

# The Means of an End: Applying the Peak-end Theory to Game-based Learning Design

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**Abstract:** This study investigates the influence of the Peak-End Theory on motivation and experience in game-based learning (GBL), focusing specifically on the role of the game's ending. Drawing on Kahneman et al.'s (1993) psychological model, which posits that people evaluate past experiences primarily based on the most intense moment (peak) and the final moment (end), we conducted an A/B test using a game titled Complex Space Adventure, designed to teach complex numbers in STEM education. Two versions were developed: one with a minimal, abrupt ending (control group) and another with a narratively enriched farewell sequence (experimental group). A total of 39 participants completed one version of the game and the Reversed Instructional Materials Motivation Survey (RIMMS) and four subscales of the Game Experience Questionnaire (GEQ). Results revealed statistically significant and medium to large effect sizes in favor of the version with the enhanced ending across all ARCS dimensions (Attention, Relevance, Confidence, Satisfaction) and the used GEQ subscales (Competence, Flow, Positive Affect, Negative Affect). Notably, the ending had no measurable impact on gameplay mechanics or content delivery, suggesting that the observed differences stem from retrospective memory evaluation rather than actual learning or engagement. These findings strongly support the applicability of the Peak-End Theory in serious game design, demonstrating that even a brief, narrative-driven conclusion can significantly shape learners' perceptions of relevance, confidence, and overall satisfaction. The study underscores the importance of intentional design of game endings, not merely as closure, but as a strategic tool to enhance motivation, foster self-efficacy, and promote future engagement.

**Keywords:** Game-based learning, Serious games, Peak-end theory, Motivation, Game experience

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## 1. Introduction

The Peak-End Theory is a psychological model proposed by Kahneman et al. (1993) that describes how people evaluate past experiences, focusing on the most intense moment (Peak) and the final moment (End) rather than the average of the entire experience. Initially studied in medical contexts, the principle extends beyond medicine, e.g. in media studies. Recently, video game related studies such as those by Martins et al. (2023) and Piton et al. (2020) found that players remember emotional peaks and endings more vividly, influencing overall satisfaction and their likelihood to replay the game. These findings suggest the potential application of the Peak-End Theory in various fields, including game design and customer satisfaction, to improve user experiences. While game-based learning content is often assumed to be inherently motivating and studies also see positive effects, the Peak-End Theory is not commonly considered for educational / serious game design and development. To explore its usage and relevance we conducted an A/B study using a game prototype on the STEM topic of "complex numbers" focusing on the "End" of the "Peak-End Theory". We created two versions of the game – one with an abrupt end (control group) and the other one with a narrative and audio-visual extended ending. The study involved 51 individuals, 39 of them completing one of the versions of the game. All participants completed the Reversed Instructional Materials Motivation Survey (RIMMS) as well as four subscales of the Game Experience Questionnaire (GEQ) (Flow, Competence, Positive Affect and Negative Affect). Somewhat to our surprise, the differences between groups were significant, often highly. Since both versions were identical, except for the ending, the differences support the Peak-End Theory and should be heeded in Serious Game / GBL development.

## 2. Core Concepts and Literature Review

The core question of this research is whether the design of an ending scene can influence the player's perception and motivation. Thus, we introduce relevant literature on the Peak-End Theory before turning to key concepts of motivation and their measurement.

### 2.1 Peak-end Theory and Gestalt Characteristics

The Peak-End Theory is a psychological model that explains how people evaluate past experiences. According to Kahneman et al. (1993), memories of an event are shaped not only by the overall average of the experience but particularly by the most intense moment (peak) and the end. The peak and end moments are considered important characteristics of the gestalt of an experience that influence its evaluation and shape decisions related to it (Ariely & Carmon, 2000). Do et al. (2008) found that moviegoers rated films more positively if they ended with a particularly strong scene, regardless of the film's overall quality. In video games, the Peak-End Theory also shows potential. While few studies directly link this theory to game-based learning, research in commercial games supports the theory. For instance, Martins et al. (2023) analyzed impressions and emotional highlights in narrative games, finding that emotional moments, turning points, and the game's end are most memorable and influence the overall game evaluation. Piton et al. (2020) explored the Peak-End effect in the digital card game *Hearthstone*, noting that memories of the game were influenced more by emotional moments and the end than by the entire gameplay duration. Similarly, Gutwin et al. (2016) reported that casual games with deliberate peaks and endings were perceived as more enjoyable and encouraged replay.

