Agile development of computer games

Reference Link to Module Handbook:

https://www.informatik.uni-heidelberg.de/images/pruef_modul/MHB_DataCompScie_MSc_WS202122_neuePO.pdf

IMP: Advanced Practical 8 ECTS 240 h – 25h in presence (online meetings), 10 h for preparation of the presentation Assessment of the project results (software, documentation), the project report (5-10 pages), and the presentation (approx. 30 minutes plus discussion) Passing the module examination

Since you are working in a team of 3 and since we are organizing the contact meetings online over heiconf: https://heiconf.uni-heidelberg.de/hes-32w-u4v the rules are modified:

10h for preparation of presentation

30h for preparation of joint report (one report for the team)

- The length of the report is 10-20 pages: details later in this document

Use of the document:

Consider the document as a guide. Please read it carefully and adhere to the concepts described below, in particular the processes and the structure of the report.

The document provides many helpful tips and links.

ToC

1. Objective of the internship:

A:

Try out game-specific **software development processes** in a "real laboratory" with a team of ideally **3 members**.

Comment:

If you cannot find a team of 3, then the absolute minimum is 2. More than 3 team members is not efficient.

Important point: You should further develop a given start-up process that you implement exactly so that you no longer have problems with the development in the course of the project, that is neither

- communication problems
- what is tested and documented as requirements
- no programming errors - 0 errors programming due to
    - good processes
    - extensive testing
    - code review processes

In other words, we interpret each problem as a problem of the software development process and hence adjust the process individually.

B:

Learn how to use and extend a commercial game engine (Unity, Unreal Engine, Godot or others). There is an excellent documentation of these engines on the respective web-pages!

C:

Learning how to define an appropriate architecture for a given game that has the characteristics like flexibility, modularity etc.

D:

efficiently solve a large software project in a team.

At the end of the internship you should have mastered a development process so that you have implemented the zero-error strategy and have also implemented your computer game with the most important elements. You can later use this experience for other projects.

2. To the organization

We meet at the beginning (physically or virtually (e.g. via heiconf: https://heiconf.uni-heidelberg.de/hes-32w-u4v)) for the first meeting - you have already received this information by email. Here I discuss the important steps described below.

Then create a 1) Trello[1] (which is a Kanban board that is free of charge for personal use – as it is here) and a 2) GitLab/GitHub[2] (which is again free of charge for personal use) account. You may also have a 3) discord[3] account.

2.1. Management:

We meet at the beginning (kick-off) and at critical points, such as storyboard, requirements document, architecture and if necessary, if there are any questions. I always have a look at Trello to see if there are any problems - possibly a separate meeting. At the end before the report we meet again.

2.2. Trello:

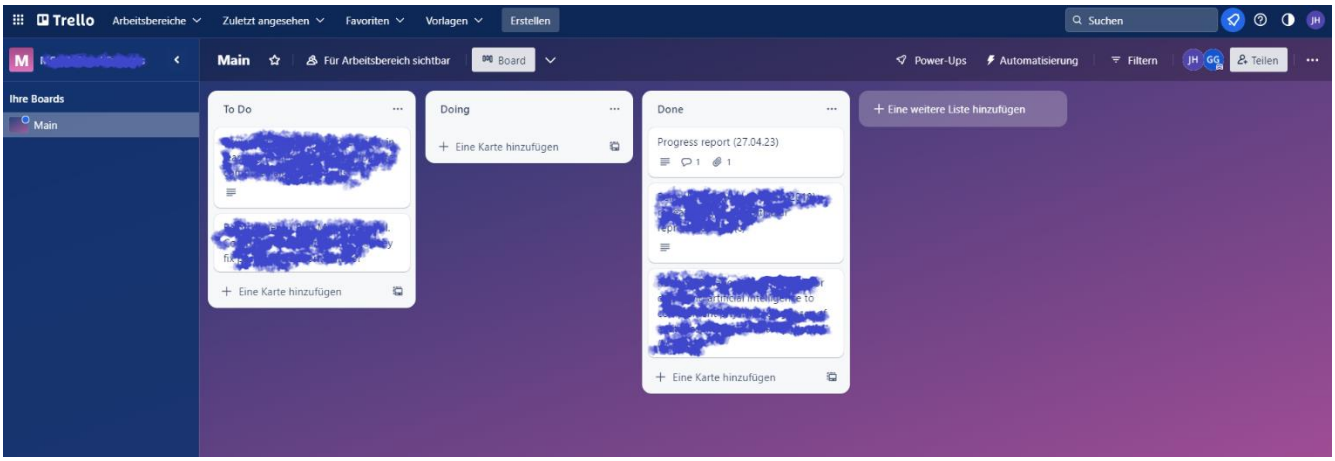
Use the Kanban structure, where at least four columns are used:

- backlog
  - contains all tasks that are still to be processed
- sprint
  - contains the tasks to be processed in the sprint, in the order in which they were processed
- active
  - on programming days, the top card is taken from Sprint and moved to Active
  - There can be more information here, such as a link to the git or the requirements
  - if the card has not been completely processed, they end up back on the sprint - right at the top
- done
  - If a card in Active has been successfully processed, it lands on Done and is therefore complete
  - if it later turns out that an error has occurred that has to do with a processed card, it ends up back on Sprint and right at the top

You can name the columns differently or add more columns. Purpose of Trello: Coordination of the project, assignment of tasks and schedule (possibly with a checklist).

