

Postgraduate Geothermal Energy Training: Geothermal Institute, New Zealand

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ABSTRACT

Geothermal energy training is a very specialised area with only two established postgraduate programmes available worldwide, in Iceland and New Zealand. In this paper we discuss the background, teaching philosophy, course content, student cohort, and the funding of the New Zealand course.

The Post Graduate Certificate in Geothermal Energy Technology (PGCertGeothermTech) is taught at the University of Auckland, New Zealand. The inaugural course was in 2007, and the course has been taught every year since then. It is a one-semester (5 month) course for Science and Engineering graduates, developed in response to the increasing demand for trained engineers and scientists to work in geothermal exploration and development nationally and internationally. The precursor to this course was the two-semester geothermal PG Diploma at the Geothermal Institute, the University of Auckland which ran from 1979 till 2002 (Hochstein, 2005).

The programme is industry-oriented and is designed to bring together graduates from different disciplines in science and engineering. The course is organized into two teaching blocks of six weeks each, followed by a short project. During the teaching period there are 4 hours of lectures per day, and two hours of tutorials. There are two major field trips of one week each, which comprise 20% of the course. Running this programme has many challenges such as the diverse technical skills needed to teach this programme, which are not all available within the University. The programme is expensive to run due to the high cost of the two week-long field trips. At the same time, student numbers have to be limited for this level of applied teaching and for health and safety considerations associated with the field work.

The PGCertGeothermTech is offered to both local and international students, with international students accounting for more than 86% of our students. A similar trend was observed during the Post Graduate Diploma in Geothermal Energy Technology (1978-2002). The course is available to graduates with bachelor degrees in science or engineering; hence the students come from a diverse of backgrounds. Since the beginning of the course, more than 40% of the students have been in the 30-34 year age group. However, there is a large range of ages, from 20-24 year to 65-69 year age group. 28.3% of the students have been self-funded. The others have been supported by either their employers, or by scholarships. It is doubtful that the course would survive if it relied on self-funded enrolments only.

Given the diversity of the student backgrounds, the early part of the course is dedicated to the principles of geothermal energy, aiming to bring the students to a common level of knowledge. The curriculum then rapidly builds up a base level of fundamentals and information in preparation for the field study for both the engineering and earth science streams of the course. The block structure of the PGCert and the short duration of the modules allow the students to undertake the program in two short periods away from their regular employment spread over two calendar years. The course coordinator and main academic staff carry out most of the teaching and field work and are strongly involved in the selection of material covered by the external lecturers and industry experts. This reduces the course overhead in terms of number of full time academic staff and prevents repetition of material covered by multiple lecturers, which also ensures a consistent course structure.

1. INTRODUCTION

We give a brief outline of the history of geothermal training worldwide, which began in the 1970's and has continued, albeit with some attrition, through to the present. The focus of this paper is the Post Graduate Certificate in Geothermal Energy Technology (PGCertGeothermTech), taught at the University of Auckland, New Zealand.

We present an outline of the teaching schedule, which is condensed into five-week blocks and includes field trips. The paper structure, field component of the course, and assessment methods are discussed, followed by an explanation of the Research Project paper.

The characteristics of the student group are described. We explain the wide variety of backgrounds in terms of science and engineering disciplines, in terms of work experience (from recent graduate to experienced professional), age range, and in terms of how the students are funded to attend the course.

2. GEOTHERMAL TRAINING PROGRAMMES WORLDWIDE

Since the 1970's there have been six postgraduate level taught geothermal courses (in contrast to research degrees) which have persisted for varying lengths of time. Unfortunately, history has witnessed the demise of several of these courses around the world when their external funding stopped, which indicates that these geothermal courses are not self-sustained and are mainly reliant on external funding (see Table 1 below):

Table 1. History of PG Geothermal programmes around the world (updated from Hochstein, 2005 and Zarrouk, 2012).

| Institution | Country | Year Started | Year Stopped | Duration (months) | Language Taught | Funding support |
|--------------|-------------|----------------------|-------------------------|----------------------------------|-----------------|--|
| Pisa | Italy | 1970 | 1992 | 6 | English | The government of Italy and UNDP ¹ |
| Kyushu | Japan | 1970 | 2001 | 2 - 4 | English | The government of Japan |
| Auckland | New Zealand | 1978 2007 | 2002 Running | 9 4.5 | English | UNDP and MFAT ² Scholarships (varying number over the years) Employer-funded students Self-supported students |
| Reykjavik | Iceland | 1979 | Running | 6 | English | UNDP and the government of Iceland Employer-funded students |
| San Salvador | El Salvador | 2010 | Running | 6 | Spanish | Inter-American Development Bank |
| Reno (NV) | USA | 2011 2013 2014 | 2012 2013 Running | 2 1 1-2 weeks ³ | English | Department of Energy, US Government Employer-funded students Self-supported students |

3. PGCERTGEOTHERMTECH PROGRAMME

3.1 Introduction

The PGCertGeothermTech is designed to accelerate the development of geothermal expertise amongst young graduates and professional engineers and scientists, and thus support them in starting and/or advancing their career in the geothermal industry. It has been designed as a block structured high-quality postgraduate qualification for professionals with an engineering (BE) or science (BSc) background.

