

Chapter 4

Microcosmos 3.0. Students' Perception in Gamified-Mixed Mobile Learning Experience



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Abstract This paper explores the effectiveness of gamified mixed mobile learning experiences in natural science education, specifically focusing on the use of the Microcosmos 3.0 interactive resource. The study uses a quantitative exploratory approach, including interviews with gamification experts and surveys with secondary school students. The results show that Microcosmos 3.0 incorporates gamification elements such as levels, challenges, rewards, feedback, and randomness; so that students perceive these elements as useful and entertaining. The study found that the majority of students found the resource to be of intermediate difficulty and useful in reinforcing classroom content. The article also discusses the mechanics and dynamics of the gamified experience, including rewards and feedback, progression, and non-linear narrative. Overall, the study suggests that gamification and mobile learning can be effective tools for enhancing science education by enhancing accessibility, flexibility, and personalization of learning while maintaining meaningful interaction in the classroom. The findings of this study have important implications for educators and instructional designers who seek to enhance the learning experience of students in natural science education.

Keywords Perception · Students · Experience · Mobile learning · Gamification

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4.1 Introduction

This study explores the use of gamification in the context of mixed mobile learning, which combines the benefits of mobile learning with the engagement and motivation of gamification. The study focuses on the use of the Microcosmos 3.0 interactive resource, which incorporates gamification elements such as levels, challenges, rewards, feedback, and randomness.

The use of gamification in education has gained increasing attention in recent years, as it has been shown to enhance student engagement, motivation, and learning outcomes. However, there is still a lack of scientific literature specifically linking gamification within the context of mixed mobile learning. This study aims to fill this gap by conducting an exploratory scope study to investigate the effectiveness of gamified mixed mobile learning experiences in natural science education. The study was conducted in Ecuador, where the Microcosmos 3.0 interactive resource was used to teach natural science to high school students. The study employed a mixed-methods approach, combining qualitative and quantitative data collection methods to provide a comprehensive understanding of the effectiveness of the gamified learning experience.

The study also involved interviews with gamification experts from different universities to gain insights into the design and implementation of gamification in education. The findings of this study have important implications for educators and instructional designers seeking to enhance the learning experience of students in natural science education. The study provides valuable insights into the effectiveness of gamification in hybrid mobile-based learning and its potential to improve student engagement and learning outcomes.

4.1.1 *Mixed Mobile Learning and Gamification*

Mixed mobile learning is a learning modality that combines mobile technology and face-to-face education (Castro et al., 2016). In this approach, students utilize mobile devices such as smartphones or tablets to access learning materials and online resources while also attending physical classes. Students can leverage their mobile devices to access multimedia content, such as videos and presentations, or to complete interactive activities and online assessments.

In other words, the objective of mixed mobile learning is to integrate classroom interaction with online learning to maximize student learning and comprehension (Grund et al., 2017). By utilizing mobile devices, students can access online learning resources beyond the classroom, allowing them to work at their own pace and in a more autonomous manner. This can also facilitate students in delving deeper into topics and better preparing for classroom discussions and activities (Elizondo et al., 2010).

Overall, mixed mobile learning is a learning modality that capitalizes on the advantages of mobile technology to enhance accessibility, flexibility, and personalization of learning while upholding significant classroom interaction (Engel & Coll, 2022). This learning modality can be particularly valuable in situations where online learning is a necessary or desirable complement to face-to-face instruction.

Valuing gamified mobile learning, the scientific literature highlights the development of different competencies developed, among which digital literacy toward information access, management and evaluation (Charinthorn & Kaiyasith, 2023), as well as the promotion of motivation, commitment, attention and apprehension of specific knowledge (Nien-Lin et al., 2023) (Natalia et al., 2023), and finally, it is also noted that learning involves particular issues such as teamwork, programming, time management, problem solving and creativity (Jaruwan & Panita, 2023).

When it comes to incorporating gamification into mixed mobile learning, it is crucial to initially comprehend that gamification entails the utilization of game elements in non-gaming contexts (Torres-Toukourmidis & Romero Rodríguez, 2018). Consequently, within the innovative configuration of mixed mobile learning, the inclusion of gamification could encompass the notion of entertainment, thereby enriching the teaching and learning process (Torres-Toukourmidis et al., 2018a).