With Trello, you can reference the Git directly. But you can also use different other options such as attaching files (e.g. your documentation, use-case, requirements analysis etc.), but also to insert checkboxes etc.

[1] www.trello.com
[2] www.github.com
[3] www.discord.com



2.3. Git: (e.g. GitHub)

This is a) the version control b) the place where the documentation is (versioned) c) the place where all the development tasks are as tickets (e.g. prototype, test code, code).

You can use the wiki there to store general information that is directly related to the code and not to project management.

Git uses a wiki where you can organize the programming issues that are distinct to the organization. For example, you might track the ongoing, collect detected errors with ticketing, you install a CI/CD pipeline and automatic unit testing. You can also version documents.

Git is not considered for managing larger chunks of data – there are specific solutions for that issue.

2.4. discord:

Communication tool - alternatively Slack or MS Teams.

2.5. Comments

In Trello I will then comment on the individual cards directly in the course of the internship.

Use the opportunity there to create checklists and the like. to use. Use the opportunity to learn how to optimally use Trello as a tool for management and organization.

Write the tasks and problems for it or links to the git.

We meet every 2 weeks via heiconf.

And in particular for

- use case discussion
- Requirements Document Discussion
- Architecture Discussion

Store this information in the trello – such as a dashboard so that we all can easily access all relevant information at one spot.

After that we meet every 2 weeks for a SCRUM meeting

- Discussion: previous plan: what was achieved, what not: current status
- Discussion: what went well, what didn't go so well: improvement of one's own process - see also the procedure below
- Discussion: next task list

For each SCRUM of 10 meetings I have a focus topic such as (assuming 1 full day per week where you work on the internship)

1. Time planning
2. Requirements analysis – discussion
3. Tests
4. Code
5. Process improvement
6. Planning concept
7. Architecture revisited
8. Code review
9. Lessons learned
10. Final steps

At the end there is a meeting for the report and before the presentation

- I emphasize again the essential things of the report or the presentation
- I look at the versions beforehand before they are submitted or presented

Once that's done and I agree with the latest version of the report, everyone gives a presentation of about 30 minutes, where they present

- goal of the project
- use case
- Requirements: what and why
- Architecture: how and why
- implementation
- SCRUM agile principle: as realized
- short presentation of the game with its features

When the lecture is finished, please send me the report and lecture and the internship is finished.

3. Important criteria for evaluation

1. the individual steps are well documented such as use-case/game storyboard, requirements analysis, architecture, documentation (including that of the tests), correct use of tools such as Git (version control, automatic testing with unit tests), Trello and correct administration with Kanban board are taken into account .
    a. it is expected that the above points will be processed in accordance with the previous courses you had in your study of computer science
2. then it is checked to what extent the goal of agile development of a game has been implemented, i.e.:
    a. Did you implement the process correctly?
    b. you have significantly improved the process
3. Documentation of the internship: Report according to the template below: clear, understandable structure, no experience report, but an objective and factual description of the procedure

    Quality of the report
    a. Presentation (legible, understandable, correct, appropriateness of language)
    b. Content: describes the main points as mentioned above

4. Presentation according to the contents of the documentation:
    a. Clear and understandable presentation of the content (no spelling mistakes, etc.)
    b. Slides are informative and well structured
    c. Content: the essential points of the report are described in the presentation
    d. Demonstration of the game (online)

PS To be on the safe side, I look at the report and slides beforehand, but please don't get out of hand, i.e. the number of iterations should be closer to 1. Hence the structure that I specify, so that nothing could actually be done on my part when it was carefully implemented.

4. Formal results

1. Report of approx. 10-20 pages see below
2. presentation of results
    a. Objectives of the internship
    b. development steps
    c. result of the game
    d. Agile development: what is the concept, how is it realized

5. The steps:

5.1. Creating a storyboard/use case: 1 day

For the use case/storyboard, the following items should be included:

1. storyboard
2. UML diagrams (see UML-diagrams)

- in any case in use-case diagram
- an activity or interaction diagram - or both
- possibly a state machine diagram
- further diagrams are possible if they still characterize the game well

5.1.1. storyboard

A storyboard is used to characterize the core graphic elements of a game, e.g. the appearance of game characters, the environment, etc. It can also be used to represent the content of a game very well.

good tool: https://www.stormboard.com/

https://www.picmention.de/blog/storyboard-erstellen-zeichn-162/

https://www.referencefilm.de/filmwissen/storyboard/storyboard-erstellen/

https://www.dummies.com/programming/programming-games/designing-video-games/

https://gamescrye.com/blog/how-to-storyboard-your-game/

https://gamestorming.com/storyboard/

https://itstillworks.com/12196599/how-to-design-a-game-storyboard

https://www.cs.cornell.edu/courses/cs3152/2013sp/labs/design1/

5.1.2. UML diagrams

It has turned out that different UML views are well suited to formulating the use-cases, including:

(see also https://creately.com/blog/diagrams/uml-diagram-types-examples/)

- use-case diagram: roughly describes the interaction between players and the components of the game
- activity diagram: describes well a game mechanic from the point of view of the processes
- state machine diagram: defines state machines that can be easily integrated into the game and formally describe the course of the game so that nothing is forgotten - many errors are based on something being created but no longer destroyed, something being opened but no longer closed; this can be seen quickly in a state machine

- interaction overview Diagram: gives an overview of the game mechanics from the point of view of interactions

5.1.3. Create requirements analysis 2 days

- as in lecture

The requirements analysis should be done at the beginning, but it is a dynamic document: You should formulate the requirements in such a way that it is clear how this is tested or how functions, for example, ensure that the requirements are met. Initially, you have no clear picture of the game and you might have not sufficient information how to realize all parts; hence you will have a first draft that reflects the state of knowledge.

The text document should be versioned in Git (e.g. GitLab or GitHub).

The final version of the requirements should then be available at the end.

Below there is a standard template for writing a requirements analysis document. Stick to it whenever it is appropriate. If some points are not appropriate, leave them out.

Sub-items are always numbered!

Structure from the lecture or as an example - ideally as a text file versioned in Git!

The first version goes in the report, the last in the appendix of the report.

Structure of the requirements analysis

- 1. Introduction
- 1.1. Purpose of the system
- 1.2. Scope of the system
- 1.3. Objectives and success criteria of the project
- 1.4. Definitions, acronyms, and abbreviations
- 1.5. References
- 1.6. Overview
- 2. Proposed system
- 2.1. Overview
- 2.2. Functional requirements

  % Please number all sub-items

  % The big mistake at the beginning is that the requirements are specified far too vaguely, so the requirements should be specified as much as is possible at the current stage and they should be verifiable

  % If a request is found to be unreachable, it will be marked as unreachable

  % BEFORE PLANNING the TASKS in SCRUM MEETINGS, the requirement is specified in detail.

- 2.3. Nonfunctional requirements

  % Please include the coding style here, as well as the performance as the frame rate that is to be achieved

  % the requirements are written in such a way that they can also be checked - later this should also be checked explicitly in the results
- 2.3.1. User interface and human factors
- 2.3.2. Documentation
- 2.3.3. Hardware considerations
- 2.3.4. Performance characteristics
- 2.3.5. Error handling and extreme conditions
- 2.3.6. Quality issues
- 2.3.7. System modifications
- 2.3.8. Physical environment
- 2.3.9. Security issues
- 2.3.10. Resource issues
- 2.4. Pseudo requirements
- 2.5. System models
- 2.5.1. Scenarios
- 2.5.2. Use case model
- 2.5.3. Object model
- 2.5.3.1. Data dictionary
- 2.5.3.2. Class diagrams
- 2.5.4. Dynamic models
- 2.5.5. User-interface -- navigational paths and screen mock-ups
- 3. Glossary

Examples:

Good practice examples for use case, functional requirements and development process:

https://docs.google.com/document/d/1CayV6jYnNfRcY_39pDNZKR3tZzQeFna2ZCIA71M8ySc/edit?usp=sharing

Slides:

https://docs.google.com/presentation/d/1YdQA-h8KIhxamIigdc7y1Dpm9j17HAF5RPyYx4YbItM/edit?usp=sharing

You might use tools such as

https://use-case-maker.sourceforge.net/features.html

that help to collect the information and display it in a structured way.

UML Designer is also a nice tool to generate UML diagrams or use instead draw.io

5.2. Develop and document architecture: 2 days

- think carefully about which architecture is chosen, test beforehand what works in game engine (unity)
- Functional and non-functional requirements
- number everything so that you can refer to it later in the tasks
- write everything in such a way that you can later objectively verify that the tasks have the desired result (test cases)

When it comes to the architecture, it should also be considered to make it as modular and expandable as possible. You start with a minimal system that leads to a first playable system. This should be created as early as possible. After that, further components are specified in the requirements and then the architecture is expanded.

Often, instead of an architecture, a class diagram is provided – which is also ok. It defines the main interfaces so that the development later would be easier.

Tip: Start with a concrete, simple example and go in two directions:

- higher abstraction
- further components / classes (e.g. through inheritance from the parent class)
    - component-based architectures are more flexible

- test beforehand what works in game engine (unity)
- Architecture must be described: see lecture
- UML diagrams: different views
    - classes - structure
    - activities
    - Behavior: State Diagrams
    - interactions

Represent architecture:

tip:

https://www.st.cs.uni-saarland.de/edu/se/2015/files/slides/08_Software%20Architecture.pdf

The architecture should be such that it can be developed incrementally! KEEP IT HIGHLY MODULAR! You never know whether you might have to modify it (in most cases this happens!)

The architecture is versioned and stored in Git.

You develop the game on the basis of a compiled language, not with the scripts, since these are not that powerful and you often lose the overview with larger projects.

Comment:

Simple games can also use a UML class diagram instead of an architecture, more complex games benefit enormously from the arrangement of the classes in modules, which then represent the respective architectural elements between which communication takes place.

