The Geothermal Postgraduate Course at the University of Auckland: A Ten Years Retrospective

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CONTEXT
Geothermal postgraduate (PG) energy training is a very specialised area offered by a very few universities in the world. The one-semester geothermal PG Certificate (PGCert) course has been running at the University of Auckland since 2007.

The programme is industry-oriented and is designed to bring together graduates from all disciplines of science and engineering. The course is organized into two teaching blocks of six weeks each, followed by a short project. Offering this programme has many challenges. One of these challenges is the diverse technical skills needed to teach this programme. The programme is also expensive to run due to the high cost of the 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.

PURPOSE
In this investigation we discuss the course background, teaching philosophy, course content, student cohort and funding in the past ten years. Then offer a vision for going forward in view of the growing number of renewable energy courses being offered and the slow down in the geothermal industry.

APPROACH
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 on 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 allows the students to undertake the program in two short blocks of time away from their regular employment spread over two calendar years. The course co-ordinator and the 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 and prevents repetition of material covered by multiple lecturers ensuring a consistent course structure.

RESULTS
A review of the student course feedback over the past ten years shows that the course in the current structure is well received and highly valued by the students. This is despite the condensed nature and high workload associated with its block structure. \However, the block structure also means that individual courses (papers) are not available to other interested students, because the course do not fits the standard academic year calendar.

The recent drop in the number of students attending the course is related to lack of company sponsored students and the drop in oil prices which affected the global geothermal energy industry.

CONCLUSIONS
Given the highly specialised field and contrary to traditional engineering teaching practices, the block structured nature of the course is one its strengths and attractions.

As long as most of the teaching is carried out by the course's academic staff, it will remain sustainable and viable to run despite the evolving energy market.

KEYWORDS
Geothermal energy training, block structured courses, field-based education.

Introduction

The history of geothermal training worldwide began in the 1970's and has continued through to the present. The focus of this work is the Post Graduate Certificate in Geothermal Energy Technology (PGCertGeothermTech) taught at the University of Auckland, New Zealand.

The teaching of the PGCertGeothermTech is condensed into six week block of work. The paper structure, field component of the course and assessment methods is discussed. This course also offers a research project paper which will be discussed.

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

Geothermal training programmes worldwide

Since the 1970's there have been five international (taught in English) postgraduate level taught geothermal courses which have continued for varying length of time. Unfortunately, history has witnessed the end of several geothermal courses around the world when their external funding stopped. This indicates that these geothermal courses are not self-sustained and are mainly reliant on external funding (Table 1):

Table 1. History of post graduate geothermal programmes around the world (updated from Hochstein, 2005 and Zarrouk, 2012).

Institution	Country	Year Started	Year Stopped	Duration (months)	Funding support
Pisa	Italy	1970	1992	8	The government of Italy and United Nations Development Program (UNDP)
Kyushu	Japan	1970 2016	2001 Continuing	2 – 4 6	The government of Japan (JICA)
Auckland	New Zealand	1978 2007	2002 Continuing	9 4	UNDP and MFAT Scholarships (varying number over the years) Employer-funded students Self-supported students
Reykjavik	Iceland	1979	Continuing	6	UNDP and the government of Iceland Employer-funded students
Reno (NV)	USA	2011 2013 2014	2012 2013 Continuing	2 1 1-2 (weeks)	Department of Energy, US Government Employer-funded students Self-supported students

The PGCertGeothermTech is designed to accelerate the development of geothermal expertise amongst young graduates and professional engineers and scientists. Thus it supports them in starting and/or advancing their career in in the geothermal industry. It has been designed in a block structured high-quality postgraduate qualification for professionals with an engineering or science 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. They are designed to build the student's confidence in understanding the assessment, development and utilization of geothermal systems.

Teaching and assessment

There is a strong focus on application, field studies, case studies and project-based learning throughout the course. The teaching periods are compressed into six week blocks of four hours per day, often with additional 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. This is in terms of the concentration and number of tasks required. It appears to suit a cohort of students with prior practical industry experience. For students that have job commitments, the intensive teaching schedule minimizes time away from their jobs.

The entire courses are 100% internally assessed. Thus 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 and reflects in their feedback. 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) and 40% final test (three hours). These tests are conducted under official university exam conditions.

Formal and informal student feedback is received on ongoing basis on the programme, individual courses and project. It has been predominantly positive. A study of course evaluations and student surveys is being undertaken and will be the subject of a separate paper.