The curriculum of the PGCertGeothermTech programme consists of two compulsory lecture courses (papers), followed by an elective course. Field trips are an integral component of these lecture courses. The PGCertGeothermTech is completed with a short research project.

There are two field trips (five days each) to the Taupo Volcanic Zone in the central North Island of New Zealand. There are also several day trips to visit geothermal companies and sites of geological or geothermal importance. The field trips (20 % of the course time) are integrated with the academic teaching to build student confidence in understanding the assessment, development, and utilization of geothermal systems.

3.2 Teaching and assessment

Throughout the course, there is a strong focus on application, field studies, case studies and project-based learning. Teaching periods are compressed into 6 week blocks of 4 hours per day, often with another two hours of tutorials in the afternoon. These teaching methods are designed to be similar (although possibly slightly more intense) to a typical professional workday, in terms of the concentration and tasks required, and appear to suit a cohort of students with prior practical industry experience. For students that work in industry, the intensive teaching schedule minimizes time away from their job.

All of the courses are 100% internally assessed, which increases the assessment load on staff, but provides the students with prompt and accurate feedback on their progress. This is much appreciated by the students. The assessment involves 40% course work (including: 10% on field-study reports, 10% for seminars and 20 % on three different assignments). There are two tests; a 20% short test (90 minutes long) and 40% final test (three hours long). The tests are conducted under official University exam conditions.

Formal and informal feedback on the programme and individual courses and project received from students and graduates on an on-going basis has been predominantly positive. A study of course evaluations and student surveys is being undertaken, and will be the subject of a separate paper. However, as an example of student feedback, we include a response to one question (Figure 1) from the standard end-of-course survey for taught papers, which has been used since 2011. The statement is "The Lecturer(s) stimulated my engagement in the learning process". The responses are largely positive (> 88% Agree or Strongly Agree).

¹ United Nations Development Program

² New Zealand Ministry of Foreign Affairs and Trade

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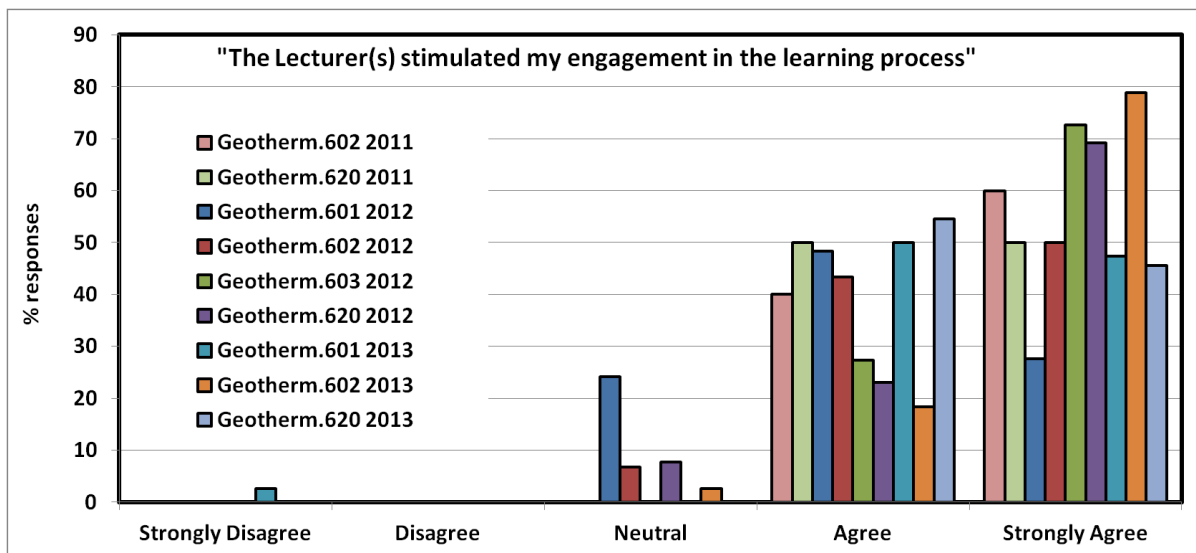


Figure 1: Student responses to the statement ‘the lecturer stimulated my engagement in the learning process’. From course evaluation surveys. This is typical of positive responses in course evaluations, and is presented here as an example of a positive student response to the course.