If you create a class diagram:

Always consider whether you can use an abstract class as an interface. Use components and inheritance hierarchies, use generic programming[4] (C++: templates) if it makes sense. And always think about sensible and suitable data structures that are simple/elegant on the one hand and efficient on the other.

Take also into consideration to use design patterns[5] such as

- manager classes (singletons)
- controllers
- factory patterns
- decorator classes etc.

5.3. SCRUM eff. 16 working days, 10-12 contact meetings

development process

At the beginning of this chapter the given development process. You must follow this process exactly at the beginning, and then expand and improve (not shorten!) it accordingly.

[4] C# https://learn.microsoft.com/en-us/dotnet/csharp/fundamentals/types/generics C++: templates
[5] https://refactoring.guru/design-patterns

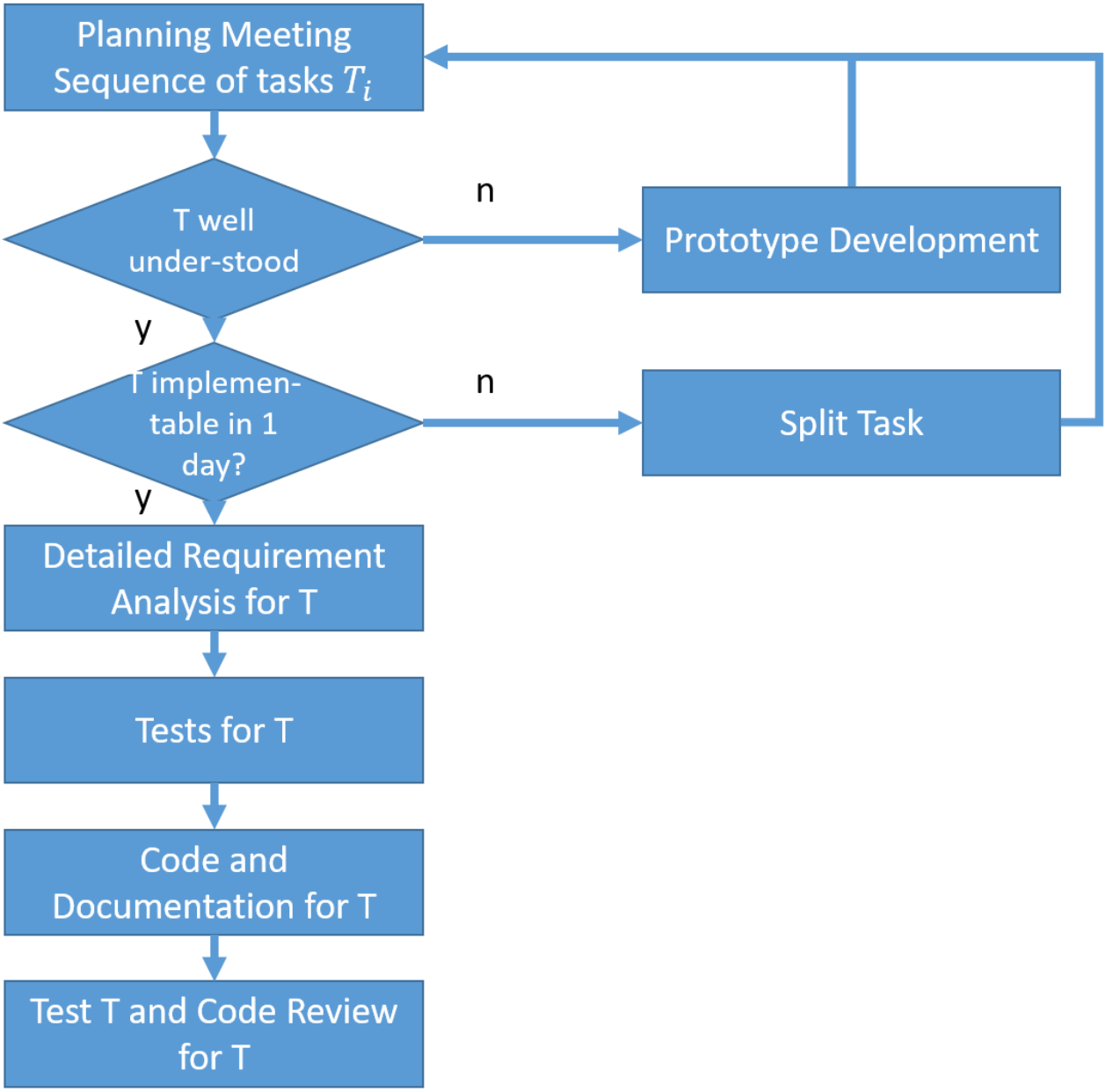


Figure: Defined process (obligatory):

1. Sequence of tasks according to necessity (abstract before concrete class) or relevance
2. Task T ok means that you completely understand how to implement it, how to correctly use the game engine interfaces and classes necessary and how to test it. If any of these conditions is not met: develop a prototype for each open question (and define this prototype development as a new task)
3. If the task takes more than a day to realize, split it into sub-tasks: Generally: The implementation strategy for a class is the following
    a. Define first the interfaces, i.e.
        i. the class header and parent class(es) including the generic model (e.g. template)
        ii. the class attributes

iii. the interface of the class methods (public, private, protected), i.e. just the method head without any content; and if this is a return-type method, return 0.

b. This interface should be written before starting writing the test since this defines how the test accesses the methods in the class.

