Object-Oriented Programming

Research Topics and Report

To achieve a High Distinction in this unit you must demonstrate your ability to think deeply about areas related to object-oriented programming. You can achieve this by performing a short research project and
writing up your findings in a research report. This document outlines some ideas for projects that you may
consider performing, and an approach for writing up the results as a research report.

Basic Research Process

For this project you will need to carry out the following steps, each of which is described in the following sections with a short demonstrative example that helps to highlight the process (note that the example is not related directly to the unit).

1. Find a topic you are interested in learning more about.
2. Determine one or more questions you can look to answer.
3. Come up with a way of getting some data to help answer the question.
4. Carry out your experiment, collecting data
5. Think about what your data are telling you
6. Write up what you found so that others can learn from what you have done.

Finding a Topic

This is mostly up to you, but make sure that your topic is related to the Unit Learning Outcomes. Remember: your objective is to demonstrate your ability to think deeply about a topic related to these learning outcomes. The *Research Topic Ideas* section contains some ideas to get you started, but you can choose any topic that interests you... just make sure that you check it with the convenor to make sure it will be suitable.

Example: If I am studying refrigeration I may have the following topic... *ice-cream*. I have noticed that people seem to enjoy ice-cream, but that it tends to have temperature related issues in summer. Perhaps what I have learned about refrigeration could help.

Determining Questions

Research should be driven by questions, ideally questions that will require us to think deeply about topics related to the Unit Learning Outcomes. Once you have your topic, think up some questions you could look to answer. Try to avoid questions that will lead to yes/no answers, you want to be able to discuss the answer in depth.

Example: For our refrigeration topic "ice-cream", we could have questions and sub questions:

- What devices are suitable for storing ice-cream?
  - How long does the ice-cream need to be stored before consuming?
  - ...
- What is the ideal temperature to store ice-cream for sale?
  - Does this change for different kinds of ice-creams?
  - Is this impacted by the storage device, and if so how?

Deciding on a Method

Now you need a method to help you answer the question. You want to have a repeatable method so that others can verify your results, so define your method as precisely as possible. Make sure that your method will let you collect some data for you to analyse.

Example: For our refrigeration topic "ice-cream", we could use the following method. Each of these steps would need to be carefully described and carried out in the same way to make it repeatable, but this should give you some idea.

1. Determine different devices that can be used to store/keep ice-cream at low temperatures
    - This will involve us selecting appropriate devices, and purchasing them
2. Select a variety of ice-cream examples
    - Come up with a way of classifying these
3. Store ice-creams in different refrigeration devices set to different temperatures for different times
    - Determine appropriate range of temperatures and times of storage
4. Eat ice-cream
    - Get multiple people to eat ice-cream, record how satisfied they are (come up with scale for this) as a function of the various control variables (type of ice-cream, type of refrigeration device, temperature of fridge, time in fridge, etc.)

Carry Out Experiment

Perform the steps in your method. If you identify shortcomings with your method you can adjust it, but make sure that all of your results are from the same method. Record the data that you collect in a spreadsheet, or something similar. Make sure you run programs a number of times to understand any variability; you can then include averages, standard deviations, etc.

Example: For our refrigeration topic "ice-cream" we would:

1. Select a freezer, fridge, and esky... record operating temperature ranges
2. Choose various ice-cream types... classify as "on stick", "in tub", "other", record weights, etc.
3. Eat lots of ice-cream with friends, recording time and temperature details

Thinking About Data

What do your data tell you? Can you come up with any advice or conclusions from looking over what you have collected?

Example: For our refrigeration topic "ice-cream" we may come up with things like:

1. Most people enjoyed the ice-cream between *x* and *y* degrees.
2. The most effective means of storage was the freezer, which maintained ...
3. With the esky and fridge you want a low initial temperature and short time, examine satisfaction graph
4. Think about usage scenarios for each device:
    - Freezer - long term storage, limited by requirement for power
    - Esky - portable but poor storage, requires other heat storage (ice)
    - Fridge - same limits as freezer, but no advantages for portability
5. Advice:
    - Use freezer most of the time
    - For trips to the park an esky can be used if ice-cream has an initial temperature of *x* and time to consumption is between *a* and *b* hours.

Writing Up Your Research

Now that you have something to tell people, its time to write up your findings. A research report for this unit would be expected to contain the following sections:

1. **Abstract**: The abstract contains a brief summary of the paper.
2. **Introduction**: Provides background details and outlines paper structure.
3. **Method**: Describes how you conducted the research.
4. **Results**: Outlines the results you obtained.
5. **Discussion**: Includes your analysis and thoughts on the results you found.
6. **Conclusion**: Summarise the paper and its findings, suggest future things people could look into following this research.