All of the students are given a ten minute individual meeting with the course co-ordinator to provide the students with feedback and direction. Well-performing students are encouraged to continue to develop and improve. For students that are not performing at an acceptable level; they are asked how they feel about their performance in the programme and what they expect to gain from doing the programme. This approach seems to trigger self-motivation without humiliation. Poorly performing students are also engaged through encouragement, direction and offer of help (additional tutorials) if needed. The head of the department is also notified early in the programme of any poor performing student.

PGCertGeothermTech is a very technical programme with long lecture hours. There is an impact on student attention levels throughout the lectures and it normally drops with time. Student’s attention is regained through the use of short technical movies; relevant stories from field experience or interesting incidents that took place in the industry. Students are asked to comment and possibly tell a similar story from their experiences. Models of equipment; rock samples and damaged/broken parts of equipment (turbine blades, heat exchangers, drill bits etc.) are used to regain attention; interest and engagement. The students find these additions to the lectures very interesting because it directly relates to their field of work.

Contingent on the nature of the PGCertGeothermTech programme and the type of students as discussed above, the human resource requirements for administrative and academic support and pastoral care are relatively high compared to other programmes.

3.3 Lecture component

The first part comprises of a fixed set of compulsory courses in both Geothermal Engineering (paper GEOTHERM 602) and Geothermal Earth Science (paper GEOTHERM 601) to the value of 30 points. These courses have been designed to provide a comprehensive and broad overview of the geothermal systems, development, and energy technology at postgraduate level. Given the diversity of student academic background, the first two weeks of these courses are dedicated to bridging the knowledge gap and bring the students to a common ground in knowledge. This is when the engineers learn more about earth science (geology, geochemistry, geophysics, environmental science) while the earth scientists learn the engineering fundamentals (thermodynamics, fluid mechanics, heat transfer). Regulatory policies on geothermal energy use, and geothermal system management are introduced at this stage. This period also serves as a refresher for returning students who have been outside the academia for some time.

Much of the classroom teaching is by academic staff, with an introduction to many aspects of geothermal development provided by other New Zealand geothermal experts. These include lectures from:

- A week-long series from the New Zealand office of Jacobs Ltd (SKM in the past) who specialize in geoscience and engineering aspects of geothermal development projects.
- Geothermal power production company, Contact Energy Ltd.
- Research and consulting company GNS Science Ltd.
- Drilling and well services company MB Century Ltd.
- Environmental regulators, the Waikato Regional Council.
- Independent geothermal experts; current examples are: -
 - Mr Andy. Bloomer, Geothermal Engineering Ltd, and Dr Kevin Brown, Geochem Ltd.

- Retired academic staff including Assoc Prof Patrick Browne and Assoc Prof Manfred Hochstein
- International guest lecturers for example: Dr. Pri Utami, Gadjah Mada University, Indonesia.

These companies and individuals donate their time and expertise because they believe in the strength of the New Zealand industry and want to share their knowledge and experience with the students. The organizers of the PGCertGeothermTech welcome their participation, which gives depth, variety, and interest to the course.

In the second part of the programme, the students have the option to learn more about either Geothermal Engineering (GEOTHERM 620) or Geothermal Geoscience (GEOTHERM 603). Again, much of the teaching is done by academic staff. But for some specialist subjects, experts from outside the University may join the lecture program (e.g. Geochemistry, Geophysics, Advanced Drilling, Power Plant Maintenance, and Pipeline Design).

There is no scope for the students to select additional electives outside this range of papers due to the block structure of the courses and highly specialized nature. However, some students choose to take the credit from doing the individual course papers into other degrees from both the Engineering and Science Faculties. The PGCertGeothermTech programme does not include distance learning courses, due to the integrated field based and lecture based education structure. This point is made very clear on the programme webpage and information pack.

3.4 Field component

Field-based education is very common in applied sciences (mainly in geology, biology and environmental sciences) and is also applied to some business and engineering courses. Many universities have established undergraduate and postgraduate courses that are run fully in the field and many of these universities have permanent field stations dedicated to this type of applied education (Douglas, Suttner and Ripley, 2009) or run field camps (Puckette and Suneson, 2009).

The PGCertGeothermTech combines both field-based and class-based teaching. The field trips (20 % of the course time) are integrated with the academic teaching to build student confidence in understanding the framework of geothermal fields: assessment, development, and utilization.

There are two field trips (five days each) to the Taupo volcanic zone in the central North Island of New Zealand. The first field trip is during the GEOTHERM 601 and GEOTHERM 602 papers in the first part of the semester. The second field trip is during GEOTHERM 603 and GEOTHERM 620 papers in the second part of the semester. The field exercises provide the basis for cementing the concepts and problem solving techniques introduced in the lectures. Students have to complete a 3000 word technical report after each field trip, recording their observations and applying the techniques they learned during the lectures. There are also several day trips to visit geothermal companies and sites of geological or geothermal importance.

