest" and "Posttest" variable groups had the significance level > .05 of .200. Thus, the variable groups of "Pretest" and "Posttest" satisfied the condition of normality (Aldrich & Cunningham, 2015, pp. 125).

The second requisite was that regression slopes should be homogeneous so that the relationships between the dependent variable ("Posttest") and the covariate ("Pretest") were similar in all the treatment groups (the two "Pedagogy" groups) (Aldrich & Cunningham, 2015, pp. 208). We used the

grouped scatter with fit lines to investigate whether the linear relationships between "Posttest" and "Pretest" presented the homogeneous regression slopes in the two pedagogical approach conditions (Aldrich & Cunningham, 2015, pp. 223).

The grouped scatter chart (see Figure 2) showed that the slopes are .57 and .61 for the lines standing for ludicization and traditional didactic pedagogy, respectively. Since the two lines were approximately parallel due to the similar slopes, the dataset presented the homogeneous regression slopes (Aldrich & Cunningham, 2015, pp. 208). Thus, the dataset fulfilled the condition of homogeneous regression slopes.

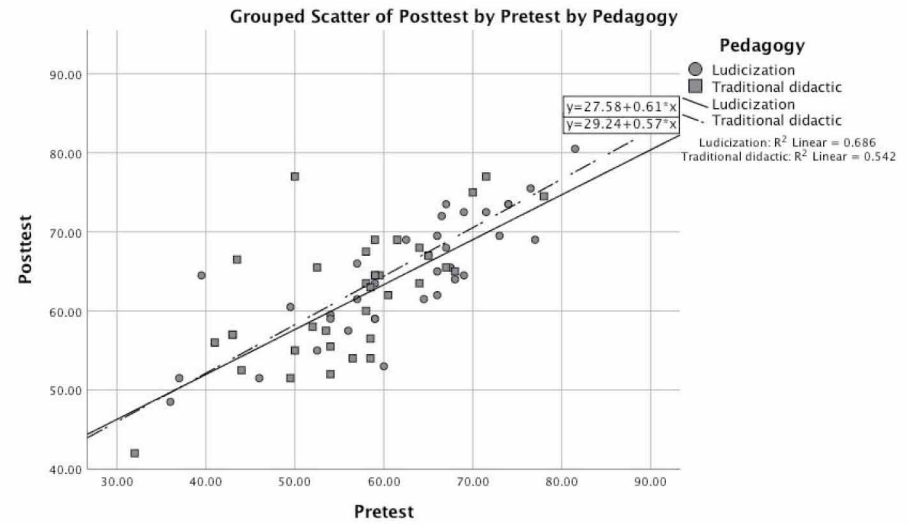
The third requisite was that the interaction between the independent variable and the covariate ("Pedagogy*Pretest") should be insignificant to avoid the significant effects of the covariate (Aldrich & Cunningham, 2015, pp. 208). Having chosen the univariate model involving "Pedagogy", "Pretest", and "Pedagogy*Pretest", we conducted the test of between-subject effects to investigate the significance of their effects and further confirm the homogeneity of slopes.

The results demonstrated that the significance levels of "Pedagogy", "Pretest", and "Pedagogy*Pretest" were .813, .000, and .697, respectively. Since the level of "Pretest" was significant ($F = 104.158$, $p = .000 < .05$), it was reasonable to regard this factor as the covariate to avoid interfering effects on ANCOVA. Since the interaction between "Pedagogy" and "Pretest" was insignificant ($F = .153$, $p = .697 > .05$), the regression slopes were homogeneous, and this interaction could weaken the excessively significant effects of "Pretest" (Aldrich & Cunningham, 2015, pp. 210). Thus, the dataset fulfilled the insignificant effect of the interaction between the fixed factor ("Pedagogy") and the covariate ("Pretest").

The fourth requisite was the equality of the variance in the dependent variable group (Aldrich & Cunningham, 2015, pp. 213). According to Levene's test, the "Posttest" variable group did not violate the assumption of the equality of variances ($p = .190 > .05$) (Aldrich & Cunningham, 2015, pp. 213). Thus, the variance of the dependent variable was equal across the research groups, meeting the demand of ANCOVA.

Since the dataset satisfied all the conditions for ANCOVA, we could perform ANCOVA to further investigate the impacts on learning achievement.

