**Business Case Study**

**Recode – A Smart Coding Challenge Generator for Students**

**Document Control**

|  |  |
| --- | --- |
| Information | Details |
| Document ID | RECODE-BC-001 |
| Document Owner | Group |
| Issue Date | 05/08/2025 |
| Last Saved Date | 06/08/2025 |
| File Name | Recode\_BC.docx |

**Document History**

|  |  |  |  |
| --- | --- | --- | --- |
| Version | Issue | Date | Changes |
| 1.0 |  | 05/08/2025 | Initial Document |
|  |  |  |  |
|  |  |  |  |

**Document Approvals**

|  |  |  |  |
| --- | --- | --- | --- |
| Role | Name | Signature | Date |
| Project Review Group |  |  |  |
| Project Manager |  |  |  |

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# 1. Executive Summary

Recode Labs is a team of twelve developers from North-West University with one clear goal which is to change the way students learn, practise, and think about coding. These twelve developers have a variety of skills and knowledge in the technological landscape, have a strong growth mindset, and show excellent analytical and collaborative abilities. Using these skills, a business case and feasibility study need to be done to check if a possible solution can be found.

Many first-year university students are introduced to coding concepts in lectures but lack regular, structured opportunities to apply this knowledge in a hands-on environment. According to Masegosa, Cabañas, Maldonado & Morales (2024: Introduction), “many students struggle to connect programming theory learned in lectures with practical problem-solving due to a lack of accessible, course-specific exercises”. Current methods often rely on generic problem sets or require significant manual preparation from lecturers, limiting reach and effectiveness. This leads to reduced engagement, slower skill development, and weaker problem-solving ability.

ReCode Labs have proposed three solutions as a solution to the problem. The first solution is Recode where a new system will be developed to address the issue. The second solution is to use a code visualisation sandbox to help students interact with coding more effectively. The third solution is to use an already existing system Moodle but adapt the code. These three solutions will be discussed in greater detail in the feasibility study.

The ranking of these solutions was made using an assessment criterion which included scalability, maintainability, affordability, user-friendliness, and delivery feasibility. From these three solutions, ReCode scored the highest. Its key advantage is an automated grading engine that offers students real-time feedback on their submissions, which enhances their learning experience while reducing staff marking workloads (Keuning et al., 2022; Mitra, 2023).

Development will follow the **Scrum agile methodology**, using short sprints to deliver core modules incrementally. This approach enables early feedback from lecturers and students, continuous quality assurance, and rapid adaptation to requirements. Automated testing of the grading engine and NLP components will ensure performance under concurrent usage. Risk mitigation includes deploying Judge0 locally to prevent grading service downtime and scheduling regular Supabase backups for data integrity.

No existing platform currently integrates lecture content directly into personalised, auto-marked coding challenges. ReCode’s innovative approach aligns with NWU’s digital learning strategy, enhances student engagement, improves learning outcomes, and reduces lecturer workloads. Based on strong feasibility, strategic alignment, and measurable projected impact, immediate development of the ReCode is recommended.

# 2. Business Problem

Across South African universities, many first-year programming students struggle to make the leap from learning theory to applying it in practice. In large classes, lecturers can explain coding concepts, but it’s not realistic to give every student personalised, hands-on opportunities to apply them immediately. This often leads to significant skills gaps; students may understand a concept in theory but still struggle to write working code and improve their practical marks. When faced with syntax errors, debugging issues, or logic mistakes, coding can quickly become overwhelming in a university setting.

At NWU, the problem is made worse by large class sizes, limited tutorial hours, and the absence of a platform that can deliver course-specific coding practice with automatic marking. Without quick feedback, students will tend to repeat the same mistakes over and over again, which slows their progress and undermines their confidence.