The first field trip, during the GEOTHERM 601 and GEOTHERM 602 courses in the first part of the semester, is designed to give an overview of geothermal energy. This is to ensure that all students learn a basic level of geothermal surface features, geology, steamfields, power stations, drilling, and direct use.

The second field trip during GEOTHERM 603 and GEOTHERM 620 in the second part of the semester addresses problems of increasing complexity and students are required to work together to record and share data for their field trip reports.

By the end of this programme, the students will have seen five different geothermal power stations, three geothermal drilling rigs sites, four steam fields, eight examples of the direct use of geothermal energy and five different geothermal systems.

Natural geothermal areas are among the most dangerous natural environments on earth. Key hazards are cold weather, hot steam and water, unstable and thin ground, potential for toxic fumes and heavy machinery. The ground can be 100°C at 10 cm depth, and may be covered with a weak, breakable crust. Pools can be boiling, or even erupting and splashing boiling water. Gas (CO₂ and/or H₂S) is also a hazard. Industrial geothermal plant may also have all these hazards, as well as hot equipment, trip, noise, and height hazards. In addition, many geothermal areas are protected environmental sites due to the botanical and geological uniqueness.

Hence, student safety and environmental protection during the field trips is a top priority and we develop a health and safety plan for each field trip. Since the start of the PGCertGeothermTech programme in 2007, there has been no accidents or injuries and we are proud of our zero harm (to human or nature) policy. One of the limiting factors for class size is the number that can be safely supervised while in the field. Experience has demonstrated that the supervisors (lecturers and tutors) are comfortable with 35 people or less.

Running the field trips normally requires significant investment due to the high costs associated with travel, food, accommodation and for access to some sites. The regulations at the University of Auckland do not permit charging the students additional fees on top of the standard course fees. This puts significant pressure on the course budget and viability. At the same time it is not possible to increase student numbers as most geothermal companies/operators put a maximum limit of 30-35 students and staff during site visits at a time. It is also not possible to run these field trips multiple times a year due the logistics, cost and limited staff. From 2014 the faculty of engineering has introduced an added fee of \$1000/paper for all international students to cover the field trip costs and consumables. The impact of this increase in fee on the enrolment of self-funded international students will be assessed in the next few years.

3.5 Research component

In the final 5 weeks of the course, the students carry out a geothermal research project (GEOTHERM 689) allowing students to develop and apply their new skills gained through the programme. The research project should demonstrate how relevant literature,

theoretical criteria and considerations, models or concepts learned in the course or through a literature review are used to address a geothermal problem.

Therefore, concepts or models relevant to each analysis should be reviewed and the most appropriate chosen for application in the project setting. The research therefore covers the theories and the methodologies used in conducting the study as well as the main conclusions. It must be written to a standard suitable for publication in an academic journal or conference. Its length should normally not exceed 6,000 words including references.

For students with industry experience, the geothermal project provides the student with the opportunity to apply the scientific and engineering concepts and tools they are exposed to during their study in a real world environment. Often their research project will include data collected from their current workplace, which provides a positive benefit for employers. Where a project report contains confidential information, the report is not made publicly available.

Emphasis in the programme is on the development of high-level, but practice-related knowledge, with practical computer and field skills. However, to date, 21 PG Cert GeothermTech graduates have continued their academic studies at ME and PhD levels.

4 STUDENTS

4.1 Characteristics

In 2007 (the inaugural year) there were nine students taking the course (Figure 2). Numbers have varied since, but 2014 saw the highest numbers of students yet, with 48 students enrolled in all, or part, of the course. International students are generally in full-time employment and some choose to do the programme over two years due to their employment commitments back home and, hence, the block structure of the courses. This is a reason why some are only enrolled in part of the course for any given year. In the first three years of the course, students were allowed to attend the lectures as Short Courses charged at a commercial rate. However, this practice was discontinued for administrative reasons.

To date, students from twenty-four countries have attended the course (Figure 3). The largest percentage comes from the Philippines and Indonesia (both at 23.9 %), followed by New Zealand and Kenya (11.48% and 10.58 % respectively). The combination of nationalities adds a lot of human interest to social interactions within the group. The most common practical problem from a teaching point of view is language. The English language requirement for the University of Auckland Engineering School postgraduate level is:

- IELTS (Academic) 6.5 (with no band less than 6.0) or
- TOEFL (paper based) with a score of 575 and TWE 4.5 or
- Internet based TOEFL with a score of 90 and a Writing score of 21 or
- Completion of the University of Auckland English Language Academy's Foundation Certificate in English for Academic Purposes (FCertEAP) programme with a minimum overall score of B-.

