Optimizing Outcome-Based Education Curriculum Design Using Generative AI DeepSeek: Case Study of D3 Computer Engineering Study Program

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Abstract
Background: The development of generative artificial intelligence (Generative AI) opens new opportunities for optimizing higher education curriculum design. DeepSeek as a generative AI offers complex analysis capabilities to develop Outcome-Based Education (OBE) curriculum integrated with the Indonesian National Qualification Framework (KKNI) and industry needs.
Objective: This study aims to develop a comprehensive model for utilizing Generative AI DeepSeek in the OBE curriculum design process for D3 Computer Engineering Study Program.
Methods: The research employs mixed-methods approach with sequential explanatory design. A structured prompt engineering framework was developed using [ROLE] + [CONTEXT] + [TASK] + [CONSTRAINTS] + [FORMAT] approach. Technical implementation followed iterative refinement process through three phases: preparation, AI implementation, and validation. Data were collected from 20 stakeholders through FGDs and validated by 5 curriculum experts.
Results: Generative AI DeepSeek successfully optimized the curriculum design process by reducing development time from 17 days to 3 days (82% efficiency improvement). The AI generated 10 learning outcomes with 95% accuracy, 5 industry-relevant graduate profiles (90% accuracy), 110-credit curriculum structure (92% accuracy), and comprehensive curriculum maps. Expert validation showed overall 92% accuracy in regulatory compliance and industry needs alignment. Chain-of-thought prompting demonstrated 94% success rate for complex tasks, while constraint-based prompting achieved 96% success for structural design.
Conclusion: The utilization of Generative AI DeepSeek with structured prompt engineering framework proves highly effective in optimizing OBE curriculum design process. This model produces comprehensive, systematic outputs that comply with national standards and industry 4.0 requirements while significantly improving efficiency and quality assurance in curriculum development.

Keywords: Generative AI, DeepSeek, Outcome-Based Education, Curriculum Design, KKNI, Computer Engineering, Prompt Engineering, Higher Education

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1. INTRODUCTION

1.1 Background and Context

The fourth industrial revolution and digital transformation have created significant disruptions in higher education ecosystems, particularly in vocational education. According to the World Economic Forum (2024), 65% of technology-related jobs require new competencies that are not fully accommodated in conventional curricula. This phenomenon demands accelerated adaptation and innovation in developing curricula that are responsive to industrial dynamics.

In Indonesia, this challenge is compounded by the complexity of higher education regulations encompassing the Indonesian National Qualification Framework (KKNI), Higher Education National Standards (SN Dikti), and Ministerial Regulation No. 39 of 2025 concerning Higher Education Quality Assurance. Traditional curriculum design processes often require significant time and resources, with program curriculum development typically taking 3-4 weeks (Ministry of Education and Culture, 2023).

The emergence of Generative Artificial Intelligence (AI) like DeepSeek offers a new paradigm in higher education curriculum development. DeepSeek, with its advanced natural language processing capabilities, context understanding, and systematic thinking, can simultaneously analyze the complexity of educational regulations, industrial needs, and competency standards. According to

Chen et al. (2023), AI utilization in education can improve administrative process efficiency by up to 70%.

However, research on the utilization of Generative AI, particularly DeepSeek, in OBE curriculum design remains limited, especially in the context of Indonesian vocational education. Most studies focus on learning aspects, while optimization of curriculum design processes remains largely unexplored.

1.2 Problem Statement

Based on this background, this research addresses the following questions:

1. How to develop an effective prompt engineering framework for OBE curriculum design using DeepSeek?
2. How effective is DeepSeek utilization in optimizing curriculum design processes and outputs?
3. What are the implications of this model for vocational education development in the digital era?

1.3 Research Objectives

This study aims to:

1. Develop a prompt engineering framework for DeepSeek utilization in OBE curriculum design
2. Evaluate the effectiveness of DeepSeek in generating curriculum components
3. Analyze the optimization impact on quality and efficiency of curriculum design processes
4. Formulate an implementation model adoptable by other educational institutions

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2. LITERATURE REVIEW

2.1 Outcome-Based Education in Vocational Education

Outcome-Based Education (OBE) is an educational approach that emphasizes the learning outcomes graduates must master. According to Spady (1994), OBE focuses on what graduates can do after completing their education, rather than the learning process itself. In vocational education context, OBE becomes a critical success factor to ensure graduate relevance with industry needs.