In a broader exploration of these concepts, the initiative encompassed in this study aims to complement previously conducted research on teachers regarding their utilization in the field of natural sciences (Vallejo-Imbaquingo et al., 2022). This time, the focus would be directly on students' perception, evaluating the elements of gamification as an interactive resource in learning. From there, the following questions are established: can gamification be used in mobile learning? Can entertainment be combined with knowledge learning through mobile platforms?

4.2 Methodology

This research employs a quantitative, exploratory approach based on the use of expert interviews within the gamification field and surveys administered to high school students regarding the use of gamification in a case related to mixed mobile learning applied to Natural Sciences. Therefore, the general objective has been established as follows: to analyze the perception of high school students regarding the incorporation of gamification in the presented mixed mobile learning in Microcosmos 3.0. Two specific objectives were subsequently established: 1. to describe the gamification elements incorporated in Microcosmos 3.0 and 2 to examine the knowledge and entertainment produced in the experience presented by Microcosmos 3.0.

Given the lack of scientific literature specifically linking gamification within the context of mixed mobile learning (Lin & Lin, 2019) (Huang, 2022), an exploratory scope study was conducted. Such a study is defined as a process to investigate an unknown or under-researched phenomenon, aiming to identify new research areas or gain a deeper understanding of a problem or situation (Torres-Toukourmidis et al., 2018a). To proceed with the intervention, Microcosmos 3.0, a portable device with a

Fig. 4.1 Microcosmos 3.0 device application



10x, 20x, and 30 × magnification clip, was selected. This device serves the functionality of exploring nature and discovering new organisms that constitute the natural world (Hernández Sampieri et al., 2014). This initiative, originating from the Technical Secretariat of Entrepreneurship and Innovation of the Salesian Polytechnic University and the Scientific Dissemination Society Quinto Pilar, began in 2018 with the support of Coworking StartUPS. They were winners of the Innova 2019 contest in the “Creative Economy” category, gradually contributing to the educational process in the field of biological sciences. Since then, Microcosmos has evolved and is currently in its third version, where the incorporation of gamification has been formalized (Fig. 4.1).

To address the first specific objective, five in-depth interviews were conducted with gamification experts from the University of Chihuahua, Mexico; the University of Malaga, Spain; and the National University of Loja, Ecuador. Gamification experts were defined as academics with over five years of experience in the field of video games and educational technologies. The interviews consisted of five questions. The first two aimed to determine the presence of gamification in both the face-to-face and online experiences of Microcosmos 3.0. The remaining three questions focused on examining the respective components, mechanics, and ludic dynamics of the device (Torres-Toukourmidis et al., 2018b). The five interviews were conducted virtually between November 18 and January 25, 2022, and were systematized through open coding to understand the gamified characteristics of Microcosmos (Fig. 4.2).

To fulfill the second specific objective, eight questions were posed regarding the ludic characteristics of Microcosmos. The questions were subdivided into five Likert scale questions with four levels assessing utility and importance. Additionally, there was a query about obtaining “collectible cards,” a dichotomous question about the reward system, and finally, an open-ended question about personal experiences related to the ludic theme (Werbach & Hunter, 2015). These questions were administered to a sample of 57 secondary school students from La Asunción School in Cuenca, Ecuador, who were enrolled in the mandatory Natural Sciences course. It is worth noting that the survey’s reliability was assessed using Cronbach’s Alpha, resulting in a value of 0.71, indicating acceptable internal consistency and allowing