Although this is a relatively high level of English language skill, teaching and learning a highly technical subject at postgraduate level is still demanding for all, particularly given the intensive nature of the teaching, where there is little time to 'catch up'.

There is a wide range of student ages (Figure 4). The youngest age group is 20-24 years, and the oldest is 65-69 years. The most commonly occurring range is 30 - 34 years. We suggest that there are two reasons for the dominance of this relatively mature age group. One is that many of the students, particularly those from the Philippines, are fully funded by their employer. Philippine employers consider the training to be 'professional development' and also desirable to maintain the strength of the Philippine geothermal industry. The other reason is that domestic (Australian and New Zealand) students are often those who have work experience, but are making a deliberate change to a renewable-energy and environmentally-friendly professional career.

There have always been more males than females in this course with an average of 24% females from 2007 till 2014. Figure 5 shows that the highest proportion of women was in 2009, when there were nine females out of a total of thirty four students (26%). However, the gender distribution is similar to that of all engineering students at the University of Auckland from 2007 to 2014, which is 22% female (pers comm Mr. John Neal, Business Analyst, Faculty of Engineering, The University of Auckland).

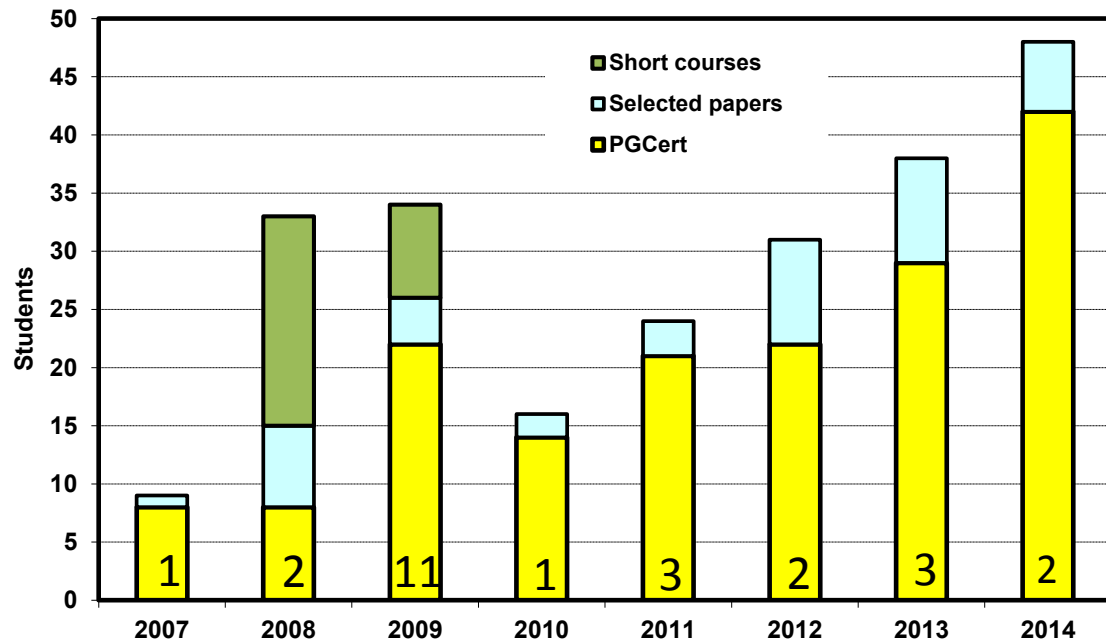


Figure 2. Students enrolment in the PG CertGeothermTech, selected papers and short courses. The numbers indicates the number of domestic students attending the full PG CertGeothermTech course each year.