From the lecturer’s perspective, preparing and marking coding exercises is both time-consuming and inefficient because:

* Creating exercises tailored to each week’s lecture content takes a considerable amount of preparation time.
* Manual marking slows down feedback, which can also lead to students disengaging from the content (Kiesler et al., 2022).
* Providing personalised feedback at scale is nearly impossible without automation tools.

While platforms like HackerRank or LeetCode offer good coding environments, they are not designed for NWU’s curriculum or any certified curriculum. The main limitation of these solutions is that they cannot automatically generate challenges from lecture slides or use module-specific topics, requiring lecturers to manually align exercises with course content. These platforms also make it more difficult for students to see a clear connection between the exercises they complete and the topics covered in class. The lack of curriculum-linked, automatically assessed practice has some clear consequences:

1. **Lower engagement** – Students disengage when practice activities are not directly connected to recent lecture content.
2. **Reduced retention and pass rates** – Skills gaps persist into assessments, lowering overall academic performance.
3. **Inefficient use of academic staff time** – Significant time is spent on repetitive marking instead of teaching or targeted student support.
4. **Institutional risk** – Underperformance in foundational programming modules can contribute to higher dropout rates in IT programmes.

ReCode is designed to solve these problems by:

* Automatically extracting key topics from lecture slides.
* Generating aligned coding challenges in real time.
* Marking submissions instantly and providing targeted feedback to students.
* Freeing up lecturer time for higher-value teaching and mentoring activities.

By removing the gap between lecture content and practice, ReCode aims to boost student confidence, improve coding ability, and raise assessment performance, while at the same time reducing lecturer workload and supporting NWU’s goals for teaching excellence, student retention, and digital innovation.

## 2.1 Macro Forces

**Overview**  
The core problem is a lack of practical, accessible coding exercises that directly match lecture content. This affects student engagement, especially for those new to coding or struggling to keep up. Recode seeks to solve this by auto-generating relevant tasks that are easy to access, complete, and learn from (Silva et al., 2022).

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| Force | Opportunity | Threat |
| Political | National support for tech education and innovation | Data Privacy Regulations may affect the usage of slides. |
| Economic | Reduces the need for expensive coding platforms | Limits the university budget for tech initiatives |
| Social | Gamified and self-paced learning leads to a positive experience | Students may prefer traditional approaches |
| Technological | Use of reliable open-source NLP tech | Rapid tech changes |
| Legal | Open-source licenses reduce cost | Possible issues with the copyrights of slides. |

### Core Focus Areas for the Proposed IT Solution:

* Cost Reduction: The platform reduces the need for extensive manual feedback by lecturers, saving time and resources while improving efficiency in large classes.
* Differentiation: Offers a unique solution that ties individual coding tasks to each student's content, making learning more personalised and effective.
* Improved Student Support: Enables scalable support through debugging assistance, variable tracking, and visualisation, even in large cohorts.
* Enhanced Learning: Students benefit from step-by-step code execution, real-time feedback, and visualised debugging that fosters better understanding (Papadopoulos et al., 2023).
* Cross-platform Support: Compatibility with Python, JavaScript, and Java makes it suitable for a wide range of teaching modules.
* Collaborative Learning: Code sharing enables collaborative problem-solving and review, enhancing the learning experience.
* Boost Institutional Efficiency and Reputation: A robust educational tool increases the institution’s appeal to prospective students, improves pass rates, and may lead to additional funding or partnerships.

The need beyond the organisation (customers):

There is strong potential for this platform to be used beyond NWU. Other faculties and institutions (including technical colleges, online coding bootcamps, and distance education providers) can adopt or adapt the system to fit their curriculum. As a reusable and flexible tool, it supports personalised learning and could set new standards in scalable programming instruction and assessment.

### The strategic impact over time and the window of opportunity to act:

Several macro forces shape the strategic value of this platform’s development and release:

**Technological Readiness:**

* While conceptually strong and aligned with best practices in educational tech, the system requires integration testing and debugging simulations to ensure robust MVP deployment.
* Given a 3–6-month window for MVP development, early adoption is achievable without immediate competitive pressure.

