

15. Testing

15.1 Testing Strategy

Testing was carried out in a practical coursework-focused way. The strategy combines manual functional testing, role-based testing, security checks, build verification, and a small set of selected unit tests. Full automated integration and end to end UI suites are not included; that scope remains a limitation and is noted in Chapter 18. Manual testing was used because the marking criteria require visible feature evidence and screenshots.

Selected xUnit test evidence is documented in Section 15.10 as supporting evidence for isolated logic such as role constants, view-model data annotations, grading bounds, CSV export bytes, calendar link generation, password-reset email HTML, and security response headers. This evidence does not replace manual functional testing, the test plan in Section 15.9, or the Visual Studio demonstration expected by the brief. The final submission should include the test source files or a current dotnet test screenshot before automated testing is treated as fully evidenced.

The strategy is simple: test each important feature with a normal case and at least one rejection case, record the result through screenshots or audit evidence where possible, and link each test back to a requirement and marking item.

15.2 Test Environment

The test environment is the author's local machine running Windows, Visual Studio 2022, .NET 8 SDK, MySQL 8, and a modern browser. The application is started with dotnet run or through Visual Studio. The seeded demonstration users are used for sign-in. The browser developer tools are used to verify HTTPS, cookie attributes, and request/response details where relevant.

15.3 Functional Testing

Functional testing covers the path through every major feature. Each functional test starts from a known state (for example a clean database after seeding) and ends with a verified outcome. The test plan in Section 15.9 lists the individual cases.

15.4 Validation Testing

Validation testing covers data annotations, ModelState behaviour, ownership checks, and file validation. Each form is tested with valid input and with input that violates one or more rules. The expected result is a friendly validation message and no database change.

15.5 Role-Based Access Testing

Role-based access testing checks whether each role can reach the correct pages and whether restricted pages stay protected. For example, a Student can be signed in and then directed to /Courses/Create; the expected result is access denied. Similar checks are repeated for Lecturer and Administrator routes.

15.6 Database Testing

Database testing confirms that records are created, updated, and deleted correctly. The verification is done by signing in to MySQL with a database tool and inspecting the table contents after each action. The unique constraints and foreign keys are also tested by attempting to violate them through the UI.

15.7 UI and Usability Testing

UI and usability testing covers navigation, layout, alerts, and responsive design. The expectation is that each page is reachable through the role-aware menu, that each form provides appropriate feedback, and that the layout adapts to a narrow viewport.

15.8 Build Verification

Build verification is performed with dotnet build --no-restore from the project root. The build has been verified to succeed with zero warnings and zero errors. The build evidence is available as a console capture. After the registration email timestamp adjustment, the project was rebuilt successfully with zero errors.

15.9 Test Plan and Results

Table 18 lists the test plan with at least twenty-five test cases.

Test ID	Test Area	Test Scenario	Input / Setup	Expected Result	Actual Result	Status
T1	Registration	Register a new Student	Valid form	User created, signed in, audit log entry written	Manual test case listed; selected evidence attached elsewhere	Manual review
T2	Registration	Register a new Lecturer	Valid form	User created, signed in	Manual test case listed; selected evidence attached elsewhere	Manual review
T3	Registration validation	Submit register form with weak password	Password "abc"	Validation message, no user created	Manual test case listed; selected evidence attached elsewhere	Manual review
T4	Login	Log in as seeded Student	Demo credentials	Redirect to Student dashboard	Manual test case listed; selected evidence attached elsewhere	Manual review
T5	Login lockout	Submit five wrong passwords	Wrong password	Account locked, audit log entry	Manual test case listed; selected evidence attached elsewhere	Manual review
T6	Logout	Sign out	Authenticated session	Redirect to home, cookie cleared	Manual test case listed; selected evidence attached elsewhere	Manual review
T7	Forgot password	Request reset for known email	Valid email	Email sent (or token logged), generic confirmation	Manual test case listed; selected evidence attached elsewhere	Manual review