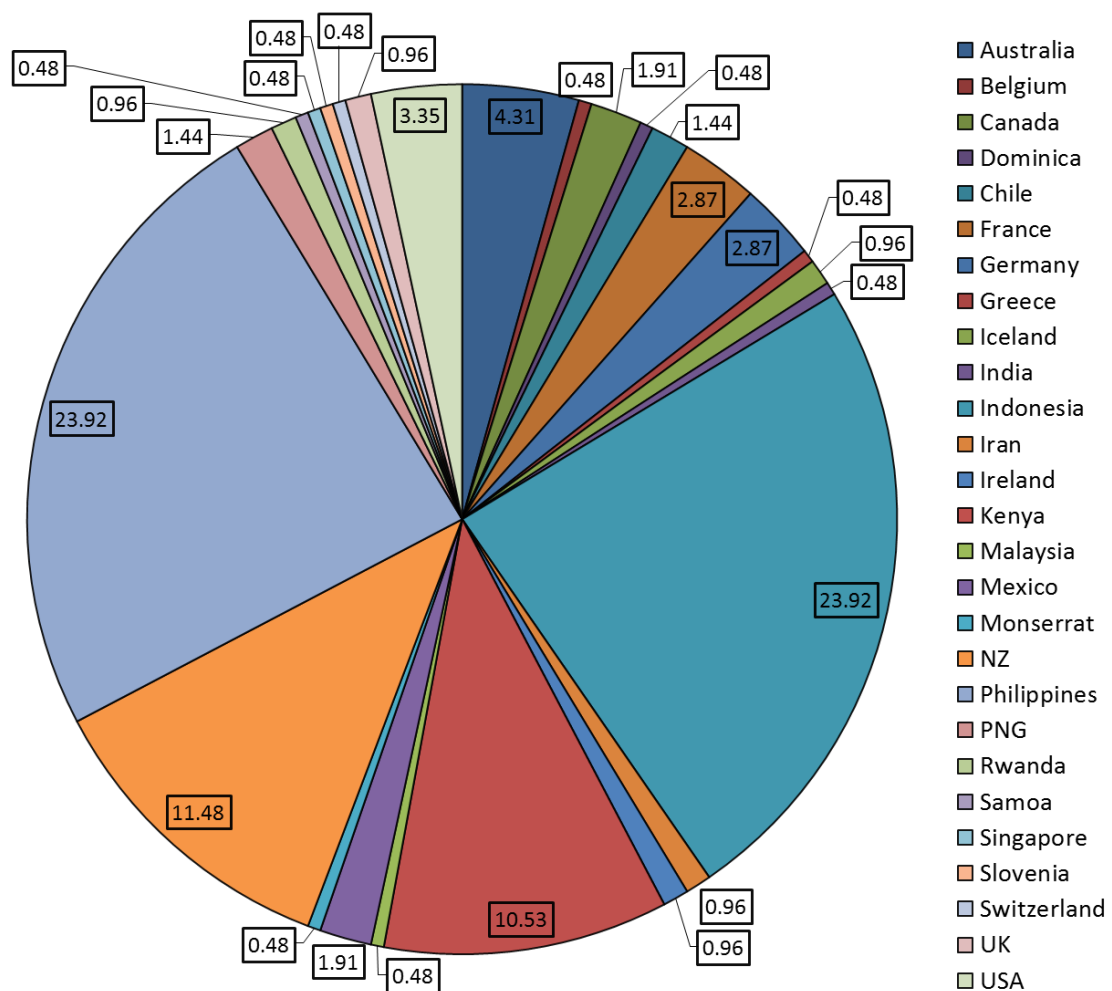


Figure 3. Students proportion by country for the past seven years (2007-2014).

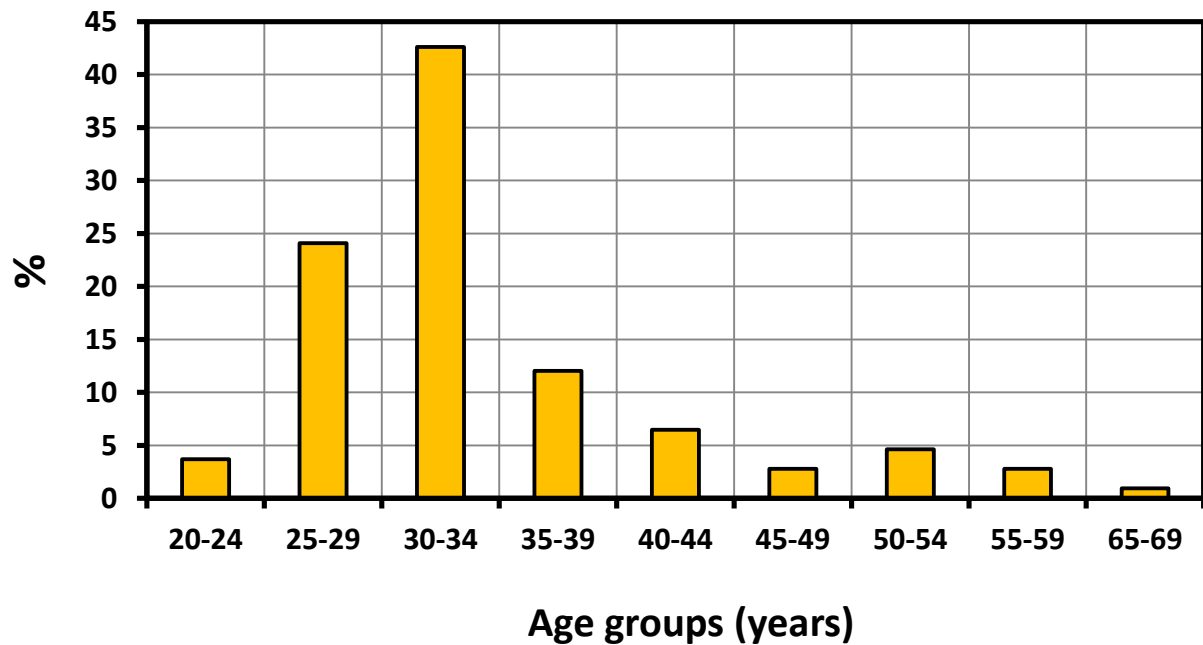


Figure 4. Students age distribution for the PGCertGeothermTech course.