**Political and Regulatory Considerations:**

* Institutions are increasingly pressured to demonstrate digital transformation and AI-readiness in education. There may be future regulations around fairness in auto-grading and data security in educational tools.
* Early implementation positions NWU as a leader in ethical and effective educational innovation.

**Social Demand:**

* There is a growing expectation for digital-first education. Students and academic staff alike demand interactive, personalised tools that bridge the gap between theory and practical coding.
* Delays in adoption may reduce student engagement and retention.

**Economic Considerations:**

* The tool supports cost-efficient teaching models, enabling fewer lecturers to manage a larger number of students without compromising quality.
* Loss of access to free-tier cloud services or decreased institutional funding could make affordable, on-premises-compatible tools like this even more vital.

**Window of Opportunity:**

* To establish market presence before similar tools emerge, development should begin no later than October 2025.
* With a 1-2-year head start, NWU can refine and promote the platform while building partnerships and user trust before competition intensifies.

### Macro-Environment Summary:

The analysis of macro forces reveals that building a customised code visualisation and debugging sandbox presents a strategically sound investment for NWU. It offers cost-effective scalability, enhances educational outcomes, and can evolve into a shared academic service platform. While risks exist in the form of potential policy changes or competing products, the window to act is favourable. A carefully timed release could place NWU at the forefront of educational innovation in computer science and digital learning.

## 2.2 Micro-Level Environmental Analysis

Once the need for a custom, context-aware coding and debugging environment for NWU students is established, it is essential to analyse the micro-level environmental factors that affect its development, implementation, and sustainability. These include competitors, substitutes, suppliers, and the potential of internal or external development initiatives.

### Problem Analysis

While coding practice platforms exist in the market, they are often not tailored to lecture-specific content or academic environments. Vendors like HackerRank and LeetCode provide reliable coding environments but lack functionality for automatic content alignment or personalised task generation based on lecture materials.

Substitute platforms typically provide generic problem sets that do not align with specific course outcomes or student-created content, thereby limiting their educational impact. New entrants (including student developers or AI-powered startups) may enter the market rapidly by leveraging large language models and generative AI technologies to create innovative, competitive solutions. These can pose a threat to NWU's solution if development is delayed.

Suppliers in the form of open-source frameworks such as Python-PPTX, SpaCy, Judge0, and HuggingFace offer powerful tools for building a custom platform but require seamless integration, rigorous testing, and ongoing support to ensure long-term reliability and performance.

A locally developed custom solution can be tailored to NWU’s specific academic needs (integrating lecture slides, student-generated content, debugging support, and real-time feedback) but would require significant development resources and a dedicated technical team.

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| Analysis Area | Details |
| Vendors | Platforms like HackerRank exist, but do not read slides or auto-generate context-based tasks |
| Substitutes | General coding practice platforms (e.g., LeetCode) don’t necessarily align with lecture content. |
| New Entrants | Student or startup projects may emerge, especially using AI or GPT-based tools |
| Suppliers | Open-source tools (python-pptx, SpaCy, Judge0, HuggingFace) are available and well-supported. (Marcus, et al., 2024) |

### Benefits and Cost Analysis of Alternative Solutions

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| Option | Strong Points | Weak Points |
| Vendors | Reliable Platform, many features | Not customised to student material resources |
| New Entrant | Bring Innovation and collaborations | May surpass the record with better/faster development and funding |
| Substitute | Readily available | Generic, not course-specific content |
| Open-Source Suppliers | Low cost, driven by community, flexible | Requires thorough integration and testing |
| Own Solution | Custom, tailored and innovative to ensure alignment with course materials | Development requires intensive effort, time and testing |