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 student performing bellow standard.

PGCertGeothermTech is a very technical programme with long lecture hours (4 hours a day). This has an effect on the student's attention levels throughout the lectures and it normally drops as expected by the end of lecture. Student's attention is regained through the use of short technical movies, relevant stories from field experience and interesting incidents that took place in the industry. Students are asked to comment and possibly share similar stories from their experience. 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 as it directly relates to their field of work.

Based 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.

Lecture component

The first part of the lectures 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. 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 mecahnics, 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 academia for sometime.

Most of the classroom teaching is done by academic staff. Introduction to different aspects of geothermal development is provided by other New Zealand geothermal experts.

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 as it 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, most of the teaching is done by academic staff. However, some experts from outside the University may join the lecture program for specialist subjects such as 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 (points) 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. This is because of its integrated field based and lecture based education structure. This is made very clear on the programme web-page and information pack.

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 taught fully in the field. Many of these universities have permanent field stations or field camps dedicated to this type of applied education (Douglas, Suttner and Ripley, 2009) (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 the students 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 takes place during the GEOTHERM 601 and GEOTHERM 602 papers in the first part of the semester. It 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, steam-fields, power stations, drilling and direct use. The second field trip is during GEOTHERM 603 and GEOTHERM 620 papers in the second part of the semester. It addresses problems of increasing complexity and students are required to work in groups to record and share data for their field trip reports. Field exercises provide the basis for cementing the concepts and problem solving techniques introduced in the lectures. Students have to complete a 3000-4000 word technical report, recording their observations and applying the techniques they learned during the lectures after each field trip. There are also several day trips to visit geothermal companies and sites of geological or geothermal importance.

By the end of this programme, the students would have visited 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 natural 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 and breakable crust. Pools can be boiling or even erupting and splashing boiling water. Gas (CO_2 and/or H_2S) is also hazardous. 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 student numbers in the course is the ability to safely supervise them while in the field. Experience has demonstrated that the supervisors (lecturers and tutors) are comfortable with up to 35 students on the field trips.

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 for field trips in addition to 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 visitors of students and staff during site visits at any one time. It is also not possible to run these field trips multiple times a year due the logistics, cost and limited staff. In 2014 the faculty of engineering has introduced an added fee of $1000/paper for all international students. This is to cover the field trip costs and consumables.

Research component

In the final four weeks of the course, the students carry out a geothermal research project (GEOTHERM 689). This project allows 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 6,000-8000 words including references.

For students with industry experience, the geothermal project provides them with the opportunity to apply the scientific and engineering concepts and tools they have learned during their study. Their research project often will include data collected from their current workplace. Thus provides a positive benefit for employers. A project report containing confidential information is not made publicly available.

Emphasis is made on the development of high-level but practice related knowledge with practical computer and field skills. However, to date, 49 out of 238 PGCertGeothermTech graduates have chosen to continue their academic studies at Masters and PhD levels.

Students

In 2007 (the inaugural year) there were nine students enrolled in the course (Figure 1). Numbers have varied since then. However, 2014 had the the highest numbers of students to date, 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, 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 (2007-2009) of the course, students were allowed to attend the lectures as short courses and charged at a commercial rate. However, this practice was discontinued for administrative reasons. Figure 1 also show the total number of individual paper enrolment per year. It is clear that there is a significant drop in student numbers by more than 40% per year in the past two years.

