別紙５－２（論文博士（和文））

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論文内容の要旨（博士）

博士学位論文名	技術者倫理教育におけるゲームを活用した学習の探究 －「楽しみながら学ぶこと」と「つくりながら学ぶこと」の実践と評価－

（要旨　1,200 字程度）

本論文は，技術者倫理教育におけるゲーム学習（Game-Based Learning：GBL）を，「ゲームを用いた学び（Playing Games for Learning：PGL）」と「ゲームをつくることの学び（Making Games for Learning：MGL）」の二つの側面から捉え，教材および授業の設計・開発，教育実践，学習成果の評価を通じて検討したものである．その結果，GBL が技術者倫理教育において有効であるとともに，21 世紀の工学教育に求められる資質・能力の形成にも寄与し，多様な教育・研修環境へ展開し得ることを示した．

第 1 章では，21 世紀の工学教育に求められる資質・能力と技術者倫理教育における課題を整理し，本研究の目的を設定した．技術者倫理教育を，価値衝突や利害調整を含む状況で判断し，技術を通じて人々の well-being や社会的価値の創出に貢献する力を育成する学習・教育領域として位置づけたうえで，主体的学びや実践的判断を促す教育方法の不足，教育目標・内容・評価の不統一，評価枠組みの未成熟等の課題に対応する教育アプローチとして GBL に着目した．

第 2 章では，ゲームと教育，工学教育および技術者倫理教育における PGL／MGL の先行研究を検討し，技術者倫理教育における GBL 研究には，学習成果の多面的評価，工学教育に求められる資質・能力との接続，志向倫理・well-being への気付きの検討，および MGL 実践研究の蓄積に課題があることを確認した．そのうえで，本研究では PGL／MGL を技術者倫理教育における教育的介入として位置づけ，研究課題を設定した．

第 3 章では，PGL の実践として，技術者倫理教育用カード型教材「ものづくりんり」を開発した．本教材では，価値衝突や利害調整を含む状況生成，複数視点からの評価，相互評価，質疑と合意形成，振り返りを組み込み，学習者が複数の立場や制約条件を踏まえて判断し，対話・協働・省察を行う学習環境を設計した．また，学習目標とゲーム要素・メカニクスの対応関係を明示し，PGL を単なるゲーム利用ではなく，教育的介入として成立させるための設計要件を示した．

第 4 章では，「ものづくりんり」を高専，大学院，企業研修，中学校において実践し，PGL の学習成果と展開可能性を検討した．その結果，技術者倫理に関する理解，倫理的判断，対話・協働，省察を促す可能性が示された．また，PERMA モデルに基づく評価や中学校実践の事前・事後比較から，PGL が工学教育に求められる資質・能力の形成および志向倫理・well-being への気付きと接続し得ることが確認された．さらに，PGL 教材は中等教育や企業研修にも展開可能である一方，その効果は対象者や教育環境に応じた授業設計に依存することが明らかとなった．

第 5 章では，学生が技術者倫理を主題とする学習用ゲームを制作する MGL 実践を分析した．学

生は，価値衝突，利害調整，責任，ステークホルダー，制約条件等を，ゲームのルール，役割，勝敗条件，評価基準として表現・モデル化していた．分析の結果，MGL は，倫理的課題の構造理解，批判的思考，創造性，協働的問題解決，省察を促すとともに，工学教育に求められる資質・能力の形成および志向倫理・well-being への気付きとも接続し得ることが示された．また，共起分析から，技術者倫理の学びとゲーム制作を通じた学びが相互に関連づけて捉えられていたことが示唆され，MGL が「創りながら学び，学びながら創る」創造的な学習方法であることが示された．

第 6 章では，以上の知見を総括し，本研究の意義と課題を整理した．本研究は，PGL と MGL の双方を工学教育に求められる資質・能力の形成および志向倫理・well-being への気付きと関連づけて分析することにより，技術者倫理教育における GBL の教育的有効性と展開可能性を示した．これらの知見は，技術者倫理教育を，専門知識と社会的実践を結び付ける重要な学習・教育領域として再定位するための基盤となるものである．一方で，本研究には，評価方法や実践対象の限定性，長期的な学習定着や行動変容の検証に課題が残されており，今後は比較研究，長期追跡調査，評価指標の精緻化，実装条件の体系化が必要であることを述べた．

別紙５－１（論文博士（英文））

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Abstract（Doctor）

Title of Thesis	Exploring Game-Based Learning in Engineering Ethics Education: Practices and Evaluations of Playing and Making Educational Games

Approx. 800 words

This dissertation examines Game-Based Learning (GBL) in engineering ethics education from two perspectives: Playing Games for Learning (PGL) and Making Games for Learning (MGL). Through the design and development of educational materials, the implementation of educational activities, and the evaluation of learning outcomes, this study demonstrates that GBL can be effective in engineering ethics education, contribute to the development of qualities and abilities required in 21st-century engineering education, and be transferred to diverse educational and training contexts.