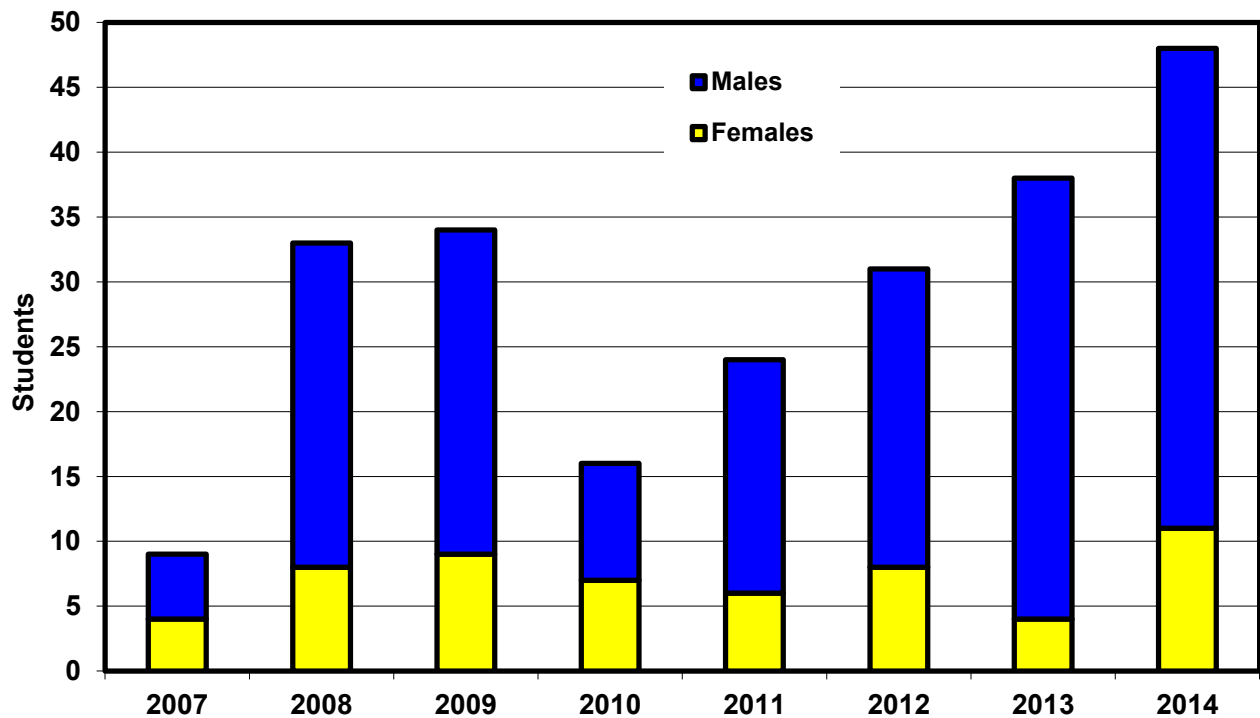


Figure 5. Gender distribution for the PGCertGeothermTech students since starting the course in 2007.

4.2 Student financial support

In 2007 and 2008, there were four industry sponsored scholarships/year (one from MBCentury Ltd. and three from Contact Energy Ltd.) for international students. These four scholarships helped to establish the PGCertGeothermTech course.

Figure 6 shows the categories of support for students, and the number of students under each category, from 2007 to 2014. The categories we define are self-supported (no official, specific funding to attend the course); company-sponsored, whereby the student is supported by their employer to attend; and scholarship, where the student has a scholarship from a body other than their employer. For the PGCertGeothermTech this is typically a New Zealand government scholarship, although Maori Trusts have offered scholarships, there is a shortage of suitable science or engineering graduates to take up such opportunities.

In 2009 and 2010 the course had only self-supported students and company sponsored students.

Since 2011 there has been several scholarships offered by the New Zealand Ministry of Foreign Affairs and Trade (MFAT) for the geothermal PGCertGeothermTech programme. Students who inquire about these scholarships are directed to the local New Zealand Embassy/High commission in their home countries, which administer/award these scholarships. MFAT has a list of receiving/eligible countries for these scholarships and this list can change from year to year. Since 2011, 26.2% of the students have been supported by MFAT scholarships.

From 2008 till 2010, we had one/year scholarship for a Maori (New Zealand) student to cover the PGCertGeothermTech course fee. This scholarship was offered by the Tuaropaki Trust (Taupo). This is the only scholarship that has been available to domestic students, which was only taken in 2008.