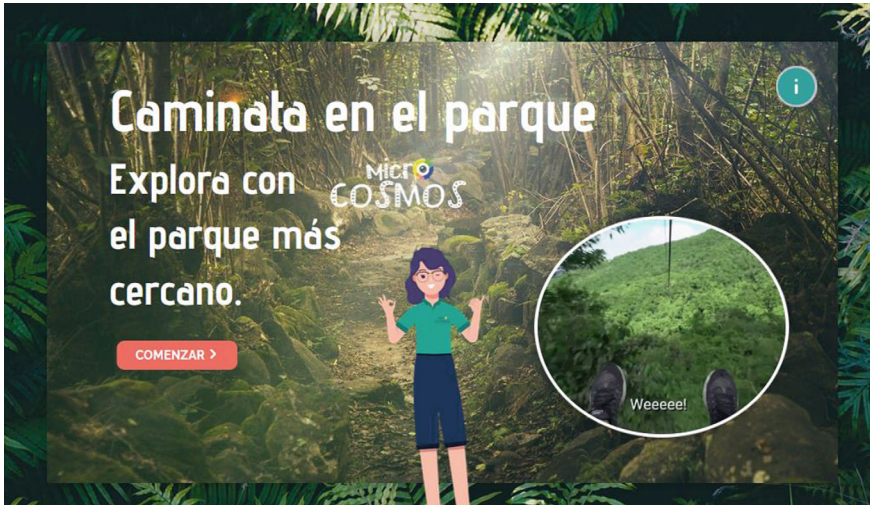


Fig. 4.2 Gamified virtual educational resource from Microcosmos 3.0

for its administration to a larger sample. The survey was conducted between February 10 and April 14, 2023, and the data were analyzed using SPSS software version 29.

4.3 Results

Organizing the expert assessment, for the first and second questions, all interviewees (100%) acknowledge the presence of ludic elements in both the virtual and in-person experiences of Microcosmos 3.0. Upon further examination, the following gamification elements are identified in the in-person experience of Microcosmos 3.0:

- **Components:** While there is not a multitude of components in Microcosmos 3.0, the presence of levels—beginner, intermediate, and advanced—is noteworthy (Fig. 4.3). These levels are embedded in challenges that allow for the improvement of skills and focus on using the device to enhance photography.
- **Mechanics:** The mechanics include challenges, rewards, feedback, and randomness. The challenge revolves around a macro-photography competition that motivates participants' creativity. For the beginner level, capturing photos of fabrics, skin, and spices is included, emphasizing the visualization of textures and surfaces. The intermediate level involves feathers, leaves, flowers, and the human eye, primarily exploring detailed aspects in photos. Lastly, the advanced level adds liquids, fruits, and insects, emphasizing the importance of lighting. In summary, the first challenge focuses on surfaces and textures, the second challenge centers on detailed shots, and the third challenge addresses lighting. Regarding rewards, upon

DESAFÍO



MICRO COSMOS

La fotografía macro requiere práctica, aprende con cada reto y disfruta de este viaje de descubrimiento. Toma fotografías con tu MicroCosmos, súbelas a Instagram con el #DesafíoMicroCosmos y etiquétanos en tus publicaciones e historias (@microcosmos_qp).

¿Cómo va tu desafío MicroCosmos? Recuerda publicar tus fotos en Instagram y etiquetarnos para compartir tus observaciones con nuestra comunidad. Continúa tu viaje, sé paciente y disfruta descubriendo tus habilidades.

PRINCIPIANTE

Tejidos
Para entender la 'visión' macro imagina que caminas con una lupa al utilizar MicroCosmos, verás texturas y colores sorprendentes en objetos cotidianos.

Piel
Explora observando con MicroCosmos desde diferentes ángulos. Comienza por aproximarte perpendicularmente a un objeto plano, así tendrás una mayor área de enfoque. Asegúrate de tener buena iluminación.

Especias
Observa superficies más complejas. Notarás que áreas y detalles pequeños pueden enfocarse y otras aparecen desenfocadas, juega con esta posibilidad para obtener imágenes impresionantes. Si es necesario iluminas.

Plumas
Identifica pequeños detalles que sólo pueden ser observados con MicroCosmos. Toma varias fotos probando el alejando y acercando tu lente al objeto, luego podrás elegir la mejor foto desde tu galería.

Hojas
Practica tu habilidad para enfocar áreas específicas de un objeto y captura imágenes de sus estructuras. Seguramente encontrarás pequeños

MEDIO

Flores
Ahora que ya puedes identificar objetos pequeños explora los contrastes de estos como el polen en las flores. Recuerda ser paciente y tomar varias fotografías.

Ojo Humano
Has adquirido varias habilidades utilizando MicroCosmos. Es hora de probar objetos en movimiento, pide la ayuda de un voluntario e intenta capturar los detalles de su ojo.

Líquidos
Un día lluvioso es la mejor oportunidad para explorar nuevos objetos. El reflejo en las gotas de agua o en diferentes líquidos y los colores de contraste en otras superficies te darán excelentes escenas.