Abstract

Write a summary of the whole paper in one paragraph. This can be written at the start to help you focus on the paper's content and message, but if you are struggling with that you can write the abstract last.

Example: For our refrigeration topic "ice-cream" we may come up with things like:

> Ice-cream is a delicious treat in summer. Unfortunately, the high temperature conditions of the summer season make it difficult to keep ice-cream at the optimal temperature for consumption. This research project investigated the use of refrigeration devices as a method of providing optimal ice-cream consumption conditions. It was found that ice-cream should be consumed between *x* and *y* degrees and that this temperature can be achieved using freezers. Where a portable solution is required an esky can be used as a temporary storage device as long as certain conditions are met. We therefore recommend the use of RDs for storing and transporting ice-cream.

Introduction

Tell the reader what you are discussing in this report. Make sure that you provide all of the background information that they will need to make sense of what you are going to communicate in the method, results, and discussion.

Example: For the refrigeration topic "ice-cream" the introduction would briefly introduce ice-cream, why it needs to be stored at low temperatures, and the various types of devices that could be used for this (including ones not used in the research).

Method

Communicate the research method as it was carried out. This should be in past tense, "It was decided to...", "We chose to include..."

Example: For the refrigeration topic "ice-cream" the method section would describe in detail how we carried out the collection of the data. "We chose to use a fridge, freezer, and esky as these devices provide a good range of ... While a blast freezer was also considered, it was not selected due to cost limitations."

Results

Present the data that you collected here, along with text to highlight sections that you think the reader should pay attention to. Do not include any of your analysis or opinion here, just the data and any descriptive text. You can present the data in tables, figures (graphs, charts and diagrams), listing (code or pseudo-code), etc. Figures are the preferred method of presenting experimental data (a figure is worth a thousand table entries).

Example: For the refrigeration topic "ice-cream" the results would include tables and graphs including a table showing the breakdown of the different types of ice-creams used, tables and graphs showing satisfaction for various times/temperatures. Descriptive text could highlight features of this data (trends in the graphs, highlights in the tables etc).

Discussion

Now you are free to analyse and interpret the results. This is where you describe what you think the data are telling you about the question(s) that you set out to answer. Can you make any recommendations, draw any conclusions, or provide some insight into the data?

It would be good to relate this back to the principles or key areas from the Unit Learning Outcomes. This will help you communicate your deep understanding of what is expected from the unit. Do not make this a direct link to the learning outcomes (this is a research report, so it's not directly related), but use the learning outcomes to help guide what you talk about.

Example: For the refrigeration topic "ice-cream" the discussion would talk about what you think the ideal temperature of ice-cream is (based on the results). If different people had different ideal ice-cream temperatures, the report could discuss some possible reasons for the variability. The report would describe the strengths and weaknesses of each of the devices compared, and scenarios where they may be the best device for ice-cream storage.

Conclusion

No surprises here... just wrap up what you have said. This should only be a couple of paragraphs. Restate what the paper is about, talk about the method used, and state your main findings from the discussion. It is also good to state what could be done next as future work.

Example: For the refrigeration topic "ice-cream" the conclusion should recap the issue "ice-cream is nice but must be kept cold", talk about the method "this experiment examined ideal ice-cream consumption temperature, and the ability of various refrigeration devices to achieve and maintain ice-cream at this temperature". Finally it would state the main findings "Freezers were found to be ...". Future work could include exploring some of the devices not included in the research including blast freezers and powered eskies.

Research Topic Ideas

This section includes a number of examples that you could use directly or as inspiration for your own research topic.

Use of Objects in a Game Development Framework (or Game Engine)

Game frameworks and engines typically make extensive use of objects and object oriented principles. In this project you will look at a game development framework like XNA, or game engine like Unity, and explore how it makes use of objects and OO principles to make game creation easier for developers.

Here are some ideas for starting points on this topic:

- Questions: How does [game engine/framework] use objects and object oriented principles in the development of games?
- Method: Explore the game framework/engine, and create a small test game using its features.
- Results: Collect information on where and how objects are used in the framework/engine.

Collection Classes and their Uses

Object Oriented programming languages typically come with a library of ready made classes to perform a variety of tasks. In this project you will look at the different collection classes, how they can be used, and the tasks they are suitable for.