These studies suggest that the Peak-End effect is present in digital games. Related to game-based learning, this means that specific peaks and conclusions can influence gaming experience — and possibly also learning motivation. As research in educational contexts is limited, this paper aims to investigate the influence of game endings on motivation in game-based learning.

### 2.2 Motivation

Motivation is a key factor in successful learning, yet it is a complex and context-dependent concept (Redondo & Martin, 2015). In education, motivation is crucial for engaging learners with content (Espinar Redondo & Ortega Martín, 2015). Psychological research distinguishes between intrinsic motivation, driven by personal interest and satisfaction, and extrinsic motivation, which is driven by external rewards like grades or recognition (Ryan & Deci, 2000:55). The Self-Determination Theory (SDT) by Ryan and Deci (2000) elaborates —as a meta-theory of motivation— on this by identifying three essential psychological needs: autonomy, competence, and relatedness (Ryan & Deci, 2000:68). Fulfilling these needs enhances intrinsic motivation, leading to better performance and persistence.

In digital learning design, the question is not just if learners are motivated, but how. Digital learning games can enhance motivation by promoting engagement within a supportive digital environment (Liu & Kang, 2014).

A well-designed game can trigger intrinsic interest by addressing all three SDT needs. Adaptive game mechanics, tailored to individual competencies and motivational states, are particularly effective (Mattheiss et al., 2009).

This research focuses on the influence of the Peak-End concept on player / learner perception of the game as well as motivation. As described above motivation can be influenced by catering to SDT needs as well as designing a learning game with state-of-the-art considerations in mind. Before describing our method and experimental setup we must consider both the relationship of game experience as well as the ARCS model to motivation.

#### 2.2.1 Game experience and flow

While SDT's "relatedness" is an important part of its motivation construct we did not include it into this study due to the fact, that we wanted to reduce confounding elements introduced by the highly individualized nature of multiplayer interactions. Instead we focused on the autonomy and competence constructs of SDT. Both are essential aspects of any game experience and thus competence is a core module of the Game Experience Question (GEQ). Although autonomy is not a core module in the GEQ, it can be considered part of the FLOW module, which encompasses both autonomy and competence. The flow concept describes a special cognitive state that is a result of an interaction in which the user's skill and the task requirements / challenge positively correlate (Csikszentmihalyi, 2013). To enter the "flow channel" Salen & Zimmermann (2004) describe a prerequisite: the feeling of being in control in an uncertain situation which goes hand in hand with a feeling of

autonomy – e.g. in e-learning “student autonomy lies in the influence of student flow experience” was found to be highly significant in a study of Yang et al. (2025).

### **2.2.2 ARCS model**

Keller’s ARCS Model (1987) provides a practical framework for designing motivating learning environments by focusing on four key components: Attention, Relevance, Confidence, and Satisfaction. These components address specific aspects that should be considered to effectively enhance motivation during the learning process. Attention involves capturing learners’ interest through novel or interactive elements, such as visual stimuli, storytelling, or challenges (Keller, 1987:3). Relevance refers to making the learning material pertinent to the learners’ personal situations, which can be achieved through real-world applications, career-related content, or familiar subjects. The greater the perceived relevance, the higher the willingness to engage with the content (Keller, 1987:4). Confidence is built by ensuring learners believe in their ability to succeed through clearly defined objectives, structured tasks of increasing difficulty, and effective feedback systems (Keller, 1987:5; Song & Keller, 2001:10). Satisfaction enhances motivation by ensuring that the learning process feels rewarding. This can be achieved through game rewards, application of learned concepts, or personal achievements. Satisfaction can be driven by extrinsic rewards like praise or points, as well as intrinsic accomplishments (Keller, 2000:5).