Figure 2. The grouped scatter chart presenting the homogeneous regression slopes of the linear relations between "Pretest" and "Posttest" by two "Pedagogy" variables



ANCOVA Examining the Effects of Ludicization on Learning Achievement

We performed ANCOVA after removing "Pedagogy*Pretest" from the univariate model. The tests of between-subject effects (see Table 2) presented that "Pedagogy" had the significance level > .05 of .409, reflecting insignificant differences of posttest scores between the ludicization and traditional didactic groups. The estimated means of "Posttest" demonstrated that the ludicization group (N = 36, M = 62.910, SD = .865) presented lower quantified learning achievement than the traditional didactic group (N = 36, M = 63.937, SD = .865) (see Table 3).

Since the significance level of the covariate ("Pretest") was .000 < .05 (see Table 2), participants' posttest scores were significantly associated with their pretest scores, and the pretest scores significantly influenced the analyses of posttest scores. These statements further confirmed the rationality of conducting ANCOVA and regarding "Pretest" as the covariate.

Thus far, ANCOVA demonstrated that participants' posttests are insignificantly different between the ludicization and traditional didactic groups. The between-subject effect test (see Table 2) revealed that participants had lower mean posttest scores in the ludicization group than the traditional didactic group. Therefore, we maintained the hypothesis that ludicization exerted counterproductive effects on learning achievement compared with the effects of the traditional didactic pedagogy.

Does Ludicization Exert Counterproductive Effects on Intrinsic Motivation?

Since the data for H2 were from the questionnaire, we first investigated whether the collected questionnaire data satisfied the conditions of reliability and validity for further analyses in ANOVA.

Table 2. ANCOVA test of between-subject effects examining the significant differences between research groups

Dependent Variable: Posttest					
Source	**Type III Sum of Squares**	**Degree of freedom**	**Mean Square**	**F**	**Significance level**
Corrected Model	2824.965[a]	2	1412.482	53.628	.000
Intercept	1784.217	1	1784.217	67.741	.000
Pedagogy	18.145	1	18.145	.689	.409
Pretest	2777.433	1	2777.433	105.451	.000
Error	1817.365	69	26.339		
Total	294266.250	72			
Corrected Total	4642.330	71			
a. R Squared = .609 (Adjusted R Squared = .597)					

Table 3. ANCOVA estimates examining the effects of ludicization and the traditional didactic pedagogy on learning achievement

Dependent Variable: Posttest				
Pedagogy	**Mean**	**Standard Error**	**95% Confidence Interval**	
			Lower Bound	**Upper Bound**
Ludicization	62.910[a]	.865	61.185	64.636
Traditional didactic	63.937[a]	.865	62.211	65.663
a. Covariates appearing in the model are evaluated at the following values: Pretest = 59.3333.				

Reliability and Validity as the Requisites of Further Analyses

Reliability reflects the stability of the results output over time (Nunnally & Bernstein, 1994, pp. 243). Internal consistency can estimate reliability based on the average correlation among items within the data (Nunnally & Bernstein, 1994, pp. 251). Thus, we employed Cronbach α to assess the internal consistency of the data about the questionnaire results.

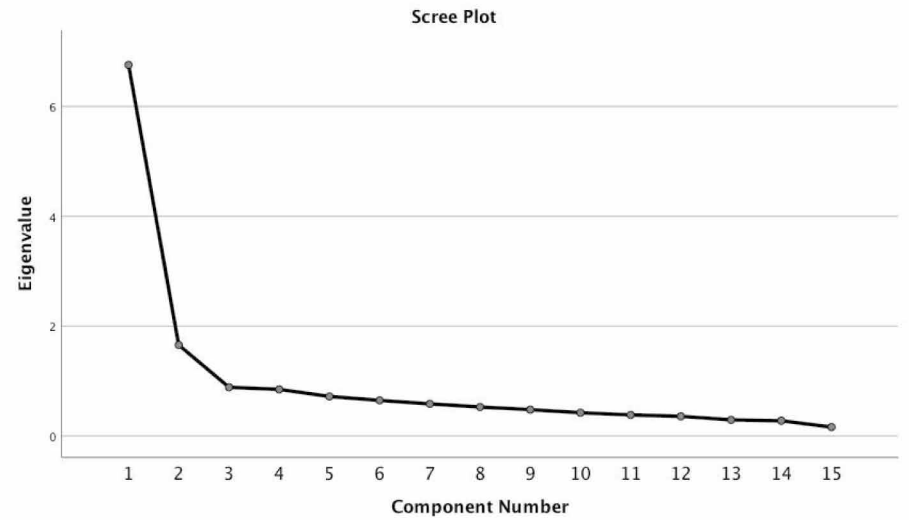
The overall Cronbach α value for all the questions was 8.55, while the Cronbach α values for the subscales of challenge (Q1.1-Q1.5), curiosity (Q2.1-Q2.5), and independent mastery (Q3.1-Q3.5) are .851, .786, and .847, respectively. The overall Cronbach α value for all questions was .911. Since all of those values exceeded the required value of .70 (Nunnally & Bernstein, 1994, pp. 265), the questionnaire results satisfied internal consistency that supports reliability.