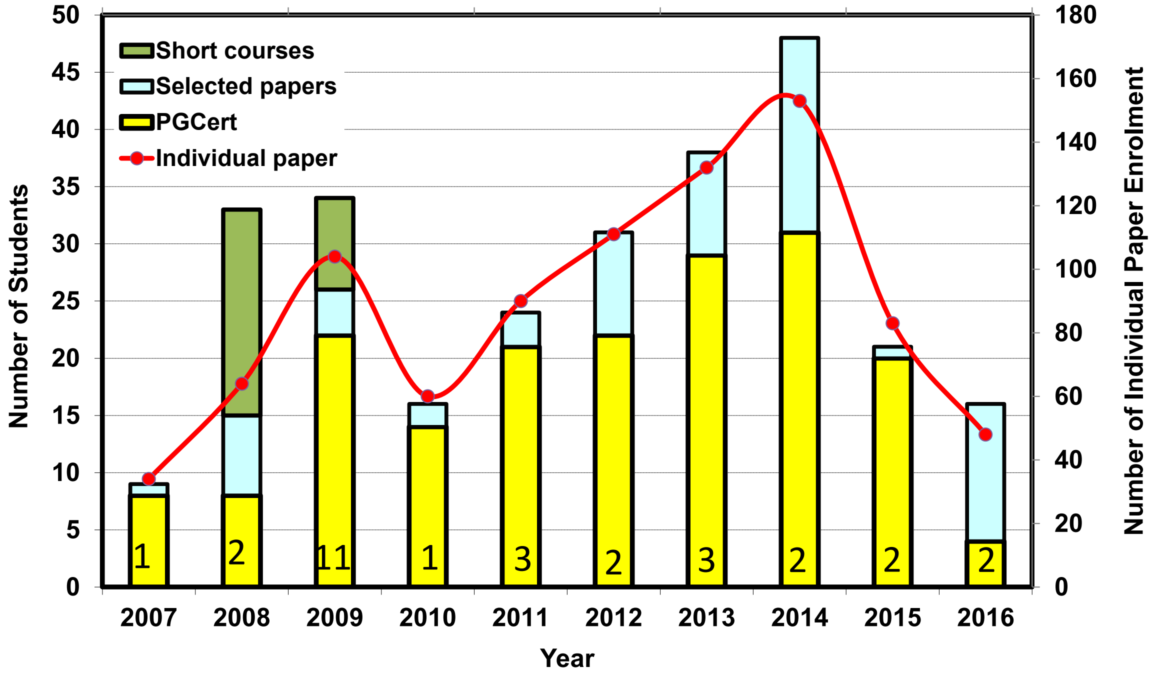

Figure 1. Annual number of student's enrolment in the PGCertGeothermTech, selected papers, short courses and the number individual paper enrolment. The numbers within the yellow bar indicates the number of domestic students attending the full PGCertGeothermTech course each year.

To date, students from thirty two countries have attended the course (Figure 2). The largest percentage is from Indonesia (29.15 %) and the Philippines (22.67%), followed by New Zealand (10.93%) and Kenya (8.91%). 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.

There is a wide range of student ages (Figure 3). 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. Philippines employers consider the training, to be 'professional development' and also desirable to maintain the strength of the Philippines geothermal industry. The other reason is that domestic (Australian and New Zealand) students are often those who have work experience, but are making a conscious change to a renewable-energy and environmentally-friendly professional career.

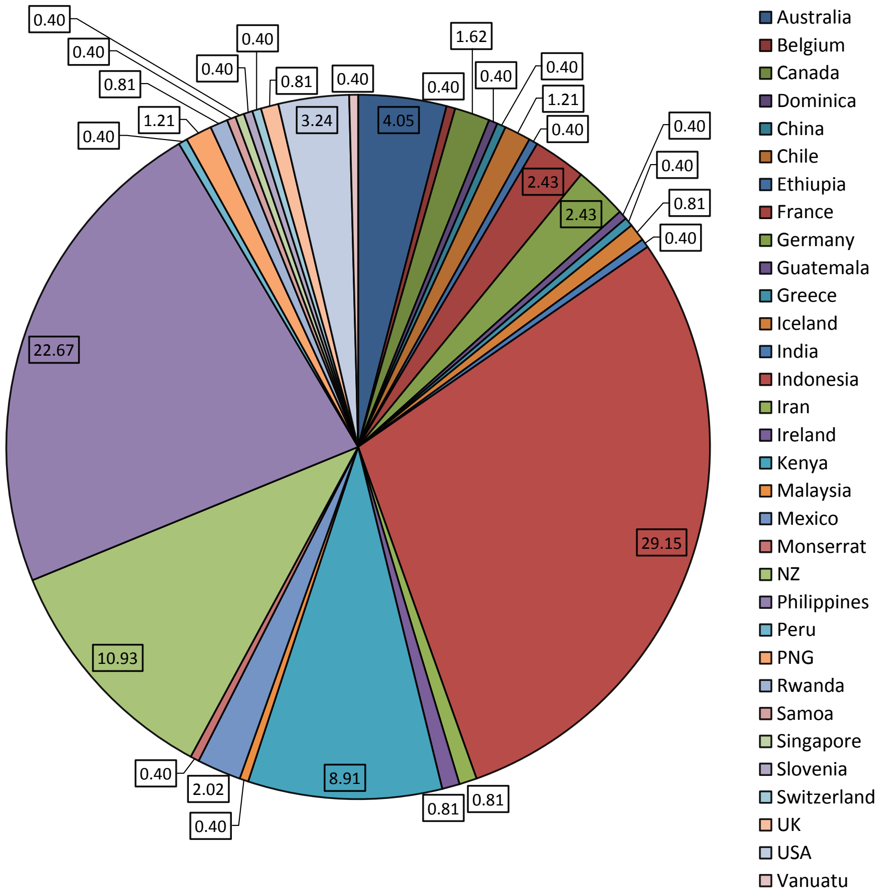

Figure 2. Total student's proportion (%) by country for the past ten years (2007-2016).