### Micro-Environment Summary

The micro-environment assessment indicates that current political, economic, social, technological, and legal conditions create a favourable climate for launching the ReCode project. Institutional priorities align with the project’s objectives, supported by strong regulatory momentum for digital transformation in education and rising expectations for AI-enabled learning tools. Social demand for interactive, curriculum-aligned coding practice is increasing, and early adoption would position NWU as a leader in innovative, ethical, and scalable educational technology. From an economic perspective, ReCode supports cost-efficient teaching models by reducing manual workload and allowing academic staff to give full focus on higher-value teaching and mentoring. The use of open-source technologies ensures affordability, while the architecture’s scalability protects the university’s investment. Technological readiness is strong, with reliable, well-supported tools available for integration. However, the fast pace of change in AI and evolving data privacy regulations will require the project team to monitor developments closely and adapt as needed.

While risks do exist, like evolving compliance requirements, competition from emerging solutions, or changes in free-tier cloud service models, they can be mitigated through careful planning, modular development, and early market positioning. Acting within the identified 12 to 18-month window will give NWU a competitive advantage, enabling it to establish credibility, refine the solution, and create strategic partnerships before similar products enter and flood the market.

## 3. Recommended Solution

The combined macro and micro analyses confirm that developing ReCode as a fully automated, curriculum-based coding challenge generator is the most effective solution. It directly addresses the identified skills gap, supports NWU’s digital transformation goals, and delivers measurable academic benefits.

ReCode offers a clear competitive advantage by integrating lecture content into automatically generated context-specific coding exercises, a capability absent in existing market solutions. This ensures a stronger connection between classroom learning and practice, leading to measurable improvements in student performance and engagement.

The recommended solution will be implemented in phases, starting with a Minimum Viable Product (MVP) focused on Python support and the core slide-to-challenge automation, followed by iterative feature expansion based on stakeholder feedback. This phased approach ensures early delivery of value, reduces risk through incremental development, and allows for continuous alignment with lecturer and student needs.

The choice of ReCode as the primary solution is supported by:

* High scalability potential for large class sizes.
* Significant reduction in lecturer preparation and marking time.
* Immediate, actionable feedback for students to reinforce learning.
* Strong alignment with NWU’s objectives for innovation, retention, and graduate readiness.

Given the favourable market timing and the 12 to 18-month window to secure first-mover advantage, immediate commencement of the MVP development phase is recommended.

**Implementation Strategy**

**Phase 1 – MVP**

* Python support only.
* Core functionality: slide parsing, NLP topic extraction, challenge generation, instant grading.

**Phase 2 – Expansion**

* Add JavaScript and Java support.
* Introduce gamification (leaderboards, badges, progression) (Chen et al., 2022; Kastrati et al., 2023).
* Improve NLP accuracy and adaptability.

**Phase 3 – Scaling**

* Extend to other faculties and institutions.
* Add advanced analytics and collaborative coding features.

## 4. Implementation Plan

The implementation of ReCode will follow a phased, agile delivery approach to ensure early value, continuous feedback, and reduced development risk. By structuring the build into smaller, iterative releases, the team can adapt quickly to lecturer and student needs while maintaining momentum.

### Phase 1 – MVP Development (Months 1 – 4)

* Core technologies: Python-pptx, SpaCy, Judge0, Supabase, Redis/Celery.
* Core functionality: slide content extraction, NLP topic mapping, coding challenge generation, automated grading with instant feedback.
* Pilot deployment within the first-year programming module at NWU.
* Success metrics: 50% reduction in lecturer preparation time; 30% increase in student challenge participation; stable uptime above 99%.

### Phase 2 – Feature Expansion (Months 4 – 10)

* Language support expansion: JavaScript and Java. (only needed for 2nd year students)
* Gamification: leaderboards, badges, ELO-style ranking (Zeng et al., 2024).
* Enhanced NLP accuracy with additional training data.
* Lecturer dashboard for manual curation, analytics, and topic weighting.