Validity stands for the degree of consistency between the measure and the target facets of the concepts (Stockemer, 2019, pp. 14). Since factor analysis combines variables that approximately assess the same concept for data reduction (Aldrich & Cunningham, 2015, pp. 286), we conducted the factor analysis to examine whether the data validly represented all facets of the target intrinsic motivation-related subscales.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Bartlett's Test of Sphericity aim to investigate whether the data present valid assessment suitable for the factor analysis (Aldrich & Cunningham, 2015, pp. 292). Since KMO reported a value > .6 of .877 and Bartlett's Test of Sphericity presented the chi-square of 503.800 at df = 105 and the significance level < .05 of .000, the questionnaire feedback data presented a valid assessment of intrinsic motivation (Aldrich & Cunningham, 2015, pp. 292).

The scree plot and the rotated component matrix provided the factor analysis results. The scree plot (see Figure 3) showed that the eigenvalue line steadily decreases from the third to the fifteenth component. Thus, the questionnaire questions could be analyzed based on two major components. The Rotated Component Matrix table (see Table 1) reflected the detailed correlations between the variables and the high-loading components (Aldrich & Cunningham, 2015, pp. 294). The results revealed that Q1.1-Q1.5 and Q2.1-Q2.5 were most positively correlated with the first component and that Q3.1-Q3.5 were most positively correlated with the second component. Therefore, we accordingly calculated the mean scores according to the high-loading components and set the variables "Challenge_and_Curiosity" and "Independent_mastery".

Figure 3. The scree plot presenting high-loading components for the factor analysis



Thus far, the questionnaire data satisfied the conditions of reliability and validity. The analyses involving these data could be persuasive at the statistical level.

ANOVA Examining the Effects of Ludicization on Intrinsic Motivation

We performed ANOVA involving the dependent factors: "Challenge_and_Curiosity" and "Independent_mastery" and the independent variable "Pedagogy". The ANOVA results (see Table 4) revealed that the mean scores of "Challenge_and_Curiosity" and "Independent_mastery" were insignificant different in the ludicization and traditional didactic groups due to the levels > .05 of .695 and .971, respectively (Aldrich & Cunningham, 2015, pp. 167).

Notably, according to the descriptive information (see Table 5), the ludicization group (N = 36, M = 3.1556, SD = .58135) presented lower quantified scores on challenge and curiosity than the traditional didactic group (N = 36, M = 3.2083, SD = .55671). Even if the quantified score on independent mastery in the ludicization group (N = 36, M = 3.1556, SD = .59543) was slightly higher than that in the traditional didactic group (N = 36, M = 3.1500, SD = .68348), such a slight increase might be ignorable.

The test of homogeneity of variance reported the significance levels > .05 of .920 and 360 for "Challenge_and_Curiosity" and "Independent_mastery", respectively. Thus, these data maintained the assumption of the equality of variances, suggesting that the ANOVA results were relatively persuasive (Aldrich & Cunningham, 2015, pp. 213).

Thus far, the factor analysis reduced the original dimensions into "Challenge_and_Curiosity" and "Independent_mastery" (see Table 1). ANOVA (see Table 4) demonstrated that the scores on "Challenge_and_Curiosity" and "Independent_mastery" were insignificantly different between the ludicization and traditional didactic groups. The descriptive table (see Table 5) revealed adverse

Table 4. ANOVA examining the effects of ludicization and the traditional didactic pedagogy on intrinsic motivation-related subscales

		Sum of Squares	Degree of freedom	Mean Square	F	Significance level
Challenge_and_Curiosity	Between Groups	.050	1	.050	.155	.695
	Within Groups	22.676	70	.324		
	Total	22.727	71			
Independent_mastery	Between Groups	.001	1	.001	.001	.971
	Within Groups	28.759	70	.411		
	Total	28.759	71			

Table 5. Descriptives comparing the effects of ludicization and the traditional didactic pedagogy on intrinsic motivation-related subscales

		Number of participants	Mean	Standard Deviation	Standard Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
Challenge_and_Curiosity	Ludicization	36	3.1556	.58135	.09689	2.9589	3.3523
	Traditional didactic	36	3.2083	.55671	.09279	3.0200	3.3967
	Total	72	3.1819	.56577	.06668	3.0490	3.3149
Independent_mastery	Ludicization	36	3.1556	.59543	.09924	2.9541	3.3570
	Traditional didactic	36	3.1500	.68348	.11391	2.9187	3.3813
	Total	72	3.1528	.63645	.07501	3.0032	3.3023

effects on challenge and curiosity and insignificant effects on independent mastery for ludicization. Therefore, we maintained the hypothesis that ludicization exerted counterproductive effects on intrinsic motivation, especially on challenge and curiosity.