Test ID	Test Area	Test Scenario	Input / Setup	Expected Result	Actual Result	Status
T8	Student dashboard	Student opens dashboard	Authenticated student	Dashboard shows enrolled courses and deadlines	Manual test case listed; selected evidence attached elsewhere	Manual review
T9	Lecturer dashboard	Lecturer opens dashboard	Authenticated lecturer	Dashboard shows teaching summary and pending submissions	Manual test case listed; selected evidence attached elsewhere	Manual review
T10	Administrator dashboard	Administrator opens dashboard	Authenticated administrator	Dashboard shows counts and popular courses	Manual test case listed; selected evidence attached elsewhere	Manual review
T11	UI navigation	Navigate using role-aware menu	Each role	Each role sees only relevant items	Manual test case listed; selected evidence attached elsewhere	Manual review
T12	Course list	Administrator views course list	Administrator	List displayed with search and paging	Manual test case listed; selected evidence attached elsewhere	Manual review
T13	Course create	Administrator creates a course	Valid form	Course saved, redirect, audit log entry	Manual test case listed; selected evidence attached elsewhere	Manual review
T14	Course code uniqueness	Administrator creates two courses with the same code	Duplicate code	Second create rejected	Manual test case listed; selected evidence attached elsewhere	Manual review

Test ID	Test Area	Test Scenario	Input / Setup	Expected Result	Actual Result	Status
T15	Course delete	Administrator deletes a course	Course id	Course removed, related records handled	Manual test case listed; selected evidence attached elsewhere	Manual review
T16	Enrolment success	Student enrolls on an open course	Course with capacity	Enrolment saved, confirmation displayed	Manual test case listed; selected evidence attached elsewhere	Manual review
T17	Enrolment rejection	Student attempts duplicate enrolment	Already enrolled	Rejection message, no new record	Manual test case listed; selected evidence attached elsewhere	Manual review
T18	Assignment create	Lecturer creates an assignment for an owned course	Valid form	Assignment saved	Manual test case listed; selected evidence attached elsewhere	Manual review
T19	Assignment ownership	Lecturer attempts to edit an assignment for another lecturer	Other lecturer's assignment	Forbidden	Manual test case listed; selected evidence attached elsewhere	Manual review
T20	Submission upload	Student submits text and file	Enrolled student	Submission saved, file stored	Manual test case listed; selected evidence attached elsewhere	Manual review
T21	Grading	Lecturer grades a submission with valid grade	Valid grade and feedback	Grade and feedback saved, submission locked	Manual test case listed; selected evidence attached elsewhere	Manual review
T22	Reporting	Administrator opens course popularity report	Administrator	Report rows displayed	Manual test case listed; selected evidence attached elsewhere	Manual review

Test ID	Test Area	Test Scenario	Input / Setup	Expected Result	Actual Result	Status
T23	CSV export	Administrator exports a report as CSV	Administrator	CSV file downloaded	Manual test case listed; selected evidence attached elsewhere	Manual review
T24	Messaging compose	Student messages an allowed lecturer	Valid recipient	Message saved, thread updated	Manual test case listed; selected evidence attached elsewhere	Manual review
T25	Messaging restriction	Student attempts to message an unrelated lecturer	Disallowed recipient	Message rejected	Manual test case listed; selected evidence attached elsewhere	Manual review
T26	Anti-forgery	Submit POST without token using developer tools	No token	Request rejected	Manual test case listed; selected evidence attached elsewhere	Manual review
T27	Rate limit	Submit eleven login requests within a minute	Eleven requests	Eleventh receives 429	Manual test case listed; selected evidence attached elsewhere	Manual review
T28	Access denied	Student opens /Courses/Create	Authenticated student	Forbidden, audit log entry	Manual test case listed; selected evidence attached elsewhere	Manual review
T29	Validation message	Submit invalid course form	Missing required fields	Inline validation messages	Manual test case listed; selected evidence attached elsewhere	Manual review
T30	Friendly error	Trigger an error in production	Production environment	Error.cshtml page displayed	Manual test case listed; selected evidence attached elsewhere	Manual review