Frutas
Ahora prueba la iluminación artificial. Utiliza objetos estáticos como frutas para iluminarlos de lado con una lámpara o linterna. Captura reflejos, sombras y estructuras que llamen tu atención.

Insectos
Puedes complementar una iluminación natural con luz artificial para obtener mejores imágenes. Pon en práctica todas tus habilidades tomando fotos de insectos en movimiento. Cuidalos y devuélvelos a su hábitat después de hacerlos una sesión fotográfica.

AVANZADO

¡Finalizaste el Desafío MicroCosmos? Escribe a microcosmos@quintopilar.com o a través de nuestras redes sociales para conocer cómo participar en nuestro taller de macro y microfotografía de manera virtual. ¡Felicidades, ¡Bienvenidx a la Comunidad Microcósmica!

Visítanos por acá para conocer más formas en las que puedes jugar con MicroCosmos.



Fig. 4.3 In-person challenges of Microcosmos 3.0

completing the challenges, participants are presented with an official membership in the “Microcosmic Community,” recognizing those who have successfully finished the challenges with a certificate of participation. The third mechanic of this experience, feedback, is observed through Instagram with the incorporation of the hashtag #DesafíoMicrocosmos in the challenge photo posts, allowing for direct interaction with users. The last identified mechanic is randomness,

where the Microcosmos 3.0 box, repurposed as a seedbed, contains three types of seeds—Godetia (*Clarkia amoena*), Calendula (*Calendula officinalis*), and Dahlia (Dahlia). Depending on the received box, different types of seeds are included, which can be examined with the device and later planted for further observation with Microcosmos 3.0.

- **Dynamics:** The main dynamics included are narrative and progression. While the narrative is not as evident to all experts, it can be translated in this experience through an ecological and environmentally friendly notion where all the materials are recyclable and promote a favorable perspective on caring for, preserving, and understanding the environment, exploring it, and facilitating learning. On the other hand, progression is evident with the levels included in the challenges, increasing the difficulty until participants achieve it and become part of the “Microcosmic Community.”

Assessing the virtual mode experience of Microcosmos 3.0, it is called “A Stroll in the Park” and includes the following gamification elements:

- **Components:** For this section, experts stated that the components are missions and content unlocking. In relation to missions, “A Stroll in the Park” has four missions: garden, ferns, forests, and moss. Each mission tests knowledge about bryophytes, pteridophytes, gymnosperms, and angiosperms. As for content unlocking, upon completing each mission, participants are given a number that, when combined, forms a code (Fig. 4.4) that, when entered correctly, allows access to exclusive images generated through artificial intelligence related to Natural Sciences.
- **Mechanics:** Among the mechanics that the experts detected as most recurring are reward and feedback. The reward is evident through the acquisition of numbers to build the code and obtain collectible cards. In addition, in each query made



Fig. 4.4 Interactive source of Microcosmos 3.0

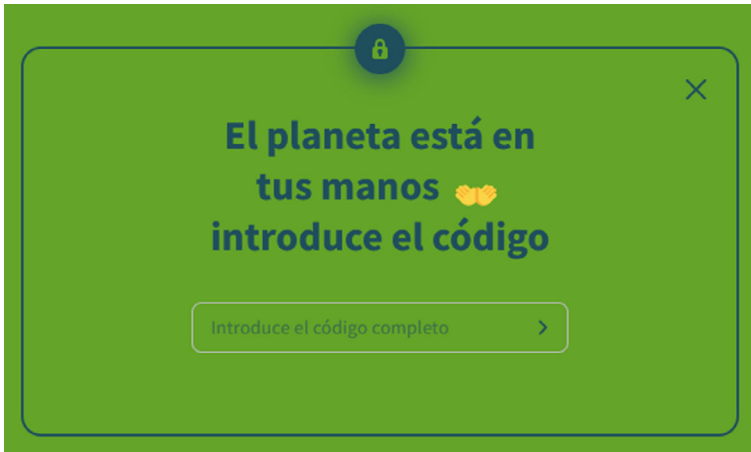


Fig. 4.5 Interface for inputting generated code in missions

during the missions, there is automated feedback on correctness or incorrectness, ensuring constant student engagement.