4. Writing tests: Use tests whenever possible (it is an essential element of the CI/CD pipeline). The game engines often provide strategies for Test Driven Design development[6].
5. Writing the code requires that you adhere to clean code development[7].
    a. Typically, the code for a method should not be more than 10 lines (which easily fits on a screen): if it is longer, group the code into private methods that are called.
    b. When methods from the game engine have a lot of arguments and only a few are relevant, there is often a good idea to have a decorator or interface method with only the few parameters that are necessary and hide the remaining complexity.
    c. It is often also a good idea to refer a structure element to a named variable with is easier to understand – the code gets shorter and easier to understand.
6. Coding should be directly followed by documentation using a standard documentation tool such as Doxygen[8] or Sphinx[9].

Structure of YOUR planning meeting:

- discussion of current status of work
    - what has been reached, what has been shifted
    - validation of process changes
- Which problems occurred?
    - Why did they occur?
    - Which process step was not optimal?
    - How to improve the process?
- Which is the next task T to be processed?
    - According to functionality and relevance
    - Consider the logical order from dependencies i.e. abstract class before concrete class

It is IMPORTANT not to forget the discussion of your planning process WHENEVER you experienced problems or errors in the code. Each of these problems is considered as a process problem and you find out what might have been the reason for this problem and reason about strategies to fix it. Always check whether the process modification was successful.

5.4. Process:

Your planning meetings

Preparation: about 1/2 day

[6] https://blog.unity.com/technology/testing-test-driven-development-with-the-unity-test-runner
[7] https://www.codingdojo.com/blog/clean-code-techniques
[8] https://www.doxygen.nl/
[9] https://www.sphinx-doc.org/en/master/

Duration: <1 hour

- 1x per week with the following agenda:
    - what was done
    - what problems occurred
    - what solutions are there, how to improve the process for the next sprint
    - what should be done, specify requirements and update the requirements document
      → It is best to enter this in a log list (see below).
    - define detailed tasks that can be completed in one day
        - Possibly use prototyping to understand how to fully specify a task or to understand how to implement it.
        - Prototypes should be small software snippets, you write down the question beforehand that the prototype should answer and then make the prototype for exactly that question e.g. by varying a similar example until it does what you want it to do. You write the result down and then you can use it for the requirements, tests and later code.
    - Priority list of tasks
- pay attention to clean code - possibly introduce code reviews

Sprint 10-12x every two weeks (with me as "product owner")

Coding:

- Use one full day for implementation once a week
    - Update (detail out) the requirement if necessary
    - Derive tests from the requirements, which means
        - trivial methods/functions: review process
            - e.g. only a few lines of code
            - no loops or branches
            - no sub-functions/complex method calls
        - test more complex functions
            - assertions for the correctness of the ranges of the input variables are useful
            - develop unit tests for each complex method/function
    - write code
    - Testing / code review
    - If not successful: back to SPRINT and document errors: see log list: this results in a process change
    - Internal list (e.g. Excel list: how long was the test writing, code writing and testing? Which errors were not caught by the tests? Where do new tests have to be written? How can this be done better: what kind of tests, what code rules?):

        - this list will help for a. planning the length and complexity of new tasks, b. formulating tests: how and what to test, c. the code quality, how to write the code to produce fewer errors.
        - see time estimate below
- In the sprint meetings, I will gradually explore the following points
    - Setup and structure of the Trello board
    - Verify requirements analysis
        - complete (all elements and their behavior defined)
        - does not contain any unclear parts, e.g. fast -> how fast, state number
        - it is formulated in such a way that it is clear how the tests are to be written
    - Tests: are the tests, given the requirements, complete, only very simple tests were left out, which were then dealt with in the code reviews (please document).
    - Code: is the code (clean code): look for details that characterizes clean code
        - well documented and structured in such a way that it is easy to read and understand,
        - Typical problems such as catching possible errors (division by 0, uninitialized variables, etc.) have been avoided - if not, there is a comment explaining why an error cannot occur,
        - it is guaranteed by means of assertions that the preconditions (i.e. e.g. variables are in the correct range - are the valid ranges specified in the documentation and
        - was it programmed conservatively, e.g. was unsigned xxx used for positive variables?
    - Code review process: how was this approached, in particular
        - what questions were asked, such as
            - good structure of the code (see point before)
            - you can follow the process so well that you can clearly see whether the requirement you are looking for is met
            - any code conventions you give yourself are met
            - Process changes: have you made any process changes?
        - Make a check list for the code review and look what are good code review practice guidelines

Table for Sprint Meetings

Date, Sprint Meeting Number	What was done: Task Number	Problems • which • why • suggestion for solution	Next Tasks • sorted List according to relevance

Please formally write down your process at the beginning and then change it each time, commenting why you are making a change and what caused it.

A graphical representation is very useful.