Studies indicate that the ARCS Model effectively addresses both extrinsic and intrinsic motivation. External incentives like points and feedback, as well as internal factors such as interest and the sense of achievement, can motivate learners (Song & Keller, 2001:5). Research by Kaneko et al. (2015) demonstrated that learning games developed with the ARCS Model in mind enhance factors like curiosity, clarity of goals, and engagement. Their study showed that students using ARCS-based games reported higher levels of interest and satisfaction than those using traditional materials (Kaneko et al., 2015:404).

Several studies confirm that ARCS not only fosters motivation but also leads to improved learning outcomes. It serves as an effective bridge between motivational theory and educational game design, making it particularly relevant for interactive educational formats like Complex Space Adventure.

## **3. Methodology**

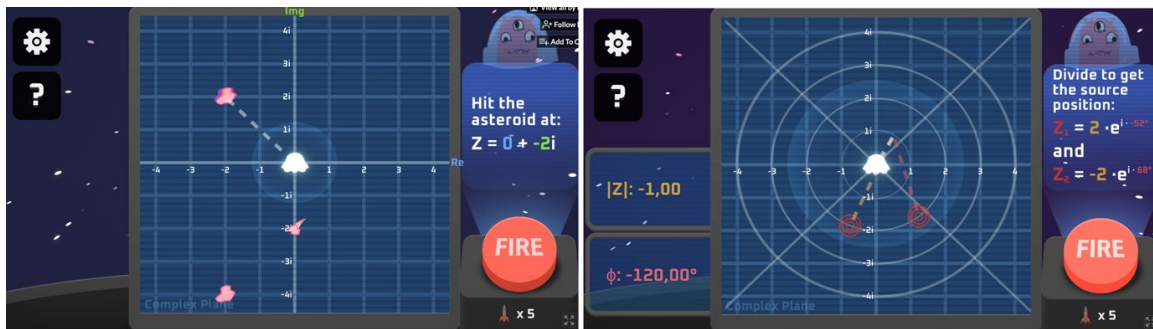
The core idea of this research was to explore the Peak-End Theory and its application to game-based learning and serious games design in relation to its influence on motivation and the perception of the experience. To test the influence of either the “peak” or the “end” we needed two versions of a game that differed only in these aspects to be able to reduce confounding influences. We thus focused on “Complex Space Adventure” (CSA) — a game-based learning prototype designed to teach the STEM topic of complex numbers. The prototype was developed at HTW Berlin in the projects “German International University of Applied Sciences” and “German International University 2024-26” funded by the Federal Ministry of Research, Technology and Space (BMFTR) via the German Academic Exchange Service (DAAD) to foster innovative digital learning approaches in the cooperation of the partner universities.

### **3.1 Complex Numbers and the Complex Space Adventure Game**

Complex numbers extend the real number system and provide a framework for solving a wide range of problems across the STEM fields. They enable experts to model and tackle phenomena that would be otherwise impossible or cumbersome using only real numbers, thus serving as a fundamental tool in both theoretical and applied contexts. The most basic reason is that complex numbers allow for the solution of equations that have no REAL solutions, such as  $x^2 = -1$ . Transferring these problems into an imaginary realm enables inter alia elegant solutions and insights into geometric problems, particularly through complex plane representations and transformations. They are essential for the design and analysis of electrical circuits and are used in control systems and signal processing. Many control systems employ transfer functions and state-space models that involve complex numbers to analyze the stability and performance of systems. Thus, we identified complex numbers as a foundational building block for STEM competencies especially in the engineering faculties.

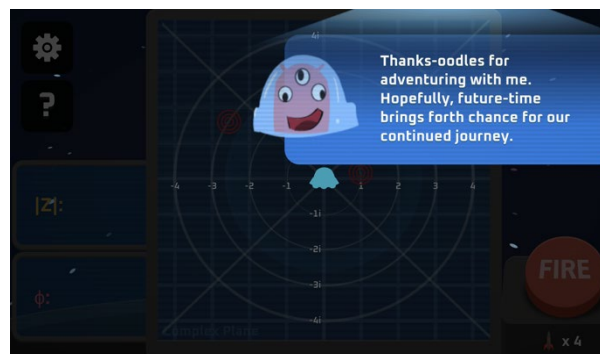
CSA was developed in an iterative design-based research process using the Unity game engine. It aims to introduce players to the world of imaginary numbers — the part that makes complex numbers “complex” in the first place. In the game, players accompany the alien Bozee on a journey through three planetary systems, each containing 4 to 6 levels. Altogether, the original version comprises 16 playable levels that build on one another step by step and address clearly defined learning objectives. Each level involves, as its core game

mechanic, determining and entering coordinates with Bozee to accurately shoot asteroids in different number / coordinate systems to safely guide the ship during its exploration.