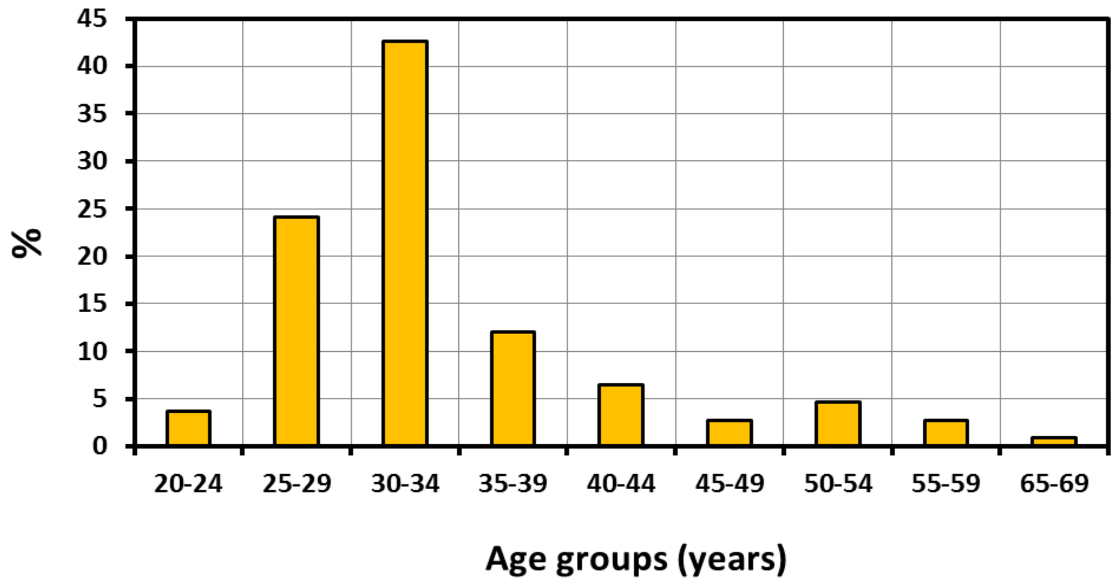

Figure 3. Students age distribution (years) for the PGCertGeothermTech course.

There have always been more male students than female students in this course with an average of 24% female students from 2007 to 2016. Figure 4 shows that the highest proportion of female students 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 2016, which is 22% female student on average.

