

# Women's Success in Mathematics: The Hypatia Scholarship Program

Stephen Lucas<sup>a</sup> and Fiona Underwood<sup>b</sup>

<sup>a</sup>School of Mathematics, University of South Australia, Mawson Lakes, SA 5095 AUSTRALIA

<sup>b</sup>Teaching and Learning, Division of Information Technology Engineering and the Environment, University of South Australia, Mawson Lakes, SA 5095 AUSTRALIA

*Please note this paper may not be reproduced or referred to in the written form in anyway as it is subject to the copyright of the authors named above*

## Abstract

This paper describes a scholarship program for undergraduate women within the School of Mathematics, University of South Australia. In addition to a moderate financial reward, the scholarship provides students with office space and a computer during semester, and employment relevant to their degree programs during summer vacations. The students report that the scholarship was a major incentive in their choosing to participate in a mathematics degree, and have in general received excellent grades for their efforts. A similar scholarship program could be of benefit in other university science disciplines, where women are traditionally under-represented.

## 1. Introduction

In 1997, the School of Mathematics at the University of South Australia set up the Hypatia Scholarship Program for Mathematically Gifted Women. It is commonly known that women have traditionally been under represented in the study of science and mathematics at the tertiary level, which has contributed to maintaining male dominance in these fields. Specifically at the School of Mathematics, of the 41 students currently enrolled in undergraduate degrees, 34% are women (inflated, we believe, by this scholarship), and only 1 of 17 tenured academic staff is female. A perusal of the web sites for other Australian mathematics departments indicates this ratio is not unusual<sup>1</sup>. The aim of the scholarship, then, is to increase participation rates of women in mathematics, both by attracting talented high school students to undertake mathematics degrees, and by increasing the awareness of the study of mathematics in the general South Australian high school student population.

The Hypatia scholarship program was originally conceived by Professor Jerzy Filar, who developed the terms of the scholarship, and has directed its progress since inception. Dr. Stephen Lucas has been the overall coordinator of the program, being directly involved with the students as a first point of contact. The program was named for Hypatia of Alexandria, who was the first woman to make a substantial contribution to the development of mathematics during the second half of the fourth century AD<sup>2,3</sup>. The scholarship is offered to 3-4 first year students each year, with a capacity of 9-12 students at any one time.

The aim of this paper is to describe the experience of setting up and running a scholarship program that offers more than just a cash incentive to a university student. We begin in section 2 by describing the scholarship itself, as well as our reasons for taking this approach. Section 3 describes some of the outcomes of the scholarship program from the School of Mathematics' point of view, including the successes of the students and our degree program as a whole. Section 4 summarises a survey of the students' experiences of the program, and section 5 concludes by summarising the lessons learnt in this process, and aims for the future.

## 2. The Hypatia scholarship

In this section we shall describe a variety of aspects of the Hypatia scholarship, including what the student receives, the application process, what is asked of the students, issues of publicising the scholarship, and the reasoning behind these choices.

### 2.1 Scholarship awards

Virtually every department of every university in Australia offers monetary scholarships to entice students with high entry scores. For example, the School of Mathematics at the University of South Australia offers single payouts of

---

<sup>1</sup> Consultation of the Administrative directory of mathematical sciences in Australasia, published by the Australian Mathematical Society, failed to provide accurate figures on the gender balance of its members.

<sup>2</sup> Deakin, M.A.B. (1994). Hypatia and Her Mathematics. *The American Mathematical Monthly* v.101 #3 234-243.

<sup>3</sup> Deakin, M.A.B. (1997). Hypatia of Alexandria, *from* Radio National Transcripts: Ockham's Razor, Sunday, 3rd August 1997, <http://www.abc.net.au/rn/science/ockham/or030897.htm>.

\$1000 to every student with a TER > 90, and \$2000 to the student with the highest TER > 90 (the TER, or Tertiary Entrance Ranking, is a number between 0 and 100 indicating a percentage ranking of the student among all those completing high school that year). The Hypatia scholarship deliberately takes a different tack, and provides the students with the following:

- *Their own computer in a study room in the Mathematics building, shared with other scholarship holders.* When the program was established, we anticipated that this would be its most important and innovative aspect. Usually, only honour's students are provided with office space and free use of a computer. By having an office on the same floor as the academic staff, we hoped that the Hypatia students would feel more a part of the School, and more confident in their interactions with the faculty. The use of a computer makes the day-to-day life of a student much easier, avoiding the difficulties of finding a free computer in a university computer pool. By sharing with other Hypatia students, usually in the same year, we hoped to develop a sense of camaraderie within the group, which would help build their confidence within the male dominated student body. The computers are provided to the school at a discount by Microbits, a sponsor of the program.
- *HECS (Higher Education Charges) paid for their first year.* While we initially considered paying HECS fees throughout a student's degree, the resulting financial obligation would have severely restricted the number of students to whom the scholarship could be offered.
- *Paid summer employment at the end of 2<sup>nd</sup> and 3<sup>rd</sup> years.* The summer employment aspect of the program was designed to provide an opportunity for students to see how their mathematical training can be used in either an industrial or academic workplace. For example, many of our students are employed at the Defence Science and Technology Organisation (DSTO, another sponsor of the program). Others have been employed on research projects within the school, under the supervision of an academic staff member. We also get as many as possible of our Hypatia students to attend the Mathematics-in-Industry Study Group (MISG) that has been run in Adelaide by our School in recent years. This weeklong workshop again involves the practical application of mathematics to problems from various industries.
- *Opportunities to spend a semester studying overseas.* While this is made available to our highest performing students, special effort is made to organise for our Hypatia students to spend a semester of their degree studying abroad as part of our school's ongoing exchange program with the University of Twente in the Netherlands and Harvey Mudd College in California.
- *Regular contact with the program coordinator.* While all students are encouraged to meet with their academic advisors, recipients of the Hypatia scholarship enjoy an additional layer of faculty contact through their interactions with the program coordinator.

## 2.2 Application process

Current year 12 students are invited to apply for the scholarship by the end of October each year, and must submit their Year 12 record, a letter of recommendation from a mathematics teacher, and a short essay describing why the scholarship suits their career goals. We hold face-to-face interviews with a short-list of selected applicants. Based upon interviews and their CVs, we choose scholarship recipients before their final exam marks and TER are released.

We feel that a student is more than simply their TER ranking, and the selection committee deliberately looks at the other criteria listed above when choosing scholarship recipients. While we hope that the students will excel in terms of grades, we are also interested in well-rounded students, able to successfully make the transition from university life to a career using the skills they have developed.

## 2.3 Additional requirements

The Hypatia program requires some extra participation by the students in other activities while at university. On occasion, the Hypatia students visit schools with staff members, particularly their own high schools, as part of our promotions for mathematics degrees. We have also occasionally asked Hypatia students to promote mathematics degrees at University Open Days, and other related events. Hypatia students, as well as other high performing undergraduates, are encouraged to attend selected School of Mathematics seminars, where we believe the seminar is not too difficult for their level of training.

One important aspect of this program is that it does *not* require students to do additional work beyond their standard undergraduate courses. Extra work without credit within the university system is a disincentive to most students, regardless of their level of ability. For example, during the initial years of the Hypatia program, Dr. Lucas made various attempts to interest the students in some additional material building on their first year classes. Most of the students were not particularly interested, and cited time pressures from their various courses. Just because a student may be more talented than the average does not mean that they spend less time studying than the average student. In fact, the reverse is usually true. Most students who achieve high grades in our courses put in a substantial amount of effort to get those grades. While they would probably be able to get average grades with substantially less effort, most are interested in putting in the extra work to achieve high grades.

### **3. Outcomes**

#### **3.1 Student success and participation**

At this point, three Hypatia students have graduated, three are doing honours, one is on leave with the intention of doing honours next year, and four are current undergraduates. This group of students, collectively, have completed 231 courses and achieved a total of 130 High Distinctions (nominally a mark of 85-100%), 64 Distinctions (75-84%), 29 Credits (65-74%) and 8 Passes (50-64%). Considering Given that a typical university course gives out around 10-15% High Distinctions, and a majority of Credits or Passes, these are a truly excellent set of results. It appears that our criteria have served us well in selecting these students. We would like to believe that a student's enthusiasm for their program and willingness to work hard are major factors in their success, and that the Hypatia scholarship benefits have increased these attributes. Dr. Lucas personally attests to the fact that Hypatia students appear confident of their ability to get help from university staff.

All three students who have graduated to date did so with first class honours, one winning a University Medal. One is currently working at DSTO, another has begun a PhD at the School of Mathematics, University of South Australia, and the third is beginning postgraduate work in Statistics at Pennsylvania State University in the USA. One of our current honours students has already obtained employment at DSTO starting next year.