The majority (51.5 %) of our students are sponsored by the companies that employ them. Most of these students are from the Philippines (Figure 3), where geothermal companies believe investing in their employee's professional development is the way to build a strong local geothermal industry.

From 2007 to 2014, only 22.3% of the students were self-supported. In all years, except 2009, the average number of self-supported students is 4.5 per year. It is doubtful that the course would survive in its present form with this small number of students per year, which demonstrates the dependence of the course on external scholarships and sponsored students. The year 2009 had the highest number of self-funded students (47%), which we suspect is anomalous due to the global financial crisis, and high unemployment. Anecdotal evidence is that at such times professional people may decide, at their own expense, to gain an extra qualification in order to be available and competitive on the job market when the economy improves.

The course fee for the 2014 academic year stands at \$NZ 21,812.8 for international students and \$NZ 4,905.6 for domestic students. Since more than 88 % of our students have been international students, the course is reliant on international students. As mentioned previously, from 2014 the tuition fee has been increased by \$1000/paper for international students. This was a Faculty of Engineering decision to cover the field trip costs and consumables.

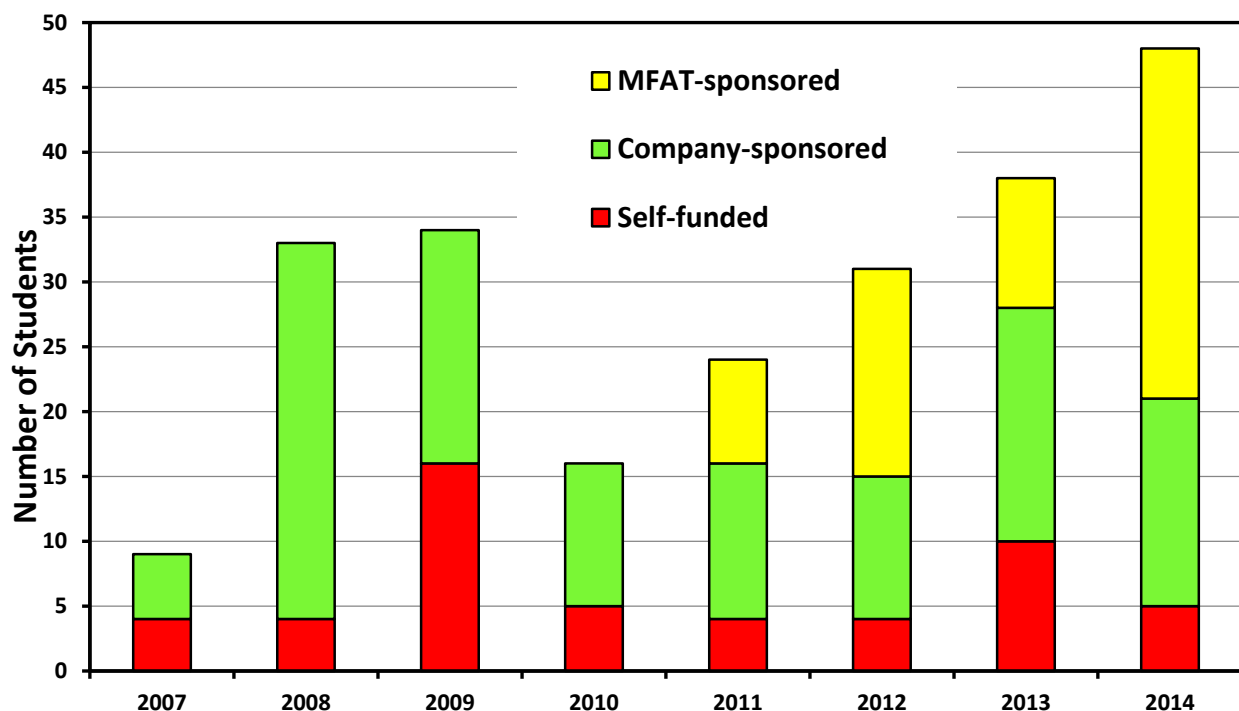


Figure 6. Support for students to attend the PGCertGeothermTech, proportions for each year.

5. CONCLUSION

The PGCertGeothermTech has been taught for eight years, from 2007 to 2014. It will continue to be offered in the second semester every year. The course is very specialized, with an integrated approach between class-based and field-based education. The course is industry oriented with a strong cross-disciplinary approach to ensure that all students have a grounding of all geothermal-related topics. The success of this approach requires research and field experience on the part of the teachers, and close co-operation between course teachers and the industry. Thanks to the support of the New Zealand and International geothermal companies, for supporting students and for contributing to teaching, the course has become established as one of the major geothermal training courses in the world.

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