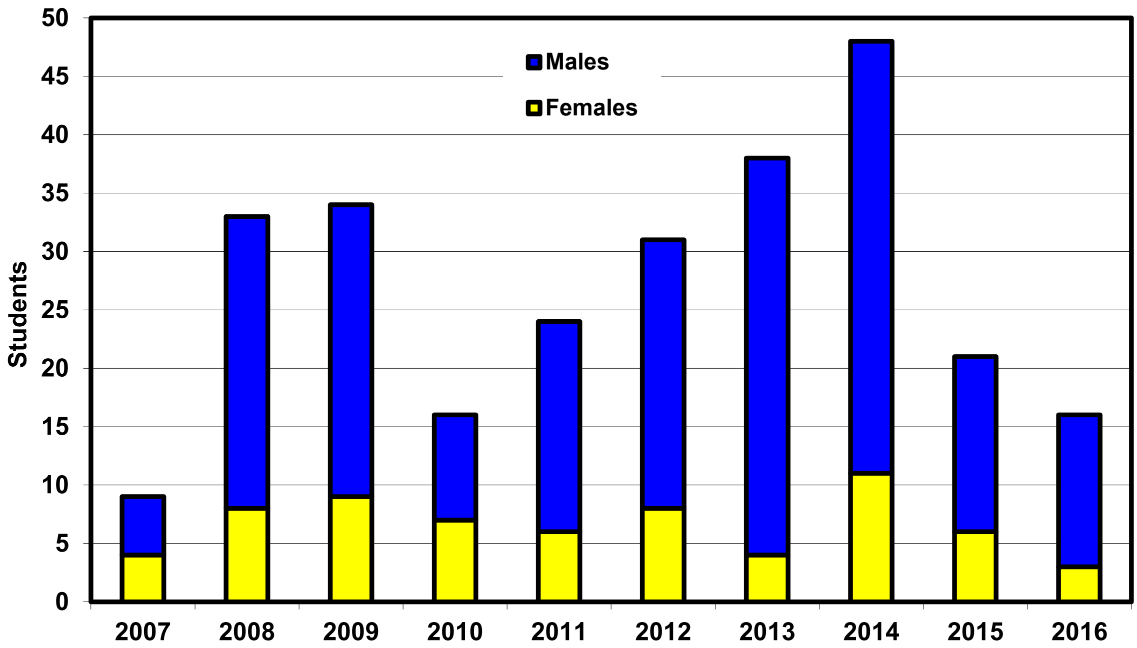

Figure 4. Annual gender distribution for the PGCertGeothermTech.

Financial support

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

Figure 5 shows the categories of support for students and the number of students under each category from 2007 to 2016. The categories we define are self-supported where no official specific funding to attend the course. Company sponsored, whereby the student is supported by their employer to attend the course. Scholarship funding, where the student have a scholarship from an organisation other than their employer. For the PGCertGeothermTech this is typically a New Zealand government scholarship. Although Maori Trusts have also offered scholarships, however, there is a shortage of eligible 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 enquire 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 annually. Since 2011, 29.2% of the students have been supported by MFAT scholarships. It is anticipated that this ratio will increase with time.

From 2008 to 2010, we had one scholarship for a Maori (New Zealand) student to fund 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. It was only granted to one eligible student so fare in 2008.

The majority (49.5 %) of our students are sponsored by the companies that employ them. Most of these students are from the Philippines (Figure 2). In the Philippines geothermal companies believe investing in their employees professional development is the way to build a strong local geothermal industry.

From 2007 to 2016, only 21.4% of the students were self-supported. In all years, except 2009, the average number of self-supported students was 4.3 per year. It is doubtful that the course would survive in its present form with this small number of self-supported students, 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 fee for the 2016 academic year stands at $NZ 23,133.6 for international students and $NZ 5,243.4 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 per paper for international students. This possibly have affected (reduced) the number of students enrolled in the course (Figure 5).

The number of students with geological background is dropping with seven students in 2015 and only three in 2016. This drop in number of enrolment meant the advanced paper on Geothermal Geology GEOTHERM 603 can be offered every other year if needed to reduce overhead until the number of applications with geological background increase.