As a general rule, you should always have improvements in your process within the first 4-6 weeks. Any problem like “I don't know what to write as a requirement” (then the task needs to be scaled down because obviously the task was too complex - or it's not so clear how EXACTLY to implement the code), “it's unclear how the test is written" (then the requirement is either incomplete or not clearly written, because it must be written in a way that makes it clear how to test), "I don't know how to implement this" (then have to you try out how you do it with a prototype beforehand), “I had bugs in the code” (then the cause was a bug in your process, e.g. you could have done a code review to avoid typos or unnecessarily complex code or it is a consequential error, then you have not tested extensively and there is a lack of control as to whether everything is complete) is therefore specifically related to the process and any problem that occurs should be accompanied by a process change on how this can be remedied.

Process change table

Ideally, you write a log list in your Trello:

Task Number	Errortype	Reason for Error	Process Change	Validation of changed process if error still occurs

Since many find it difficult to understand how a process should be changed to make it better, here are a few examples:

<u>Example 1:</u>

Errors: Similar errors always occur during programming, e.g. uninitialized variables.

Process change:

Specifically, the code review process should include further investigation and see if this type of error was avoided here.

The code review process is expanded to include a check list containing all items to be checked.

<u>Example 2:</u>

Error: The process was changed, but the errors reappeared.

Process change:

In the case of process changes, this process is described in a table (see above) and specifically examined at each planning meeting to determine whether the change was successful.

<u>Example 3:</u>

Bug: The game engine was misused due to not fully understanding how to use some elements.

Process change:

Prototyping is done using examples to understand how the game engine is used. But this does not cover the case that e.g. in the given context the game engine behaves differently than in the example.

Therefore, a branch is created and then a prototype is written, how the implementation is imagined. If this implementation works, the requirements are fully defined, the tests are written and then the code including code review.

If it doesn't work, the prototype is further investigated and experimentally modified until it works.

Example 4:

Error: The prototype was too big and took more than a day:

Process Change: Make a list of how long it will take you to implement a small prototype. To do this, estimate the complexity, e.g. based on the required elements of the game engine or the number of functional elements such as transfer variables, etc. and write the time you needed to implement the prototype.

They can also introduce elements like integration tests, tables to document all test cases, establish coding guidelines, introduce structures for their planning meetings, etc.

It is very helpful if you also use Trello for all collected information and tables.

5.5. time estimate

You should learn to estimate how much time you need at the beginning.

It is best to keep a diary in which you enter the following data for each task:

Task - develop code:

Supplementing the list of requirements (at the time you know exactly which functionalities of the Unity Framework, for example, you want to use and you already have the code in mind - now you should also be able to write down exactly what the method does)

Formulate and implement the tests that should ultimately test all requirements. If you have trouble here, you have not written the requirements completely and clearly.

Writing the code, always considering whether you are actually only implementing the requirements that you have written.

Testing: when a test goes wrong, your best bet is to note what goes wrong and why - and finally investigate what point in your process led to it: that's the point in your SCRUM meeting.

So each journal entry has the following line with minutes taken for each part:

Time estimation table

Date and Task Number	Complexity of Tasks 1-10 (estimated)	Formulate requirements	Tests writing	Code writing	Test execution and error reporting	Comment what went wrong

Over time you will learn how much time what costs and how this has to do with the complexity of the task. If you want, you can estimate that using linear regression.

6. Test-Driven Design - a must!!!!

This part is written since often there are difficulties to test the own code.

6.1. Recommendations

For information on how to develop tests:

https://www.informatik-aktuell.de/entwicklung/instrumente/was-ist-ein-guter-unit-test-und-wie-develops-man-ihn.html

See also:

https://www.browserstack.com/guide/learn-software-application-testing

https://techbeacon.com/app-dev-testing/5-key-software-testing-steps-every-engineer-should-perform

https://www.guru99.com/software-testing.html

https://www.testim.io/blog/software-testing-basics/

Here we have to distinguish two things:

- If it is clear what exactly is being developed and how something is needed, then test-driven design is used.
- If it is not entirely clear what is to be done, how something is to be realized or whether something is going to work the way it is imagined, a prototype is developed first. If the prototype works, it can be used as a further test, if it works without errors - if not, then it only serves as a construction site from which you can use for the final development (only concepts, no copy-paste of the code, because that otherwise leads to careless mistakes and ugly code).
- for each point that is implemented, the requirement defines what is to be tested
- then unit tests are written that show that the requirement is met

    - Interface tests: correct ranges, correct values in output given inputs: Interfaces are defined in architecture and both sides must be tested
    - Assertions: Intercepting errors with incorrect inputs or incorrect outputs and bounds checks / is switched off again in productive operation
    - Try-catch for file handling problems or over/underflow

- write tests first, then code
- a task should last one day
- if the task turns out to be too complex to implement, identify reasons and then return to the task list: reconsider
    - Often there are too many dependencies
    - Too much is often put into the task
    - When programming, you often notice that some things were not taken into account: only then do you understand how it works (prototype) and back to the task list
- use unit tests
- Use test tools to find memory leaks (depends on the programming language)
- Use assertions to catch cases on the fly, no printouts, and only debug when there's no other option.
- Define lint or coding style (for all languages there is a lint that can be used to check the coding style: e.g. cpplint or pylint).
- Set up code review boards, i.e. when code is written, have another review meeting in pairs
- Early deployment - develop to always have a running game, i.e. incremental functionality!