- **Dynamics:** Both progression and narrative are evident. Progression is achieved by completing the four missions established in the gamified activity to finalize the code (Fig. 4.5). As for the narrative, it is non-linear and non-sequential. Although the code is organized by missions, students can choose which mission to start with and which one to finish. Similarly, the narrative focuses on the theme of plants, delving into their structures and organisms.

Considering the knowledge and entertainment provided by the gamified experience, both in-person and digital, presented in *Microcosmos 3.0*, the findings obtained allow us to state that the majority of students (45.6%) perceive the level of difficulty of the hybrid interactive resource as intermediate. 26.3% find it “easy,” and 15.5% find it “very easy.” Conversely, only 7% rate it as “difficult,” and 5.3% as “very difficult.” Regarding the number of completed missions in the digital gaming experience, the majority managed to complete all four missions (36.8%), closely followed by those who completed only three missions (35.1%). 28% only reached two missions, and no one was able to complete a single mission. In contrast, regarding the in-person gaming challenges using a device, 28% reached the advanced level, 64% reached the intermediate level, and 7% reached the beginner level.

In addition, when asked about the attractiveness of the rewards offered in the gaming experience, 94.7% admitted that the rewards had a significant degree of appeal in the digital mode, while the rewards in the in-person mode only obtained 54.3%. This indicates that the gamified digital experience prevailed over the in-person gamified experience.

Regarding knowledge, the overall usefulness of the complete *Microcosmos 3.0* experience in reinforcing the content seen in the Natural Sciences class was assessed (Fig. 4.6). 63.2% considered it very useful, 26.3% found it useful, 8.8% found it

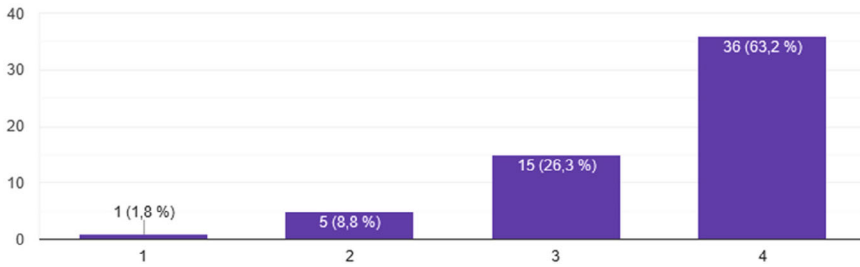


Fig. 4.6 Utility level of Microcosmos 3.0

somewhat useful, and only 1.8% found it not useful at all. Ultimately, it is demonstrated that both the in-person and digital interactive resources have a certain degree of usefulness regarding the subjects taught.

To conclude, an open-ended question was included in which participating students shared their perspective on the balance between knowledge and entertainment evident in Microcosmos 3.0. In this question, it was observed through the frequency of words used that students highlighted its practicality, ability to break the boredom of classes, increased attention from the teacher, and integration with class content.

4.4 Conclusions

This research presents the results of a study that aimed to evaluate the effectiveness of a gamified learning experience, both in a digital and a hybrid format, for teaching natural sciences to students. The study found that the majority of students found the experience to be of intermediate difficulty, with a high level of attraction toward the rewards offered in the digital mode. The study also found that the gamified learning experience had a certain degree of usefulness in reinforcing the content taught in class. The study is significant because it highlights the potential of gamification in education, particularly in the context of mobile learning.

The use of gamification in education has been gaining popularity in recent years, as it has been found to be an effective way of engaging students and enhancing their learning experience. The study adds to the existing body of literature on gamification in education by providing empirical evidence of its effectiveness in a specific context. One of the key findings of the study is that many students found the gamified learning experience to be of intermediate difficulty. This suggests that the experience was challenging enough to keep the students engaged, but not so difficult as to discourage them. This finding is important because it highlights the importance of finding the right balance between challenge and engagement in gamified learning experiences. If the experience is too easy, it may not be engaging enough, while if it is too difficult, it may discourage students from participating. Another important finding of the study

is that the rewards offered in the digital mode were more attractive to students than those offered in the hybrid mode.

This suggests that students are more likely to be motivated by rewards that are directly related to the digital experience, such as points, badges, and leaderboards, than by rewards that are related to the physical experience, such as certificates or prizes.