**Figure 1: Core mechanic of Complex Space Adventure, drag target marker (left), later entering coordinates (right)**

In the base version of Complex Space Adventure, the game ends immediately after completing the final mission: Bozee briefly comments in two sentences, that this was the last asteroid and the journey is thus over. Without further narrative integration, players are returned to the level selection screen. The original goal of this approach was to enable students to replay the game and thus exercise the concepts. The game supports this by using randomly generated mathematical values for the tasks of each level. In heuristic evaluations as well as beta tests with students this ending did not appear particularly satisfying. It signals completion but fails to provide a meaningful emotional peak or a sense of reward for their achievement.



**Figure 2: Ending scene of group with “standard ending”**

### 3.2 Adapting the Complex Space Adventure Game

To expand on this and test the “end”-part of the Peak-End Theory we thus developed a second version of the game, extending the ending with a deliberately staged farewell scene (see Fig. 2): Immediately after the final shot, the mission display fades out, and Bozee begins expressing triumph and gratitude toward the players. He then presents a virtual medal as colorful confetti fills the screen. In a short speech, Bozee reflects on the journey they shared and thanks the players for their help. He bids farewell and finally flies away in his UFO. Only after this sequence concludes does the game automatically return to the main menu. This sequence of visual rewards, heightened emotional engagement, and a concluding farewell is intended to create a sense of narrative “closure,” leaving a lasting positive impression. This enhancement is designed to make the finale feel less like an abrupt cutoff and more like the crowning conclusion of a hero’s journey. In contrast to the base ending, which simply closes the final level, the extended ending —while being a comparatively small change to the overall game— provides a coherent narrative conclusion and brings the learning journey to a satisfying close.