Here are some ideas for starting points on this topic:

- Questions: What different collection classes are provided by the [language library]? How well do each of these classes perform common collection operations (adding, inserting, removing, finding, etc)? How do these operations perform as the size of the collection grows? When is it most appropriate to use each collection class?
- Method: Investigate the different collection classes available. Create small demo programs that perform a range of operations on the collections, with collections of various sizes.
- Results: Collect timing information, how long does it take to perform N add operations etc.

Using Reflections to Examine Objects

Languages like C# and Java allow you to inspect objects using a reflection API. In this project you will explore the reflections API and see how it can be used to perform different tasks.

Here are some ideas for starting points on this topic:

- Questions: How can the reflections APIs be used to explore object features? How could these features be used to make programs more flexible and extensible?
- Method: Create one or more program that use reflections to explore objects and examine the capabilities.
- Results: List features of the reflections APIs, with demonstrations of their use.

Comparing dynamic and static type systems

Type systems can work out if objects are able to receive messages either dynamically at run time or statically at compile time. In this project you will compare features of dynamic and static type systems across two different languages.

Here are some ideas for starting points on this topic:

- Questions: What is duck typing? How do static and dynamic type systems differ? What are the advantages and disadvantages of each approach?
- Method: Create small test programs using languages that support static and dynamic type systems, comparing ease of implementation, complexity of code, and time spent debugging (compile time and run time errors).
- Results: List features of each kind of program based on type system, record the ease of achieving different tasks with the different approaches.

Use of Metrics to Evaluate Object Oriented Programs

Metrics provide a means of measuring programs to evaluate various qualities. In this project you will use metrics to evaluate some aspects of a object oriented program, and report on your findings.

Here are some ideas for starting points on this topic:

- Questions: How can metrics be used to evaluate object oriented programs? Are there tools to automate the collection of these metrics? What do the metrics tell us about programs we have created?
- Method: Collect one or more metrics for a project you have built.
- Results: Details of metrics collected, broken down by project, class, method, etc.

Comparing an OO and Procedural Implementation of [something]

Object oriented programming and procedural programming provide different way of approaching program creation. In this project you will compare two implementations of the same program, an object oriented solution and a procedural solution.

Here are some ideas for starting points on this topic:

- Questions: What are the differences between an object oriented and a procedural implementation of a program? How can you measure these differences?
- Method: Construct a program using both approaches, use some form of measure to compare them.
- Results: Collect metrics, and compare experiences from implementing the two solutions

How are objects used in [some framework/library]

Object oriented programming languages typically come with a library of ready made classes to perform a variety of tasks. In this project you will look at one area of that library and evaluate it in terms of how it makes use of the object oriented principles. For example, you could perform this on a GUI library and how it makes use of objects in GUI creation.

Here are some ideas for starting points on this topic:

- Questions: What different classes are provided by the [language library] to achieve [task]? How do these classes take advantage of the OO principles? How can the functionality be extended by others?
- Method: Investigate the features offered by the library, examine the inheritance hierarchy and relationships between classes.
- Results: List the features that make use of various principles and record details on how to take advantage of them.

Implementing the [name] pattern in [language]

Design Patterns are suggested to be good solutions to common problems. In this project you will implement a well known pattern using an object oriented language and discuss how it achieves its task and how the language features allow the creation of the pattern.

Here are some ideas for starting points on this topic:

- Questions: How can [pattern] be implemented in [language]? Does this make appropriate use of the language features? Can your implementation be used as intended?
- Method: Implement pattern, use pattern in a program, discuss your experience
- Results: Record issues you had implementing the solution, the structure of the final code, the structure of the program that used your implementation of the pattern

Memory Management Strategies

Languages like C++ require you to manage memory yourself. In this project you will explore various strategies for managing memory.

Here are some ideas for starting points on this topic:

- Questions: What are effective ways of managing memory in an object oriented program? How can these approaches help you implement manual memory management in C++?
- Method: Examine how memory management is performed by various languages and frameworks. Suggest ways this can help with manual memory management. Trial your ideas by creating a small program that exhibits the obvious challenges for managing memory and test if your strategies help to avoid memory leaks or bad references.
- Results: Record your experiences: how many issues did you have? what kinds of issues? how did you get around them?

Summary

Research can be very rewarding; it allows you to deeply examine a topic of interest to you and to communicate your findings to others. It requires imagination and determination to think of a research topic and related research questions, design a suitable research method, use it to collect some data, analyse and interpret the data, and express your conclusions in a research report.

To achieve a High Distinction in this unit you will need to produce a research report that demonstrates deep thinking about a topic related to the Unit Learning Outcomes. Use the advice provided here and the support of the teaching staff to help you achieve this outcome.