This finding is consistent with previous research on gamification, which has found that digital rewards are more effective in motivating students than physical rewards. The study also found that the gamified learning experience had a certain degree of usefulness in reinforcing the content taught in class. This suggests that gamification can be an effective way of enhancing the learning experience of students, particularly in subjects that are traditionally considered to be difficult or boring. By making the learning experience more engaging and interactive, gamification can help students to better understand and retain the content taught in class. Overall, the study provides valuable insights into the effectiveness of gamification in hybrid mobile-based learning. It is recommended that future research delve into other variables that support the use of Microcosmos, among them, student motivation, differentiation in its application in rural and urban contexts, differentiation in the acquisition of knowledge with other resources such as virtual reality and inverted classroom in the biological sciences.

References

- Castro, E. P., Figueiras, S. C., Ramírez, L. (2016). El aprendizaje móvil: revisión de dimensiones y propuesta de un modelo teórico. *DIM: Didáctica, Innovación y Multimedia*, 34, 1–13.
- Charinthorn, A., & Kaiyasith, A. (2023). Model component analysis of online storytelling media via gamification to enhance the digital literacy skills of students in computer education Thailand. *International Journal of Information and Education Technology*, 13(7), 1101–1108.
- Elizondo, A. I. R., Bernal, J. A. H., Montoya, M. S. R. (2010). Desarrollo de habilidades cognitivas con aprendizaje móvil: un estudio de casos. *Comunicar: Revista Científica Iberoamericana de Comunicación y Educación*, 34, 201–209.
- Engel, A., & Coll, C. (2022). Entornos híbridos de enseñanza y aprendizaje para promover la personalización del aprendizaje. *RIED. Revista Iberoamericana de Educación a Distancia*, 25(1), 225–242.
- Grund, F. B., Gil, D. J. G., González, M. L. C. (2017). Los docentes ante la integración educativa del teléfono móvil en el aula. *Revista de Educación a Distancia (RED)*, 52.
- Hernández Sampieri, R., Fernández Collado, C., & Baptista Lucio, P. (2014). *Metodología de la investigación*. McGraw Hill.
- Huang, Y. (2022). The effectiveness of mobile learning strategies based on pervasive animated games: an example in a vocational technology college. *Library Hi Tech*.
- Jaruwan, K., & Panita, W. (2023). Immersive digital storytelling learning experience with a meta-verse gamification game platform to enhance game developer competency. *International Journal of Information and Education Technology*, 13(6), 890–898.
- Lin, J. J., & Lin, H. (2019). Mobile-assisted ESL/EFL vocabulary learning: A systematic review and meta-analysis. *Computer Assisted Language Learning*, 32(8), 878–919.

- Natalia, L., Meyliana, N., Gaol, F. L., & Prabowo, H. (2023). Designing gamified learning management systems for higher education. *International Journal of Information and Education Technology*, 13(1), 25–32.
- Nien-Lin, H., Zeng, H. X., & Bilegjargal, D. (2023). Design and implementation of gamified learning system for mutation testing. *International Journal of Information and Education Technology*, 13(7), 1150–1155.
- Torres-Toukoumidis, A., Portilla, F., Cárdenas, J., Álvarez-Rodas, L., & Salgado, J. P. (2018b). Interacción y eficacia de la tecnología de comunicación móvil en la gestión del conocimiento. *Revista Ibérica De Sistemas e Tecnologías De Informação*, E16, 28–40.
- Torres-Toukoumidis, Á., & Romero Rodríguez, L. M. (2018). *Gamificación en Iberoamérica. Experiencias desde la comunicación y la educación*. Editorial Abya-Yala.
- Torres-Toukoumidis, Á., Rodríguez, L. M. R., & Rodríguez, A. P. (2018). Ludificación y sus posibilidades en el entorno de blended learning: revisión documental. *RIED. Revista Iberoamericana de Educación a Distancia*, 21(1), 95–111.
- Vallejo-Imbaquingo, R., Ortiz, S., Torres-Toukoumidis, A. (2022). Microcosmos® 3.0 perception of teachers in outdoor hybrid playing based on mobile learning for natural sciences. In *Games and learning alliance: 11th international conference GALA 2022 proceedings* (pp. 77–85). Springer International Publishing.
- Werbach, K., & Hunter, D. (2015). *The gamification toolkit: Dynamics, mechanics, and components for the win*. University of Pennsylvania Press.