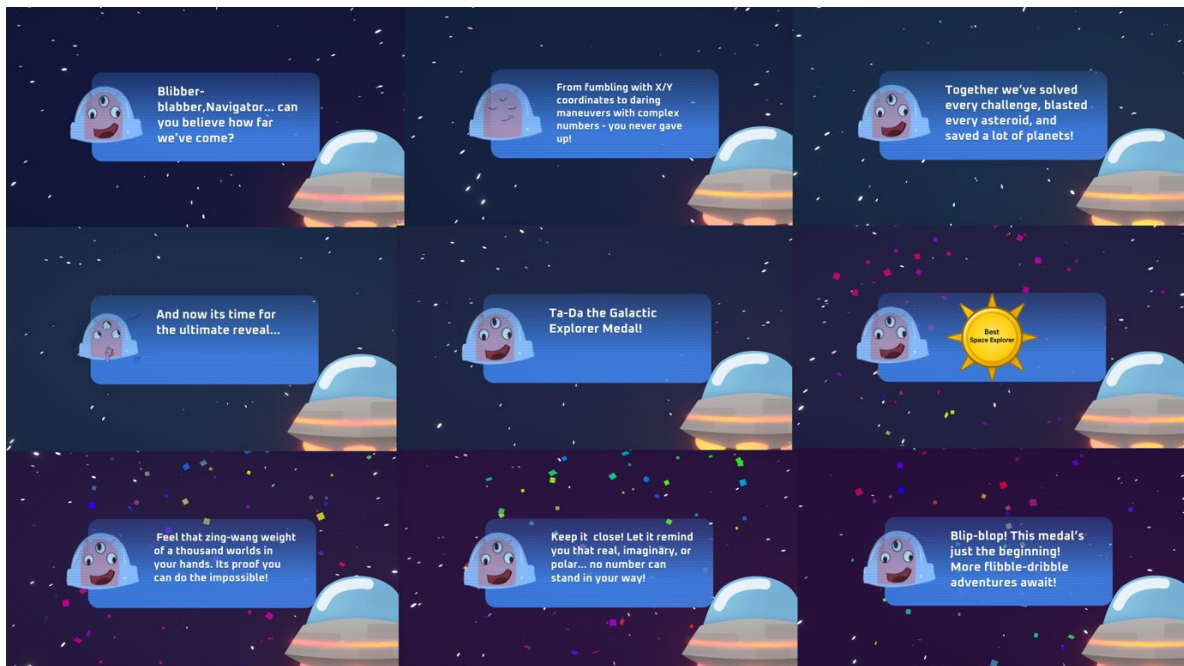


Figure 3: Ending scenes (12 of 14) of experimental group “with extended ending”

### 3.3 Experimental Setup

Due to the fact that we had the original version of the game and the “extended” one we were able to conduct an A/B test using a between subjects design. For data collection, identical questionnaires were created, differing only in the link to each game version. One questionnaire contained a link to the base version of the game, while the other linked to the modified final version. Both questionnaires contained the same assessment tools and were randomly distributed to participants.

Each questionnaire was divided into three main sections. Demographic information was collected through questions about gender, age, and educational background. If applicable, the field of study was also requested to characterize the sample as this might provide further information on the familiarity with general math concepts. Additionally, a question about gaming behavior was included: “Did you play the game to the end?”. This is crucial as the influence of the ending can only be examined with a complete gaming experience and was thus intended and used as an exclusion criteria. Thus, the overall number of users was reduced from 51 to 39 – 7 users from the with extended-ending (EE) and 5 users of the base-ending (BE) sample had to be excluded resulting to 19 EE-players and 20 BE-players.

To assess learning motivation and subjective gaming experience, two standardized instruments specifically developed for studying learning and gaming contexts were used.

The Reversed Instructional Materials Motivation Survey (RIMMS) is a condensed and validated version of Keller’s original Instructional Materials Motivation Survey (IMMS) and directly aligns with the ARCS Model described above. While the original IMMS includes 36 items, the RIMMS selects three items per dimension to provide a shorter and more efficient measurement of the four motivational factors: Attention, Relevance, Confidence, and Satisfaction (Loorbach et al., 2015:209).

To complement motivation assessment, four key subscales of the Game Experience Questionnaire (GEQ) Core Module were used: Flow, Competence, Positive Affect, and Negative Affect. These dimensions were selected due to their relevance to game satisfaction and intrinsic motivation, allowing for a nuanced examination of the gaming experience (Brockmyer et al., 2009). The Flow factor captures the experience of immersion and optimal challenge, while Competence measures the sense of competence and self-efficacy. Positive and Negative Affect reflect the emotional responses to the gaming experience. The decision to focus on these four subscales instead of the complete GEQ helped to keep the overall length of the questionnaire concise thereby increasing the probability of completed questionnaires in a non-lab setting.

All items were rated on a five-point Likert scale from 1 (totally disagree) to 5 (totally agree).

While it is not uncommon for studies to use t-tests on Likert scale data we opted for a more conservative interpretation in the sense that these scales should be considered ordinal not interval-level data. Thus, we used Mann-Whitney U test in addition to descriptive statistics.

All tests and calculations have been done in GNU PSPP version 2.0.1. However, this version does not compute one-sided significance (p) levels for the Mann-Whitney U test. Therefore, these values were calculated using Mac Numbers version 14.5 (7045.0.17) by halving the asymptotic significance levels, in accordance with standard statistical practice.

#### 4. Results

Somewhat contrary to our expectations, the results are pretty clear-cut. As shown in Table 1. averages are higher for participants in Group 1 (with ending, N=19) for all dimensions of ARCS and almost all of the used GEQ core modules. The only exception is the GEQ core “Negative Affect” dimension that has the biggest difference of all – but in a positive direction. Since the items in this dimension ask the user for agreement to statements about negative feelings this is actually good as it means that the participants who experienced the ending agreed less to negative statements (e.g. “It gave me a bad mood.”) than those in the control group.