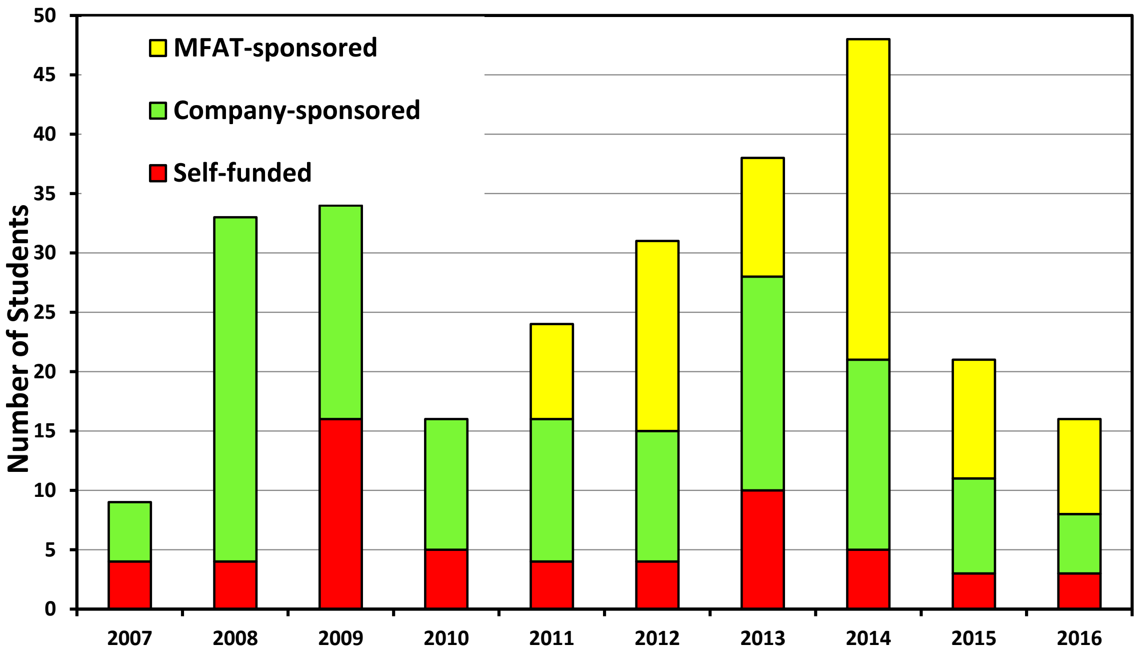

Figure 5. Financial support for students to attend the PGCertGeothermTech, proportions for each year.

Conclusion

The PGCertGeothermTech has been taught for ten years, from 2007 to 2016. It will continue to be offered in the second semester of 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 the course lecturers and the industry.

We are thankful 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.

Based on our experience and the experience of other similar courses from around the world, given the fluctuation in the energy market and the volatile oil prices; it is not possible to run a financially self-sustaining geothermal course. This is without ongoing financial support either directly or indirectly (through student scholarships). This explains the decline (Table-1) of geothermal training programs when their funding stops.

It is anticipated that the worldwide slowdown in the geothermal industry (Indonesia-Investment, 2015). This is reflected in the declining number of students in the past two years mainly the self-funded and company sponsored students. Measures are in place to run one of the elective papers (GEOTHERM 603) every other year to reduce overhead until the demand increases in the future.

References

Dickson, M. H. & Fanelli, M. (1998): *Geothermal Training Centers in the World*. GHC Bulletin, December, 1998.

Dickson, M. H. & Fanelli, M. (1995*): Geothermal Training at the International Institute for Geothermal Research in Pisa*: Twenty-five years of activity, Proceedings, World Geothermal Congress, Pisa, Italy.

Douglas, B.J., Suttner, L.J. & Ripley, E. Indiana university geological field programmes based in Montana G429 and other field courses, a balance of tradition and innovation. In W.J. Steven, D. W. Mogk & E. J. Pyle (Ed) *Field Geology Education* (pp. 1-14). The Geological Society of America, Special paper 461.

Fridleifsson, I. B. *Twenty-five years of geothermal training in Iceland*, Proceedings, World Geothermal Congress 2005, Antalya, Turkey.

Hochstein, M. P. (2005). *25 years Geothermal Institute*, Proceedings, World Geothermal Congress 2005, Antalya, Turkey.

Indonesia-Investment (2015) *Indonesia's Low Electricity Price Discourages Investment in Geothermal Energy*: http://www.indonesia-investments.com/news/todays-headlines/indonesia-s-low-electricity-price-discourages-investment-in-geothermal-energy/item6313.

Massachusetts Institute of Technology (2006). *The Future of Geothermal Energy*. Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century. An assessment by an MIT-led interdisciplinary panel, prepared under Idaho National Laboratory Subcontract No 63 00019 for the US Department of Energy. http://www.geothermal.inel.gov.

McLennan Magasanik Associates Pty Ltd. (2008). *Installed capacity and generation from geothermal sources by 2020*. Report to the Australian Geothermal Energy. Association, August 2008. http://www.infrastructureaustralia.gov.au/public_submissions/published/files/374_agea_SUB3.pdf

Newson, J., O'Sullivan, M.J. & Zarrouk S.J. (2010). *Postgraduate Geothermal Training in New Zealand*. World Geothermal Congress. Bali, Indonesia.

Puckette J. O. & Suneson N. H. (2009). Field camp: Using traditional methods to train the next generation of Petroleum Geologists. In W.J. Steven, D. W. Mogk & E. J. Pyle (Ed) *Field Geology Education* (pp. 25-34). The Geological Society of America, Special paper 461.

Sinclair Knight Merz (2005). *Review of Current and Future Personnel Capability Requirements of the NZ Geothermal Industry*. Report prepared for NZ Geothermal Association. http://www.nzgeothermal.org.nz/publications/Reports/ NZGA_Geothermal_Capability_Review.pdf.

Zarrouk S.J. (2012). *The Challenges of Running Specialised Taught Courses: The Geothermal Postgraduate Course, University of Auckland*, Proceedings of the 2012 AAEE Conference, Melbourne, Victoria, Australia, 3-5 December, 2012.

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