2.2 Generative AI in Education

Generative AI has shown significant potential in educational transformation. According to UNESCO (2024), generative AI can optimize various educational aspects, including personalized learning, administrative automation, and curriculum design. DeepSeek, as one of the leading generative AI models, offers capabilities for complex document analysis and structured content generation.

2.3 Prompt Engineering for Educational Applications

Prompt engineering has emerged as a critical discipline in generative AI utilization. According to White et al. (2023), AI output effectiveness heavily depends on prompt quality. Techniques such as chain-of-thought prompting, few-shot learning, and constraint-based prompting have proven to improve AI output quality in educational contexts.

2.4 Integration of Educational Regulations with Technology

Technology integration in educational regulation implementation remains challenging. Previous research shows that automated compliance checking can improve accreditation process efficiency and curriculum development (Smith & Johnson, 2022).

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3. RESEARCH METHODOLOGY

3.1 Research Design

This research uses mixed-methods approach with sequential explanatory design. This approach was chosen to integrate quantitative data (time efficiency, output accuracy) with qualitative data (expert validation, stakeholder feedback).

3.2 Prompt Engineering Framework

This study develops a specialized prompt engineering framework for curriculum design using structured prompting approach:

[ROLE] + [CONTEXT] + [TASK] + [CONSTRAINTS] + [FORMAT]

3.2.1 Developed Prompt Categories

Category 1: Regulatory and Needs Analysis

"As a vocational education curriculum expert, analyze Ministerial Regulation No. 39 of 2025 and KKNI Level 5 to identify main requirements in developing D3 Computer Engineering curriculum. Provide in table format with columns: Regulatory Aspect, Requirement, Curriculum Implication."

Category 2: Learning Outcomes and Graduate Profile Formulation

"Based on IT industry needs analysis and educational regulations, formulate 5 graduate profiles and 10 learning outcomes for D3 Computer Engineering. Each learning outcome must:

1. Refer to KKNI Level 5
2. Begin with 'Able to'
3. Cover attitude, knowledge, skill aspects
4. Be relevant to IoT, cybersecurity, and computer networking trends

Format: Table with learning outcome code and description."

Category 3: Curriculum Structure

"Design 110-credit curriculum structure for 6 semesters with specifications:

- Semester 1-5: 20 credits, Semester 6: 10 credits
- Theory:practice ratio 60:40
- Course groups: General Courses, Basic Competency Courses, Core Competency Courses, Career Development Courses, Internship, Final Project
- Include mandatory courses: Religion, Pancasila, Civics, Indonesian Language

Output: Semester distribution table with course code, course name, credits, group."

3.2.2 Prompt Optimization Techniques

The research implements three main prompt optimization techniques:

a. Chain-of-Thought Prompting

"Step 1: Analyze computer networking and IoT industry needs
Step 2: Identify main competencies based on KKNI Level 5
Step 3: Determine relevant graduate profiles
Step 4: Formulate learning outcomes for each profile
Step 5: Arrange supporting courses for each learning outcome"

b. Few-Shot Learning Prompting

"Example learning outcome for KKNI Level 4: 'Able to complete limited scope work'
Example learning outcome for KKNI Level 5: 'Able to complete wide scope work'
Based on these examples, formulate learning outcomes for KKNI Level 5 in computer engineering:"

c. Constraint-Based Prompting

"With the following constraints:
- Maximum 110 credits
- Minimum 6 credits industrial internship
- Mandatory religion and Pancasila courses
- Cisco and IoT certification integration
Design curriculum that meets all these constraints."

3.3 DeepSeek Technical Implementation

3.3.1 Technical Implementation Architecture

```
INPUT LAYER
├── Regulatory Documents (Ministerial Regulation, KKNI, SN Dikti)
├── Industry Needs Data (FGD results, job market analysis)
├── Benchmarking Curriculum (domestic/international)
└── Institutional Context (vision-mission, resources)

PROCESSING LAYER (DeepSeek)
├── Natural Language Understanding
├── Contextual Analysis
├── Pattern Recognition
├── Constraint Satisfaction
└── Output Generation

OUTPUT LAYER
├── Curriculum Components (learning outcomes, graduate profiles)
├── Structural Design (credit distribution, course sequence)
├── Mapping & Visualization (matrices, diagrams)
└── Documentation (academic manual, syllabi templates)
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3.3.2 Technical Implementation Workflow

The research was conducted through three main phases:

Phase 1: Data Preparation and Pre-processing

- Collection and analysis of regulatory documents
- Conducted FGD with 20 stakeholders (industry, lecturers, alumni)
- Benchmarking against 8 similar study programs
- Preparation of structured dataset for AI consumption

Phase 2: Iterative Prompt Engineering Cycle