Test ID	Test Area	Test Scenario	Input / Setup	Expected Result	Actual Result	Status
T31	Responsive layout	Open dashboard on a narrow viewport	Browser resize	Layout adapts, navigation collapses	Manual test case listed; selected evidence attached elsewhere	Manual review
T32	Build verification	Run dotnet build --no-restore	Project root	Zero warnings and zero errors	Confirmed (build succeeded)	Confirmed
T33	Google OAuth	Open Google sign-in when OAuth values are configured	Configure d OAuth client	OAuth challenge starts and returns to the application	Manual test case listed; selected evidence attached elsewhere	Manual review
T34	Admin User Management	Administrator opens user-management list	Administrator account	User list shows username, email, role and lock status	Manual test case listed; selected evidence attached elsewhere	Manual review
T35	Admin lock/unlock	Administrator locks or unlocks a non-self account	Target user account	Status changes and audit entry is written	Manual test case listed; selected evidence attached elsewhere	Manual review
T36	Admin safety rule	Administrator attempts unsafe self-lock or last-admin action	Current administrator account	Action is blocked with a friendly message	Manual test case listed; selected evidence attached elsewhere	Manual review
T37	Mobile viewport	Open login, dashboard, navigation and form in mobile viewport	Browser responsive tools	Controls remain visible and usable	Manual test case listed; selected evidence attached elsewhere	Manual review

Table 18: Test Plan and Results

15.10 Selected Unit Testing Evidence

Selected automated unit tests are treated as supporting testing evidence only. They do not replace manual functional testing, screenshot evidence, local Visual Studio build verification, or the viva demonstration.

The tests focus on role constants, view-model data-annotation validation, and small infrastructure utilities. External dependencies such as live MySQL, SMTP, Google OAuth, and Google Cloud hosting were deliberately excluded from the automated test scope.

The test project is named `UniManage.Tests`, targets .NET 8, and uses xUnit with FluentAssertions where included in the final package. A shared `ValidationTestHelper.ValidateModel` wrapper around `Validator.TryValidateObject` is used so that each test exercises the same data-annotation validation that the controller would see during model binding. The view-model checks cover `LoginViewModel`, `RegisterViewModel`, `CourseInputViewModel`, `AssignmentInputViewModel`, and `MessageComposeViewModel`. The utility checks cover `CsvWriter`, `CalendarLink`, `MeetLinkGenerator`, `EmailTemplates.BuildPasswordResetEmail`, `SecurityHeadersMiddleware`, and grading bounds. Figure 19 shows the selected unit-test output used as supporting evidence.

Test Area	Example Test	Purpose	Evidence	Status
Role constants	AppRolesTests.AppRoles_ShouldContainExpectedRoleNames	Confirms RBAC role string constants are stable	UniManage. Tests	Source evidence and selected unit-test output included
Login validation	ViewModelValidationTests.LoginViewModel_WithMissingEmailAndPassword_ShouldBeInvalid	Confirms required login fields are enforced	UniManage. Tests	Source evidence and selected unit-test output included
Register validation	ViewModelValidationTests.RegisterViewModel_WithValidInput_ShouldBeValid and the matching negative tests	Confirms registration data annotations	UniManage. Tests	Source evidence and selected unit-test output included
Course validation	ViewModelValidationTests.CourseInputViewModel_WithMissingCodeAndName_ShouldBeInvalid	Confirms course form rules	UniManage. Tests	Source evidence and selected unit-test output included
Assignment validation	ViewModelValidationTests.AssignmentInputViewModel_WithMissingTitle_ShouldBeInvalid	Confirms assignment form rules	UniManage. Tests	Source evidence and selected unit-test output included
Messaging validation	ViewModelValidationTests.MessageComposeViewModel_WithMissingRecipientSubjectAndContent_ShouldBeInvalid	Confirms required messaging fields	UniManage. Tests	Source evidence and selected unit-test output included
Grading bounds	InfrastructureUtilityTests.SubmissionGradingRules_IsValidGrade_ShouldRespectInclusiveZeroToMax	Confirms inclusive grade bounds used with MaxPoints	UniManage. Tests	Source evidence and selected unit-test output included
CSV utility	InfrastructureUtilityTests.CsvWriter_Build_ShouldIncludeHeadersAndUtf8Bom	Confirms UTF-8 BOM and CSV header output	UniManage. Tests	Source evidence and selected unit-test output included