All Mann-Whitney U tests revealed that the differences were significant for the ARCS dimensions ( $p < 0.05$ ) and highly significant for GEQ modules ( $p < 0.01$ ). Given the assumed direction of the influence (ending implies better scores) the one-sided p-values have been derived by halving the computed asymptotic p-values.

Calculated effect sizes are of medium strength for ARCS and GEQ Competence ( $0.3 < x \leq 0.5$ ) and high strength for GEQ Flow and the Affect dimensions ( $x > 0.5$ ).

**Table 1: ARCS & GEQ results, significance marked with \*, highly significant with \*\***

| ARCS            | Ending? | $\bar{x}$ | $\Delta\bar{x}$ | SD   | Median | $\Delta M$ | MWU 1-sided p | MWU Z-Value | Effect Size |
|-----------------|---------|-----------|-----------------|------|--------|------------|---------------|-------------|-------------|
| Attention       | 0       | 3.37      |                 | .66  | 3.50   |            |               |             |             |
|                 | 1       | 3.84      | .47             | .46  | 3.67   | 0.17       | .015*         | -2.18       | .35         |
| Relevance       | 0       | 2.95      |                 | .79  | 3.00   |            |               |             |             |
|                 | 1       | 3.54      | .59             | .54  | 3.33   | 0.33       | .010*         | -2.35       | .38         |
| Confidence      | 0       | 3.18      |                 | .86  | 3.17   |            |               |             |             |
|                 | 1       | 3.82      | .64             | .73  | 3.67   | 0.50       | .016*         | -2.15       | .34         |
| Satisfaction    | 0       | 3.12      |                 | 1.07 | 3.00   |            |               |             |             |
|                 | 1       | 3.77      | .65             | .73  | 4.00   | 1.00       | .019*         | -2.07       | .33         |
| GEQ             |         |           |                 |      |        |            |               |             |             |
| Competence      | 0       | 2.79      |                 | .77  | 2.70   |            |               |             |             |
|                 | 1       | 3.55      | .76             | .95  | 3.60   | 0.90       | .006**        | -2.55       | .41         |
| Flow            | 0       | 2.69      |                 | .48  | 2.60   |            |               |             |             |
|                 | 1       | 3.43      | .74             | .86  | 3.40   | 0.80       | .000**        | -3.53       | .57         |
| Positive Affect | 0       | 2.91      |                 | .64  | 2.80   |            |               |             |             |
|                 | 1       | 3.74      | .83             | .75  | 3.80   | 1.00       | .000**        | -3.68       | .59         |
| Negative Affect | 0       | 2.91      |                 | .35  | 3.00   |            |               |             |             |
|                 | 1       | 1.96      | -.95            | .63  | 2.00   | -1.00      | .000**        | -4.42       | .71         |

While it can generally be assumed that the aggregated values are more stable and informative we wish to discuss some of the individual items. Therefore, we present a selection of questionnaire items with their respective Mann-WhitneyU test p-values, Z-values and the calculated effect size in Table 2.

## 5. Discussion

As shown in Table 1, the results are in agreement with the predictions of the Peak-End Theory — but to a surprisingly clear and strong degree. Participants who experienced the exact same learning medium as the control group, but with an attached short ending scene evaluated the experience as more relevant and satisfactory. They rated the way and variety of the information provided more positively in terms of supporting their focus of attention and feeling more competent. Group 1 participants (extended ending) had a highly significant better view of the experience with a large effect size. The same pattern was observed for the reported level of flow and negative/positive affect. The treatment received by both groups was nearly identical, differing only in the described short ending scene. While some of the differences might actually be “real” in the sense that the ending is part of the experience we do not believe that participants did have a better / higher flow or that the content was more relevant to Group 1. The ending is so brief and lacks typical prerequisites for flow — as a challenging activity fitting the competence level, feeling of control in an uncertain situation, etc — that it is rather unlikely that the reported results stem from the experience itself. Instead we argue that the results demonstrate that — as predicted by the Peak-End Theory — users remembered the experience more positively than it actually was. A further indicator of this is that the ending is primarily “story-based”, yet the difference in “The quality of the writing helped to hold my attention” was not significant and would have been weak (see Table 2).