```
def iterative_prompt_optimization(base_prompt, validation_feedback):
    for iteration in range(max_iterations):
        ai_response = deepseek_api.call(base_prompt)
        validation_score = expert_validator.evaluate(ai_response)
        if validation_score >= threshold:
            return ai_response
        else:
            base_prompt = refine_prompt(base_prompt, validation_feedback)
    return best_response
```

Phase 3: Multi-Stage Validation Pipeline

VALIDATION PIPELINE:
1. Automated Compliance Check
   - Regulatory requirement matching
   - Credit distribution validation
   - Prerequisite coherence check
2. Expert Human Validation
   - Content relevance assessment (5 experts)
   - Industrial applicability evaluation (3 practitioners)
   - Academic quality assurance (2 curriculum specialists)
3. Stakeholder Feedback Integration
   - Industry practitioner review
   - Alumni feedback incorporation
   - Student representative input

3.4 Research Instruments

1. **Structured Prompts** for DeepSeek (15 prompt variations)
2. **Evaluation Rubric** for curriculum (1-5 scale)
3. **Interview Protocol** for FGD
4. **Validation Checklist** for expert review
5. **Time Tracking Sheet** for process efficiency

3.5 Data Analysis Techniques

- **Quantitative data** analyzed using descriptive statistics and comparative analysis
- **Qualitative data** analyzed with thematic analysis and content analysis
- **Method triangulation** to ensure reliability and validity

3.6 Experimental Protocol

Independent Variables:

- Prompt engineering technique types
- Input data quality and quantity
- Constraint specificity level

Dependent Variables:

- Curriculum output quality (expert rating)
- Task completion time
- Regulatory compliance level
- User satisfaction (usability score)

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4. RESULTS AND FINDINGS

4.1 Curriculum Design Process Optimization

Table 1. Curriculum Development Time Efficiency Comparison

Process	Conventional Method	With DeepSeek	Efficiency Gain
Needs Analysis	5 days	1 day	80%
Learning Outcomes Development	4 days	6 hours	85%
Structure Design	3 days	4 hours	87%

Process	Conventional Method	With DeepSeek	Efficiency Gain
Curriculum Mapping	5 days	1 day	80%
Total	**17 days**	**3 days**	**82%**

DeepSeek successfully optimized the process through capabilities:

- **Natural Language Understanding**: Comprehending educational regulation complexity
- **Systematic Thinking**: Structuring curriculum components systematically
- **Context Awareness**: Integrating industrial and academic needs

4.2 Generative AI Output Quality

Table 2. DeepSeek Output Accuracy Based on Expert Validation

Curriculum Component	Accuracy Rate	Remarks
Learning Outcomes	95%	Compliant with KKNI Level 5
Graduate Profiles	90%	Industry-relevant
Curriculum Structure	92%	Meets Ministerial Regulation
Curriculum Map	88%	Logical and systematic
Competency Tree	93%	Shows progressivity
Average	**92%**	**Excellent**

4.3 Prompt Engineering Technique Effectiveness

Analysis shows that chain-of-thought prompting produced best results for complex tasks like learning outcomes formulation, while constraint-based prompting was most effective for structural design.

Table 3. Prompt Engineering Technique Effectiveness Comparison

Prompt Technique	Best For	Success Rate	Remarks
Chain-of-Thought	Learning Outcomes Formulation	94%	Breaking down complex tasks
Few-Shot Learning	Course Sequencing	89%	Learning from examples
Constraint-Based	Structural Design	96%	Handling multiple constraints
Structured Prompting	Documentation	91%	Standardized outputs

4.4 Generated Curriculum Components Analysis

4.4.1 Learning Outcomes

DeepSeek generated 10 comprehensive learning outcomes:

- Outcomes 1-3: General attitude and value aspects (KKNI general descriptor)
- Outcomes 4-7: Main technical competencies (KKNI work ability)
- Outcomes 8-10: Soft skills and self-development (KKNI managerial & responsibility)

4.4.2 Graduate Profiles

AI analyzed industry needs and generated 5 specific profiles:

1. Computer Network and Systems Technician
2. Embedded System and IoT Developer
3. Cybersecurity Technician
4. Technology Entrepreneur
5. IT Support Specialist

4.4.3 Curriculum Structure

DeepSeek designed 110-credit distribution with characteristics:

- Theory-practice balance (62:38)
- Logical competency progressivity
- Internship integration (6 credits) and professional certification
- Compliance with Ministerial Regulation 39/2025

4.5 Challenges and Limitations

Several identified challenges:

- **Context Limitation**: DeepSeek requires specific input data about local context
- **Regulatory Updates**: Need for periodic updates on regulation changes
- **Human Oversight**: Still requires human validation to ensure relevance
- **Bias Mitigation**: Potential bias in training data needs anticipation

Implemented Mitigation Strategies:

```
def safety_checks(ai_response):
  # Check for regulatory compliance
  if not check_compliance(ai_response, regulations):
    return flag_for_review(ai_response)
  # Check for bias in course recommendations
  if detect_bias(ai_response, bias_keywords):
    return apply_debiasing(ai_response)
  # Check for implementation feasibility
  if not check_feasibility(ai_response, resources):
    return suggest_alternatives(ai_response)
  return ai_response
```

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5. IMPLEMENTATION AND IMPACT

5.1 Operational Efficiency

- 70% reduction in curriculum consultation costs
- Optimization of lecturer time for other academic activities
- Acceleration of study program accreditation process

5.2 Quality Improvement

- More responsive curriculum to industry changes
- Better integration between theory and practice
- Stronger alignment with national and international standards

5.3 Institutional Capacity

- Improved digital literacy among faculty members
- Development of best practices in AI utilization for academics
- Institutional positioning as vocational education innovator

5.4 Replication and Scalability

This model has been replicated in two other study programs with consistent results:

- D4 Animation Study Program: 85% success rate
- D3 Information Management Study Program: 88% success rate

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6. DISCUSSION

6.1 Theoretical and Practical Contributions

This study provides significant contributions in:

- **AI in Education Theory**: Developing generative AI utilization framework in curriculum development
- **Curriculum Design Practice**: Providing practical model adoptable by other institutions
- **Policy Implementation**: Demonstrating educational regulation implementation through AI technology

6.2 Stakeholder Implications

For Educational Institutions:

- This model can be adopted for other study programs
- Opens collaboration opportunities with tech companies
- Enhances competitiveness in digital era

For Policy Makers:

- Consider AI integration in curriculum development guidelines
- Develop capacity building for AI utilization
- Supportive regulations for educational technology innovation

For Technology Industry:

- Opportunities for developing specialized AI tools for education
- Partnership with educational institutions for R&D
- Access to better-prepared talent matching industry needs

6.3 Research Limitations and Future Directions

Several research limitations:

- Scope limited to computer engineering vocational education
- Long-term validation not yet conducted
- Ethical AI aspects require deeper exploration

Future research directions:

- Development of AI specialized tools for education
- Longitudinal studies of implementation impact
- Exploration of ethical AI aspects in education

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7. CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

The utilization of Generative AI DeepSeek with structured prompt engineering framework proves highly effective in optimizing OBE curriculum design process. The developed model successfully:

1. Reduced curriculum development time from 17 days to 3 days (82% efficiency gain)
2. Generated curriculum components with average 92% accuracy
3. Provided systematic and replicable framework
4. Ensured compliance with national regulations and industry needs

7.2 Recommendations

Practical Recommendations:

1. **For Educational Institutions**: Develop AI integration framework for various academic aspects
2. **For Lecturers**: Enhance AI literacy and prompt engineering skills
3. **For Developers**: Create specialized AI tools for Indonesian vocational education

Policy Recommendations:

1. **For Government**: Develop guidelines for AI utilization in national curriculum development
2. **For Accreditation Bodies**: Consider AI integration in accreditation processes
3. **For Professional Associations**: Develop standard competency framework for AI-assisted curriculum design

Future Research Recommendations:

1. Model expansion to other educational fields
2. Comparative studies with other AI tools
3. Development of ethical framework for AI in education

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