Test Area	Example Test	Purpose	Evidence	Status
Calendar utility	InfrastructureUtilityTests.CalendarLink_BuildIcs_ShouldContainTitleStartAndUrl	Confirms .ics content and Google Calendar URL shape	UniManage. Tests	Source evidence and selected unit-test output included
Meeting link generator	InfrastructureUtilityTests.MeetLinkGenerator_GenerateGoogleMeetUrl_ShouldReturnNonEmptyMeetUrl	Confirms generated meeting URL and validator	UniManage. Tests	Source evidence and selected unit-test output included
Password reset email	InfrastructureUtilityTests.EmailTemplates_BuildPasswordResetEmail_ShouldContainResetGuidanceAndEncodedLink	Confirms reset email content and encoded link	UniManage. Tests	Source evidence and selected unit-test output included
Security headers	InfrastructureUtilityTests.SecurityHeadersMiddleware_ShouldAddExpectedResponseHeaders	Confirms security headers added to responses	UniManage. Tests	Source evidence and selected unit-test output included

Table 19: Selected Unit Test Evidence

```
Windows PowerShell
PS C:\Users\HP\source\repos\AD COURSEWORK 2\AD COURSEWORK 2 unit-test> dotnet test ".\AD COURSEWORK 2.sln" --logger "console;verbosity=detailed"
Restore complete (0.65s)
AD COURSEWORK 2 succeeded (13.2s) + bin\Debug\net8.0\AD COURSEWORK 2.dll
UniManage.Tests succeeded (1.7s) + UniManage.Tests\bin\Debug\net8.0\UniManage.Tests.dll
A total of 1 test files matched the specified pattern.
C:\Users\HP\source\repos\AD COURSEWORK 2\AD COURSEWORK 2 unit-test\UniManage.Tests\bin\Debug\net8.0\UniManage.Tests.dll
[xUnit.net 00:00:00.00] xUnit.net VSTest Adapter v2.8.2+699d445a1a (64-bit .NET 8.0.23)
[xUnit.net 00:00:00.00] xUnit.net VSTest Adapter v2.8.2+699d445a1a (64-bit .NET 8.0.23)
[xUnit.net 00:00:01.20] Discovering: UniManage.Tests
[xUnit.net 00:00:01.29] Discovered: UniManage.Tests
[xUnit.net 00:00:01.29] Discovered: UniManage.Tests
[xUnit.net 00:00:01.30] Starting: UniManage.Tests
[xUnit.net 00:00:01.30] Starting: UniManage.Tests
Passed UniManage.Tests.AppRolesTests.AppRoles_ShouldNotContainEmptyValues [448 ms]
Passed UniManage.Tests.ViewModelValidationTests.RegisterViewModel_WithValidInput_ShouldBeValid [450 ms]
Passed UniManage.Tests.InfrastructureUtilityTests.SubmissionGradingRules_IsValidGrade_ShouldRespectInclusiveZeroToMax(grade: 100, maxPoints: 100, expected: True) [448 ms]
Passed UniManage.Tests.InfrastructureUtilityTests.SubmissionGradingRules_IsValidGrade_ShouldRespectInclusiveZeroToMax(grade: 0, maxPoints: 100, expected: True) [1 ms]
Passed UniManage.Tests.InfrastructureUtilityTests.SubmissionGradingRules_IsValidGrade_ShouldRespectInclusiveZeroToMax(grade: -0.01, maxPoints: 100, expected: False) [1 ms]
Passed UniManage.Tests.InfrastructureUtilityTests.SubmissionGradingRules_IsValidGrade_ShouldRespectInclusiveZeroToMax(grade: 100.01, maxPoints: 100, expected: False) [1 ms]
Passed UniManage.Tests.InfrastructureUtilityTests.SubmissionGradingRules_IsValidGrade_ShouldRespectInclusiveZeroToMax(grade: 50, maxPoints: 100, expected: True) [1 ms]
Passed UniManage.Tests.AppRolesTests.AppRoles_ShouldContainExpectedRoleNames [3 ms]
Passed UniManage.Tests.InfrastructureUtilityTests.MeetLinkGenerator_GenerateGoogleMeetUrl_ShouldReturnNonEmptyMeetUrl [2 ms]
