# Reflective Report

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My experience carrying out my research project this summer has been truly eye-opening. I have learned a lot, both about my chosen research area of particle physics and, arguably more importantly, about myself as a student, a researcher, and a leader. The project at times affirmed my beliefs that I would enjoy a career in research and that I would be well suited to this type of work, and at other times challenged my expectations of what self-led projects can really be like. I developed many key skills during the six weeks and really feel that I am going to feel the benefits of the carrying out this project for years to come.

When I applied for the Laidlaw Programme this past January, I was very apprehensive. It was the first time I had really put myself out there and pushed myself since taking a year off for my mental health. I was worried about how not being accepted would affect me – I felt confident I could cope with college life at this point but dealing with rejection is always anxiety inducing. I was also worried about what being accepted would mean for me; I knew it would be a lot of additional work and I did not want to put myself under any additional stress that might once again put my mental wellbeing in jeopardy. However, I also knew that pushing myself to apply and put myself out there would only strengthen my resolve.

When I was notified that I had been accepted, I was ecstatic. It made me reflect on how far I had come in the previous year. I could not wait to get started on my research and to meet the other scholars. Having spoken with several Laidlaw scholars in the years above, I had some idea of what to expect, but my experience so far has in fact already exceeded those expectations. The connections I have made, the lessons I have learned and the skills I have developed will stay with me for a long time, and I am very excited to continue to develop them throughout the programme.

I carried out my research project this past summer on “Exotic Matter: What can we understand about exotic states of matter and their properties under the strong interaction?” under the supervision of Prof Sinéad Ryan with the School of Maths. My project was an investigation into particles that have a structure that contradicts the traditional quark model (so called “exotic states”) using a mathematical modelling method called Lattice Quantum Chromodynamics. I was very excited to be working on this topic as it is at the cutting edge of particle physics at the moment. In fact, CERN announced that they had found evidence of new types of such particles while I was carrying out my research project!

My initial meetings with my supervisor before writing my proposal were spent discussing the particular type of physics and maths I am interested in and hope to work with, and this area really piqued my interest. However, I must admit I was also nervous to be doing a project on a topic which relies on theory that I had not yet encountered in college. I knew going into the project that there was going to be a steep learning curve and that I would need to put in the hours and do a lot of reading in order to properly understand the theory behind my project.

The first few weeks were spent almost exclusively reading papers and learning new mathematical tools that I would need to carry out the project. I was surprised to find that, although some of the papers I read were far beyond the level of material I had encountered in college thus far, I was able to get a good grasp on most of the theory quite quickly. My supervisor was very helpful when it came to this, as she was able to provide me with relevant material that was at a good level for me. She also reassured me that I did not need to understand absolutely everything in order to complete

a good research project; I have a tendency to get caught up in attempting to understand every little detail of a paper and one thing I learned over the course of this project is that that is definitely not always possible, nor is it always helpful! I soon realised that it would be better, both to reduce the stress I was feeling about not understanding and to succeed in completing my project on time, if I were to concentrate only on the relevant material and accept that some of the mathematical derivations are simply beyond my current understanding. It was difficult to come to this realisation but once I had it became far easier to narrow down my readings and really concentrate only on the relevant material.

Another tool that helped me deal with the initial apprehension I felt about the tough material was taking the time at the beginning to plan my project and set manageable weekly goals. Time management is something that I have always struggled with and my tendency to procrastinate has gotten in between me and completing work to my full ability before. Knowing this, I went into the research with a plan to really develop that skill over the summer. It is not often I spend such a long stretch of time solely on a self-led project, so I knew that this would be one of the best opportunities I would have to figure out what works best for me in terms of planning and using my time productively. The Laidlaw programme is of course also for developing leadership skills, so I felt that it made sense to concentrate on developing these skills during this time. Although I was not leading a team of people, I did have to make sure I myself stuck to a schedule and remained disciplined enough to get my work done over the course of the project. I feel I have improved greatly in terms of planning and maintaining a healthy work life balance while doing this project.

In order to develop my time management skills, I also needed to work on my self-discipline. I was lucky enough that Prof Ryan was able to provide me with an office space to work in as the PhD students who normally use it were away for the summer. This really made a difference for me, as I do not work well at home. I always find myself getting distracted and wasting time. Before beginning my project, I made a commitment to myself to going to college every day at 9 and working through to four. This meant that I had both a dedicated space and a dedicated time to carry out my research. It enabled me to work productively but also to spend my free time well and be able to leave the work behind in the evenings.

When I felt I had a good grasp on the theory, I began to play around with some sample data that Prof. Ryan provided. I used Python to experiment with the data so that I could begin to get a feel for what working with Lattice QCD is actually like. I read several papers on the numerical simulation methods, and through this I was able to attempt to replicate similar results using the sample data for an exotic meson. The graphs I produced were not perfect – the sample data was created using a simple algorithm which only uses one operator – but it was still a very good exercise from which I learned a lot. I have realised that I really benefit from trying to figure out problems myself because it pushes me to really try and understand the fundamentals of the issue. I found that concepts which had seemed clear to me when reading the papers where in fact not as straightforward as I had imagined once I tried to apply them, and that although trying and failing to obtain good results can be frustrating, it ultimately allows you to learn about what you are researching in a much more comprehensive way.

I then went on to using more sophisticated methods to model the charmonium and bottomonium mesons. Using SEAGULL, one of the high-performance computer systems in TCD, I was able to run lattice simulations on bottomonium and charmonium exotic mesons.
I had not used anything similar before and so it took me a while to get used to the commands and interface. It was really exciting to be able to use the same machines that the high level theoretical physics researchers in trinity are using, and it really felt like I was getting a real insight into what working in theoretical physics research is actually like!

Another interesting aspect of this project for me was that it involved a lot of time spent alone. Although I met with my supervisor relatively frequently and occasionally met up with other friends doing internships for the summer, most of my days were spent largely alone. It was, in fact, a quite isolating experience at times. Speaking with the other Laidlaw scholars really helped combat this issue. It was incredibly beneficial to talk through some of the issues that were coming up during the project with people who were in the same boat at the ALS meetings, and often made me realise that I was catastrophising minor issues that almost everyone experiences while carrying out their projects. I realised that being around other people and having peers to bounce ideas off and talk through problems is crucial for my mental well being and for being able to remain motivated in the face of adversity.

Despite this, I did discover that I actually work quite well alone! It had been a while since I had attempted to learn something new completely on my own terms and I found that I really enjoyed studying for the first time in quite a while. Since the external pressure of doing well on exams was not an issue, I felt I could go at my own pace and read material that truly interests me. I could spend time gaining a deeper understanding of the topics rather than simply learning set material in order to pass an exam. Something which I gained from the project that I did not expect was a renewed excitement about theoretical physics. It is very easy to forget what you are working towards during the academic year, to simply take each module as a new obstacle to get past rather than as an opportunity to learn something important and interesting. Too often I forget that the hours I put into understanding complicated mathematics and intimidating physical theories will enable me to work on exciting new research in the future. This project reminded me to consider the big picture; Although I may not enjoy some small area of maths or physics or it may seem unnecessary, it is often these areas that lead you to a deeper understanding of the bigger, more exciting concepts.

I would like to reiterate my thanks to the Laidlaw Programme for funding my research and especially the TCD Laidlaw team for their ongoing support and advice this past summer. I would also of course like to emphasise my appreciation of all of the invaluable help and guidance my supervisor, Prof Sinéad Ryan, provided me with over the course of the project. I look forward to my continued engagement with the Laidlaw Programme and I cannot wait to find out what the next year of leadership development will bring!