There was always the question of how to test. So here's a quick note:

The requirements in the requirements document must be formulated in such a way that it is clear how they can be verified - if this is not possible, the requirements are formulated incorrectly and cannot be verified and are therefore not a requirement in the classic sense.

The verification of the requirements can be done in two ways:

- Is the functionality available?

- Does the requirement meet your criteria: this can be tested automatically by writing a test routine.

A requirement exists if it is correctly implemented: In the case of methods in particular, one formulates:

A test is carried out to determine whether the input variables are set correctly.

For a set of pairs of input variables - correct output takes place, so that statistically the typical application scenarios are covered: i.e. typical inputs, wrong inputs (should be caught), inputs on the edge (e.g. positive integer expected, test for -1, 0, +1)

These are the methods of black-box testing, which are the bare minimum for a reasonable test.

https://www.guru99.com/test-driven-development.html

The wiki also offers a good overview: https://de.wikipedia.org/wiki/Testtriebe_Entwicklung

or this lecture: https://www.cs.colorado.edu/~kena/classes/5828/s09/lectures/21-tdd.pdf

Each test is documented, i.e. it is described exactly how what is tested. If test stimuli are used (input-output pairs), then justification is given for how these are chosen. The documentation of a test is part of the program documentation.

https://de.wikipedia.org/wiki/Software_Test_Documentation

Use static code analysis whenever possible. It is recommended to perform a static code analysis

Here is a link to tools:

https://en.wikipedia.org/wiki/List_of_tools_for_static_code_analysis

6.2. code review

It makes sense to carry out a code review, this allows major errors to be eliminated before the test. You can then document this either in Trello or, even better, in Git, then you always know the current status of the project.

Good approach for code review:

- Is the code easy to read and well documented: if not: comment
- Have the requirements been formulated under which the code should be correct: in which range are the input variables, is this also checked?
- Are the variables always maximally constrained that are passed to let the compiler do the static test
- If the names of all variables, etc. are good, the code is well formatted, brackets are set sensibly, coding guidelines may have been correctly implemented
- Is only implemented what is also tested or what is trivial to check.
- Can you walk through the code and clearly demonstrate that it's doing the right thing? If not, then tests must be written

Here is a nice link that gives you valuable help in how to perform efficient code review:

https://www.atlassian.com/blog/add-ons/code-review-best-practices

Using the Kanban Board for Agile Development: Columns (can be named slightly differently, but should contain this information)

1. backlog
2. SPRINT: Tasks for current sprint: each task should include one day:
3. please plan, write down how long it really lasted
4. for the subsequent planning, the complexity of the tasks is reduced, tasks may be split
5. ACTIVE: In progress: for each max. 1-2 tasks
6. DONE: Completed
7. (possibly) improvements

Swimming lane in Kanban board: each has its own row

A new sprint every 5 working days

1. consider what went well and what didn't go so well - retrospective view
2. new task list for the next sprint: Adjust task complexity based on experience
3. Test-driven design: were the tests sufficient, if not, define how the tests are made better
    a. possibly schedule code reviews if task is complex: extra day for two team members
4. Cross check with requirements
    a. missing requirements
    b. if the requirements are not precise: then do not develop any code, but first adapt the requirements
    c. tasks are too complex because there is a lack of experience: first develop the prototype, then the task

Tip: An essential point at the beginning will be that you learn to correctly estimate the time you need for each task.

7. Version control

Use GitLab or GitHub

- Use version control for the code
    - initially build a minimal version that serves as a deployment reference - can be quite minimal that it just shows an empty window without any function.
    - Everyone who checks out first builds their own branch and when it runs, it is transferred back to the main branch
        - this is tested by running the unit tests all successfully
        - This is then documented in such a way that everyone is informed
    - each unit test is run again with each transfer
    - if it turns out that there are still bugs, the unit tests will need to be updated to include that test
        - a ticket is created in GitLab/GitHub and processed
    - Ideally, refactoring is not necessary with a structured approach:
        - if it turns out that something has been forgotten, this must first be documented and then the refactoring carried out
        - The same goes for the requirement: if it turns out that requirements are missing or imprecise, they must be specified, then it must be checked whether the architecture still needs to be updated and then move on
        - Ditto for the architecture - which, however, is defined as early as possible with regard to interfaces so that no refactorings are necessary
    - You can use the wiki in GitLab/GitHub
    - You can automatically run the unit tests before check-in so that it doesn't forget.
    - Trello has a GitHub plugin that you can use to manage GitHub from Trello.

Unity also offers a version control system - that would be the alternative but you can also use the standard git – to use less memory, you can use the gitignore option.

Take your time to better understand the possibilities of the given version control systems.

8. Documentation of the code

The code should be documented in e.g. Doxygen or Sphinx. You can also use other tools for UML, and I would be happy to include a list of tools here that make sense from your side.

The documentation files are versioned in Git.

9. Communication

discord can be recommended for group discussion with a clear conscience, but of course you can use any other tool as well.