Passed UniManage.Tests.ViewModelValidationTests.CourseInputViewModel_WithEnrolmentLimitOutOfRange_ShouldBeInvalid [5 ms]
Passed UniManage.Tests.InfrastructureUtilityTests.AssignmentInputViewModel_WithMissingTitle_ShouldBeInvalid [2 ms]
Passed UniManage.Tests.InfrastructureUtilityTests.CalendarLink_GoogleCalendarUrl_ShouldContainEncodedTitleAndCalendarHost [3 ms]
Passed UniManage.Tests.ViewModelValidationTests.MessageComposeViewModel_WithMissingRecipientsSubjectAndContent_ShouldBeInvalid [2 ms]
Passed UniManage.Tests.ViewModelValidationTests.LoginViewModel_WithIdentifierAndPassword_ShouldBeValid [1 ms]
Passed UniManage.Tests.ViewModelValidationTests.RegisterViewModel_WithPasswordBelowMinimumLength_ShouldBeInvalid [1 ms]
Passed UniManage.Tests.InfrastructureUtilityTests.CsvWriter_Build_ShouldIncludeHeadersAndUtf8Bom [6 ms]
Passed UniManage.Tests.ViewModelValidationTests.RegisterViewModel_WithMismatchedConfirmPassword_ShouldBeInvalid [1 ms]
Passed UniManage.Tests.InfrastructureUtilityTests.EmailTemplates_BuildPasswordResetEmail_ShouldContainResetGuidanceAndEncodedLink [6 ms]
Passed UniManage.Tests.InfrastructureUtilityTests.CalendarLink_BuildIcs_ShouldContainTitleStartAndUrl [1 ms]
Passed UniManage.Tests.InfrastructureUtilityTests.SecurityHeadersMiddleware_ShouldAddExpectedResponseHeaders [18 ms]
Passed UniManage.Tests.ViewModelValidationTests.RegisterViewModel_AllowedRoles_ShouldContainOnlyStudentAndLecturer [49 ms]
[xUnit.net 00:00:01.90] Finished: UniManage.Tests
[xUnit.net 00:00:01.90] Finished: UniManage.Tests
Passed UniManage.Tests.ViewModelValidationTests.CourseInputViewModel_WithMissingLecturerId_ShouldBeInvalid [1 ms]
Passed UniManage.Tests.ViewModelValidationTests.RegisterViewModel_WithMissingRequiredFields_ShouldBeInvalid [2 ms]
Passed UniManage.Tests.ViewModelValidationTests.AssignmentInputViewModel_WithInvalidMaxPoints_ShouldBeInvalid [1 ms]
Passed UniManage.Tests.ViewModelValidationTests.MessageComposeViewModel_WithAllRequiredFields_ShouldBeValid [1 ms]
Test Run Successful.
Total tests: 28
Passed: 28
Total time: 4.0832 Seconds
UniManage.Tests test succeeded (4.9s)
Test summary: total: 28, failed: 0, succeeded: 28, skipped: 0, duration: 4.9s
Build succeeded in 21.0s
PS C:\Users\HP\source\repos\AD COURSEWORK 2\AD COURSEWORK 2 unit-test>
```

Figure 19: Selected Unit Test Output

This screenshot shows the selected unit-test output. The test run completed successfully with 28 tests passed and 0 failed tests.

16. Challenges Faced

16.1 Technical Challenges

The main technical challenges were Identity integration with Pomelo MySQL, EF Core retry configuration, the two rate-limiting policies, QuestPDF Community licence setup, and the audit logger. These were handled by checking the official documentation, running the application, and using the audit log to confirm that important events were captured.

One challenge was keeping the final changes useful without making the system unstable close to submission. The author refined Admin User Management, environment-based configuration, seed data, and hosted testing, but avoided adding optional modules that were not central to the marking scheme. This kept the focus on authentication, dashboards, course management, enrolment, assignment and grading, reporting, communication, and security.