### Phase 3 – Scaling and Partnerships (Months 10 – 20)

* Deployment across multiple NWU modules and faculties.
* Institutional partnerships with other universities and coding academies.
* Integration with learning management systems (e.g., Moodle, Canvas).

**Key Enablers**

* Agile Scrum methodology with 2–3-week sprints.
* Continuous integration/continuous deployment (CI/CD) pipeline via GitHub Actions.
* Regular stakeholder reviews to validate progress against objectives.

## Risk Analysis & Mitigation

The development and deployment of ReCode carry inherent risks that must be actively managed to protect delivery timelines, quality, and adoption (Zeng et al., 2024)..

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| Risk | Impact | Likelihood | Mitigation Strategy |
| Integration challenges with open-source tools | Medium | Medium | Allocate extra time in Phase 1 for API and compatibility testing. |
| Changes in data privacy regulations | High | Low | Build a POPIA-compliant architecture from the start and review legislative changes quarterly. |
| Low adoption by lecturers | Medium | Medium | Involve lecturers early in the design process, provide training, and ensure an intuitive dashboard. |
| Emergence of competing tools | High | Medium | Move quickly to secure first-mover advantage and emphasise NWU-specific integration as a unique differentiator. |
| Technical performance issues under heavy usage | High | Medium | |  | | --- | |  |  |  | | --- | | Run stress tests and use scalable infrastructure with caching to maintain performance. | |
| Loss of free-tier cloud benefits | Medium | Medium | |  | | --- | |  |  |  | | --- | | Make sure the platform can run on local infrastructure as a backup option. | |

## 6. Conclusion & Recommendation

ReCode offers NWU a clear and timely strategic advantage in transforming programming education from passive learning into an interactive, feedback-driven experience. By directly linking lecture content to automatically generated, curriculum-specific coding challenges, ReCode addresses a long-standing gap in higher education — the lack of scalable, personalised practice opportunities that both engage students and reduce lecturer workload.

The platform is built on reliable, mature open-source technologies — Python-pptx for slide parsing, SpaCy for NLP topic extraction, Judge0 for secure code execution, Supabase for database/auth/storage, and Redis + Celery for background task handling. This tech stack not only ensures affordability and scalability but also minimises vendor lock-in, allowing NWU to maintain control over its infrastructure and adapt as technologies evolve. Its design supports both cloud and on-premises deployment, ensuring resilience if free-tier services change or funding fluctuates.

From an academic perspective, ReCode aligns perfectly with NWU’s digital transformation strategy and supports institutional KPIs around student retention, pass rates, and graduate readiness. By offering instant feedback and adaptive challenges, students can correct misunderstandings before they become ingrained, while lecturers can focus on higher-value teaching rather than repetitive marking (Mitra, 2023; Hagerer et al., 2021). This creates a measurable impact: reduced preparation time by up to 50%, increased student practice engagement by at least 30%, and a projected 20% improvement in challenge completion accuracy in the first semester of use.

Beyond NWU, the platform’s architecture and features make it a strong candidate for expansion to other faculties, institutions, and even online learning providers. With modest adjustments, ReCode could become a licensable or white-label solution, opening new revenue and partnership opportunities for the university.

The market window for this innovation is narrow but highly favourable. The identified 12 to 18-month lead time over potential competitors allows NWU to position itself as a leader in AI-enabled, curriculum-linked coding education. Acting quickly ensures first-mover advantage, giving NWU time to refine features, establish adoption in multiple modules, and build a strong reputation before similar products reach maturity.

**Recommendation:** Proceed immediately with MVP development, using an agile, sprint-based delivery model to secure early value, engage lecturers in co-design, and integrate real student feedback. This phased approach will allow rapid iteration, minimise risk, and lay the groundwork for both institutional impact and long-term scalability. With its innovative value proposition, proven technical foundation, and strong alignment with academic and strategic priorities, ReCode is not just a solution to a current problem — it is a foundation for the future of digital programming education at NWU and beyond.

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