DISCUSSION

This section discussed the potential reasons for the limited or counterproductive effects of ludicization.

Potential Reasons for Potentially Counterproductive Effects of Ludicization

The first potential reason is that players would utilize the gamified systems deviating from the original intention. Individuals prefer motivating experiences and perform behaviors inconsistent with common senses in practice (Diefenbach & Müssig, 2019). Game developers combine game-related mechanics, dynamics, and aesthetics into game-related experiences (Hunicke, LeBlanc, Zubek, 2004). In most cases, players could not directly apply the prototype behaviors or strategies to playful experiences to practical contexts. That gap would produce undesired side effects on players' unintended or undesired behaviors (Diefenbach & Müssig, 2019).

The second potential reason is the simplification of game-related experiences. The simulated models in game-related environments are often less complex than real-world situations (Knaving & Björk, 2013). Simplification of the real-world activities might allow players to excessively interpret the given gamified models and overlook the phenomena that could not appear in reality (Diefenbach & Müssig, 2019). Admittedly, players excessively engaged in gamified experiments tend to concentrate on the simplified model emphasizing points (Knaving & Björk, 2013). Excessive orientation to points might negatively influence participants' self-efficacy in the main activities (Knaving & Björk, 2013).

The third potential reason is the unbalanced relation between rewards and intention. Undifferentiated uses of rewards, such as points and badges, discourage players from considering whether these rewards are appropriate or acceptable in the given circumstances (Rapp, 2017). Ideally, designers would provide subjective ontologies of rewards worth pursuing (Rapp, 2017). Points or badges are only the components of game-related designs rather than a comprehensive representation of the complete designs (Diefenfach & Müssig, 2019). However, some players might excessively emphasize points or badges with the reward-orientation attitude to perform behaviors (Zichermann & Cunningham, 2011).

Overall, ludicization experiences would exert effects inconsistent with the original objectives of the desired behaviors. Misuse of gamified mechanics, excessively simplified designs, addiction to extrinsic stimuli might lead to the potentially counterproductive effects of ludicization.

Potential Reasons for Limited Effects of Ludicization on Intrinsic Motivation

The first potential reason is the distracting process of "gaming the system". "Gaming the system" refers to the action of taking advantage of game-related mechanics to achieve goals regardless of original intentions in behavioral changes or progress (Diefenfach & Müssig, 2019). If players excessively depend on "gaming the system" actions, ludicization experiences distract them from achieving the initial motivating progress or behavioral changes to reaching the superficial goals (Diefenfach & Müssig, 2019). Some individuals even prefer to take undermining actions because these actions can bring them intrinsic satisfaction and free them from control (Diefenfach & Müssig, 2019).

The second potential reason is the overdependence on extrinsic stimuli. Individual preferences for extrinsic and intrinsic motivations might influence participants' usage behaviors and preferences in gamified experiences (Diefenfach & Müssig, 2019). Game-related designs involve rewards to promote participants' behaviors in the target activities and avoid confusing reproduction with duplication of playful experiences (Rapp, 2017). However, excessive extrinsic motivation would negatively influence intrinsic motivation (Deci, Koestner, Ryan, & Cameron, 2001). Overdependence on extrinsic rewards might diminish or even undermine the influence of intrinsic motivation in the playful experiences, i.e.,

participants' intrinsic orientation to perform corresponding behaviors (Deci et al., 2001; Diefenfach & Müssig, 2019). In worse cases, participants would addictively engage themselves in the reward loop to keep their intentions to perform behaviors (Zichermann & Cunningham, 2011).