10. Report: 10-20 pages 5 days

Summarize all documents such as storyboard, specification (at the beginning and end), architecture and documented result in one report; short presentation at the end.

Issues:

- must write clearly in writing
- what agile development should look like
- how test driven design should be
    - how to do tests
- how game description or use case should be
- how the requirements analysis should be and how precise that the tests that describe the fulfillment of the requirements are derived from it
- how architectures are described and which essential architectures exist
- how to estimate and then improve the working time per task
- how to do a retrospective analysis every 5 days
- The report
    - must be structured more clearly - specify structure
    - the discussion should be like this
    - what was specified
    - How did we implement this as close to the specifications as possible
    - why did we deviate
    - did it make sense to deviate?
    - what went well, what didn't
    - if not, why not
    - how can this be done better

https://softwareresearch.net/fileadmin/src/docs/teaching/WS05/SE1/04Folien_Kapitel6_Teil2.pdf

10.1. Contents

Chapter - Introduction & Basics:

Goal of the internship:

"The goal of the internship is to learn agile development processes similar to SCRUM and to further optimize the own process in order to achieve a 0-error level."

Most important frameworks and classes and terms of Unreal Engine or Unity (these are the most often used game engines).

Chapter - Use case, requirements analysis and architecture (each sub-chapter)

Brief description of what the end product should look like. So basically a short version of the GDD (Game Development Document), starting with the storyboard, the requirements derived from it and the architecture with which the requirements are to be realized.

The respective documents (at the beginning and at the end should follow as an attachment).

Chapter - Implementation

How were the requirements technically implemented?

Brief description of the components.

Then essential results/scenes as a screenshot.

Chapter - Development Process (should cover about half of the report)

Describe and analyze the development process and present it graphically as a process, namely how it was at the beginning and how it developed - and what was the cause and the change in the process).

What components did the agile development process have and what is it based on.

The best thing to do is to first write the given process that you implemented first and then your changes. Use a graphical representation of the process as you should implement it (containing Test Driven Development (TDD) and Prototyping). And then you depict on this graphics how you modified the process.

Keep in mind that with the changes there was always a reason why the process was improved and you made a change on the basis and examined whether it also achieved the goal.

- What is the role of each component?
- How were the components implemented in each case?
- for each component: what worked, what didn't and if not, why not
- If you had to play the game again, how would you do it now after that experience?
- What was good/bad? How good was our effort estimation / time planning in hindsight? What have we learned (Lessons Learned)? Perspective on what can be done better.

Main focus: These two components MUST be used to successfully accomplish the internship

Test-Driven Development

- Agile development strategy
- How good were the use cases for characterizing the requirements
- How good were the requirements for the later implementation
- How appropriate was the architecture, what went well and what didn't

Prototyping

- Use prototypes whenever there are open questions of

    - How to realize the requirements – make a prototype that tells you what can be realized and what components are necessary as requirement
    - How to realize the code: unknown functions from the game engine, unclear API and specification, unclear how to test
- Each open question is an own prototype (keep it short) and register it as a task
- Each prototype should be as simple as possible just as big as necessary to answer a task
    - You should be able to implement the prototype within a few hours
- To understand interfaces/API, start with an example provided by the game engine documentation and modify that slightly until you end up with the code that solves your problem
- You can use the scripting abilities for prototyping since this guarantees a shorter cycle time

What was the development process like

- Test-driven development: What went well, where were problems
- Agile development with estimation of effort, management, improvement of the process

Development Environment:

It makes sense to use the same development environment for each party of the team.

Use code documentation tools (Doxygen, Sphinx) - available for all languages, saves a lot of work, should always be used and for every task (last step if task is otherwise completed): assign meaningful names, document not what, but why (clean code principles).

Use good programming style

- Maximum restriction for the variables: don't use an `int` but use a range if the values should be in a range - errors will then be recognized automatically
- Always use try - catch when loading or saving things - because there's always a chance that something isn't there.
- Division by zero, overflow, underflow: this should always be tested at least in the development stage - see also `try – catch`
- Quality before quantity:
- rather less features than poorly implemented or documented/planned features
- always make it clear what you are currently working on in the specification/requirement with the task
- Document what didn't go so well in the process and how it could be done better

It is also instructive how you changed the development process in the course of the project: what was the reason, what was changed and how did that affect it?

Outline the process flow with a sketch and make it clear where and why you have made changes compared to the original version.

Attachment/Appendix

1. Final requirements analysis - latest Git release
2. Doxygen document synthesized from the documented code
3. Possibly further systems, if useful

11. Presentation 4 days

The presentation is based on the structure of the report. It should last about 30 minutes (about 15-20 slides), then the game should be presented and at the end there are questions about the lecture and the game.

Orientation of the structure according to the report

We do a trial presentation about 1 week before the presentation date

Please send me the following information for each participant by this time at the latest:

Surname, first name, matriculation number

12. Tips and experiences

Start with a minimum viable product

Carry out usability tests with friends and revise the design based on the feedback

Agree on a programming style

Use same versions, use CI in GitLab/GitHub

Consider tests sensibly:

And consider which tests are necessary, which are minimal, automate

Use a good tool for communication

- WhatsApp
- discord
- note

Take care of clean code