Chapter 1 clarifies the qualities and abilities required in 21st-century engineering education and the challenges faced by engineering ethics education, and sets out the purpose of this study. Engineering ethics education is positioned not merely as the learning of ethical codes, accidents, or misconduct cases, but as an important learning domain that enables learners to make judgments in situations involving value conflicts and stakeholder interests while considering multiple perspectives and constraints, and to contribute to human well-being and the creation of social value through technology. At the same time, engineering ethics education faces challenges such as the lack of educational methods that promote active learning and practical judgment, inconsistencies in educational objectives, content, and assessment, and the underdevelopment of assessment frameworks. In response to these challenges, this study focuses on GBL as an educational approach.

Chapter 2 reviews previous studies on games and education, as well as PGL and MGL in engineering education and engineering ethics education. The review confirms that research on GBL in engineering ethics education still faces several challenges, including the need for multidimensional evaluation of learning outcomes, stronger connections with the qualities and abilities required in engineering education, examination of awareness of aspirational ethics and well-being, and further accumulation of MGL practices. Based on this review, this study positions PGL and MGL as educational interventions in engineering ethics education and formulates its research questions.

Chapter 3 describes the development of *Monozukurinri,* a card-based educational tool for engineering ethics education, as a PGL practice. The tool incorporates situation generation involving value conflicts and trade-offs, evaluation from multiple perspectives, peer evaluation, questioning and consensus building, and reflection. It was designed as a learning environment in which learners make judgments while considering multiple perspectives and constraints, and engage in dialogue, collaboration, and reflection. The chapter also clarifies the relationship between learning objectives and game elements or mechanics, and presents design

requirements for establishing PGL not merely as the use of a game, but as an educational intervention.

Chapter 4 reports the implementation of *Monozukurinri* in a college of technology, a graduate school, corporate training, and a junior high school, and examines the learning outcomes and transferability of PGL. The results suggest that the tool may promote understanding of engineering ethics, ethical judgment, dialogue, collaboration, and reflection. Evaluations based on the PERMA model and pre- and post-questionnaire surveys in the junior high school practice further indicate that PGL can be connected with the development of qualities and abilities expected in engineering education and awareness of aspirational ethics and well-being. The findings also show that the PGL tool can be adapted not only to higher education but also to secondary education and corporate training, while its effects depend on instructional design tailored to learners and educational contexts.

Chapter 5 analyzes an MGL practice in which students created educational games on engineering ethics. The students represented and modeled value conflicts, trade-offs, responsibilities, stakeholders, and constraints through game rules, roles, win conditions, and evaluation criteria. The analysis shows that MGL can foster structural understanding of ethical issues, critical thinking, creativity, collaborative problem solving, and reflection, while also connecting with the development of qualities and abilities expected in engineering education and awareness of aspirational ethics and well-being. Furthermore, co-occurrence analysis suggests that students perceived their learning of engineering ethics and their learning through game creation as mutually related. In this sense, MGL can be understood as a creative learning approach in which learners "learn by making and make by learning."

Chapter 6 summarizes the findings and discusses the significance and limitations of the study. By analyzing both PGL and MGL in relation to the qualities and abilities expected in engineering education and awareness of aspirational ethics and well-being, this study demonstrates the educational effectiveness and transferability of GBL in engineering ethics education. These findings provide a basis for repositioning engineering ethics education as an important learning domain that connects specialized knowledge with social practice, rather than as a peripheral subject in engineering education. At the same time, this study has several limitations, including the limited scope of assessment methods and research settings, as well as insufficient examination of long-term learning retention and behavioral change. Future research should include comparative studies, longitudinal investigations, refinement of assessment indicators, and systematization of implementation conditions.