The third reason is the relatively low controllability of intrinsic motivation. Intrinsic motivation reflects individuals' spontaneous satisfaction, while extrinsic motivation could be associated with separable outcomes from the activities (Ryan & Deci, 2000). Individuals' competence and autonomy, the factors conducive to intrinsic motivation (Ryan & Deci, 2000), are the relatively abstract dimensions that require further quantified assessments subject to external factors, e.g., circumstances or pressure. By contrast, individuals' relatedness needs, as the factors conducive to their extrinsic motivation (Kim et al., 2018; Ryan & Deci, 2000). Since educators could use rewards or punishments as the controllable signals to promote learners' relatedness needs conducive to extrinsic motivation (Kim et al., 2018; Ryan & Deci, 2000), they could attempt to simultaneously promote individuals' extrinsic and intrinsic motivation (Asigigan & Samur, 2021; Kim et al., 2018).

Overall, "gaming the system" actions, overdependence on external stimuli, and relatively low controllability of intrinsic motivation would lead to potential counterproductive effects of ludicization on intrinsic motivation. These factors might distract players from achieving intrinsic motivation through progress or behavioral changes in practice.

CONCLUSION

This section presented the summary, implications, and insights of the findings.

Major Findings

H1 focused on the effects of ludicization on learning achievement. ANCOVA demonstrated that the effects of the ludicization and traditional didactic pedagogies were insignificantly different ($p = .409 > .05$) (see Table 2). Compared with the control group ($N = 36$, $M = 63.937$, $SD = .865$), ludicization showed adverse effects on posttest scores ($N = 36$, $M = 62.910$, $SD = .865$) (see Table 3). Therefore, we maintained the hypothesis that ludicization showed counterproductive effects on learning achievement compared with the effects of the traditional didactic pedagogy.

H2 concentrated on the effects of ludicization on intrinsic motivation. The questionnaire data satisfied the demand of Cronbach α value > 7.00. The factor analysis demonstrated that data provided a valid evaluation of challenge and curiosity ("Challenge_and_Curiosity") and independent mastery ("Independent_mastery") as the intrinsic motivation-related subscales (see Table 1). ANOVA demonstrated that ludicization had an overall insignificant enhancement on "Challenge_and_Curiosity" and "Independent_mastery" due to the significant levels > .05 of .695 and .971, respectively (see Table 4). The descriptive information revealed the adverse effects of ludicization on challenge and curiosity and its insignificant impacts on independent mastery (see Table 5). Therefore, we maintained the hypothesis that ludicization showed counterproductive effects on intrinsic motivation, especially on challenge and curiosity.

Implications of the Current Findings

Based on the tested hypotheses and discussed contents in the current study, we arrived at the main conclusion that ludicization exerted potentially counterproductive effects on learning achievement and intrinsic motivation. We summarized the implications of the findings at the theoretical and practical levels as follows.

At the theoretical level, the current study demonstrated that ludicization as a game-related pedagogy would adversely influence learning achievement and intrinsic motivation. Thus, game-related pedagogies should not be directly hypothesized as the necessarily promising pedagogy. The current study could provide the potential dimensions that might demonstrate the counterproductive effects of game-related pedagogies. Additionally, this study also presented the theoretical association

between learning achievement and intrinsic motivation. Future designs on the education model could be concerned with the relation between these concepts.

At the practical level, the current findings reflected that ludicization as a game-related pedagogy would not necessarily positively affect pedagogical practice. Educators would not employ any pedagogy without considering the potential drawbacks or side effects. Although game-related pedagogies involving vivid presentations of information could stimulate learners' interest in achieving goals, we should still consider the whether the positive effects would be stable in the corresponding contexts where learners would raise various needs. Admittedly, although the experiment in the current study demonstrated the counterproductive effects of ludicization, we would not deny the contributive power and overall efficiency of game-related pedagogies. If implemented appropriately to maximize the efficiency, these pedagogies still have bright prospect in the education area.

Limitations of This Study and Insights for Future Research

The first limitation of this study was the domain design. We concentrated on statistical analyses on learning achievement and intrinsic motivation. For comprehensiveness, we could conduct qualitative research, e.g., interview and content analyses. A combination of quantitative and qualitative research can report more accurate results based on statistical findings and participants' feedback.

Considering the coverage of participants, we focused on senior students and investigated their learning achievement and intrinsic motivation. For more persuasiveness, we could extend the coverage of participants to groups of pupils, junior high students, senior high students, postgraduates, or doctors.

These points provided the following insights for future research. Future research could involve combining quantitative and qualitative research about the correlation between learning achievement and intrinsic motivation. Future research could also involve participant groups in two or three of the following grades: pupils, junior high students, senior high students, graduates, postgraduates, or doctors.

CONFLICT OF INTEREST

We have no conflicts of interest to declare that are relevant to the content of this article.

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AUTHORS' CONTRIBUTIONS

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