**Table 2: selected ARCS & GEQ item results, significance marked with \*, highly significant with \*\***

| Selected ARCS & GEQ items                                                                              | MWU 1-sided p | MWU Z-Value | Effect Size |
|--------------------------------------------------------------------------------------------------------|---------------|-------------|-------------|
| The quality of the writing helped to hold my attention                                                 | .203          | -.83        | .133        |
| The way the information is arranged helped keep my attention.                                          | .012*         | -2.27       | .363        |
| The variety of game scenes, exercises, illustrations, etc., helped keep my attention on the game.      | .018*         | -2.10       | .336        |
| It is clear to me how the content of this game is related to things I already know.                    | .012*         | -2.26       | .362        |
| The content and style of writing in this game convey the impression that its content is worth knowing. | .012*         | -2.28       | .365        |
| The content of this game will be useful to me.                                                         | .154          | -1.02       | .163        |
| As I played this game, I was confident that I could learn the content.                                 | .047*         | -1.67       | .267        |
| After playing this game for a while, I was confident that I would be able to pass a test on it.        | .016*         | -2.16       | .346        |
| The good organization of the game content helped me be confident that I would learn this material.     | .034*         | -1.83       | .293        |
| I enjoyed this game so much that I would like to know more about this topic.                           | .033*         | -1.84       | .295        |

## 6. Limitation of the Study and Future Work

While the observed effects are stronger than anticipated, the study certainly has its limitations. The number of participants (N=51) after applying exclusion criteria is not huge (N=39). The participants were not randomly sampled (only their assignment to one of the groups was), so the results are certainly not representative. Although data on age and demographics were collected the spread is too wide and the number of participants too small to actually conduct a meaningful of whether factors such as age, study program, highest degree, etc might mediate or confound the results. We aim to conduct a follow-up study with international students and students of a specific academic programm to increase the overall number as well as look for mediating

influences. Additionally it would be worthwhile to include item batteries measuring (content-specific) self-efficacy to assess whether there is a substantial influence as argued in the discussion. A further direction for future work would be to test a game that focuses on repeated use and see whether adding specific session endings has the same influence on players and whether this increases the likelihood of repeated engagement (as can be argued by / with the ARCS model). Another approach could involve using the the same game to investigate the “peak” component of the Peak-End Theory.

## 7. Conclusion

While it is of interest to observe the predictive power of the Peak-End Theory in itself, one may question the practical value of this. Creating a satisfying ending that “modulates” the user’s memory is certainly an intriguing academic exercise but does it hold relevance for serious games / game-based learning design? Is it meaningful for a one-play-through game to consider player’s retrospective feelings? Should we care about learner motivation after the game has ended? We argue: Yes! We create games that impact learners with experiences that influence future experiences —echoing Dewey’s (1986) notion of experiential learning— and may contribute to their worldview, and most importantly their self-perception. This, in turn, has a direct influence on personality development, as highlighted by self-efficacy theory (Bandura, 1997; Kholifah et al., 2025). If the ending leads players to view the content as more worth to know ( $p < 0,05$ ; medium Effect Size), to feel more confident in their ability to learn the content ( $p < 0,05$ ; nearly medium ES) and would like to know more about the topic ( $p < 0,05$ ; almost medium ES) this has the potential to alter the learner’s trajectory. If a simple ending alone reduces negative and increases positive feelings toward an experience it can foster the drive to engage in similar experiences (Ariely & Carmon, 2000). Therefore, every (serious) game developer should place special emphasis on the design of their game’s ending.

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**Ethics Declaration:** This study was conducted in accordance with the ethical guidelines for educational research. Participation was voluntary, and all participants were informed about the purpose of the research, their rights, and the procedures involved. Their responses were treated confidentially, stored securely, and used solely for research purposes in accordance with applicable data protection regulations.

**AI Declaration:** Artificial intelligence tools (specifically ChatGPT 4.0 by OpenAI) were used to support the preparation of this paper. AI assistance was employed for translation and improving language clarity as well as shortening text to fit the paper guidelines and formalizing style. All intellectual contributions, research design, data interpretation, and final decisions were made by the authors.

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