At this point four Hypatia students have used the opportunity to study overseas, and have found the experience valuable and broadening. Most have also attended the MISG workshop each year, and reported to have gained valuable experience from it. This workshop is a concentration of mathematicians brainstorming on industry problems, and serves as an excellent way of showing students what lies beyond an undergraduate education.

#### **3.2 Difficulties with the program**

As with any program, not all aspects are equally satisfying. One potential area of difficulty is personality conflict; Hypatia students from each year of the program share the same office, so any animosities could cause difficulties. From the staff's perspective, we believe we have been lucky to not have any major disputes up till now, but this may be more luck than good management. However, the coordinator of the program and others in the School try and keep in regular contact with Hypatia students to ensure that any potential problems are caught early.

The astute reader may have noticed that the current number of Hypatia students is below the number one would expect from four years of intake (remembering that the first group of three have graduated). Currently there is only one third year Hypatia student, and none in first year. Three Hypatia scholarships were awarded in 2000. One dropped out at the end of first year, spent a year at Bible College, and has returned to university in 2002 to do a degree in Physiotherapy. Another dropped out of the mathematics degree in the middle of second year, and has continued at university in a Commerce degree. In both cases, it seems that the students were torn at the end of high school between different career paths, and eventually decided to enrol in a Mathematics degree partly due to being offered the Hypatia scholarship. In the first case, the student decided she had made the wrong choice after a year of study (despite achieving the superb results of 7 High Distinctions and 1 Distinction). The second was doing reasonably well through to halfway through second year (1 High Distinction, 3 Distinctions, 3 Credits, 4 Passes), but lost confidence in her abilities as the course content became more difficult. Unfortunate as these losses were, we still believe offering them scholarships was realistic. One aim of the program is to attract talented high school students to a degree in Mathematics that they might not have otherwise considered. While some may decide that this is not the path for them, our experience has been that other succeed beyond their expectations and discover opportunities they would otherwise never have encountered. We intend to continue offering the scholarship to students who have not made up their mind on final career directions.

A serious problem is the fact that we didn't have any new Hypatia students entering the program in 2002. Only three high school students applied, all of whom were worthy of being offered the scholarship, but none took up the scholarship, deciding to pursue other careers. Clearly, the information about the scholarship and how the curriculum is constructed that might be more conducive to women's participation was not as well promoted within high schools last year as we would have hoped, a problem that needs to be addressed. Then again, overall numbers entering the Mathematics degrees in 2002 are substantially down on previous years, and the issue of marketing is an important one for the School as a whole to address. We would like to believe that the two are closely linked, and that greater efforts this year will improve the situation in 2003.

### **4. Student experiences of the Hypatia Scholarship program**

The evaluation questions asked about the women's experiences of the program, with a focus on the social and environmental factors that shape their learning. Face-to-face, semi-structured interviews were conducted with seven Hypatia students, while three others participated by responding to the same prompt questions by email. The questions

addressed these topics: why they applied for and later accepted the scholarship; how they have survived, financially and/or emotionally; what they learned, and what research activities they have engaged in; what concerns, issues or constraints, if any, they experienced during the scholarship program; what changes they recommend; what are their future plans; how effective the scholarship has been, and what outcomes have the candidates achieved, since they undertook the scholarship; is the scholarship needed to assist more women to study mathematics; and, finally, their comments on their experiences of the scholarship program. Two key themes emerged from the interviews: the value of the scholarships' social resources, and the meaning of gendered identities in the scholarship program.

• **Reasons for accepting the scholarship:** The Hypatia students identified their reasons for accepting the scholarship as including the learning advantages of the resources offered, the reputation which participating in a scholarship program brings to graduates, and envisaged career opportunities. One student singled out the advantages of the social resources provided by the scholarship:

*'The idea of having a personal workspace on campus is what appealed the most, because I knew this would be a big advantage for when I'm studying. I also thought it would be an opportunity to meet like-minded girls and form friendships' (interview #3).*

In a few cases Hypatia students were particularly clear that they wanted to study mathematics, and the impetus for applying for the scholarship was to obtain bonus-learning resources. Others had not chosen a career direction until year twelve, and had expressed earlier interests in studying journalism, cognitive science, or computer science. The conditions of the Hypatia Scholarship were a critical factor in their decisions to study mathematics.

One student who was offered a scholarship elected to defer for a year while she worked in an accounting firm before deciding to pursue a career in mathematics. Another Hypatia student described her decision to study mathematics thus:

*And my dad rang up and said, 'Look you got it, they've written you a letter saying you've got it, do you want to accept it'? And I thought I don't know. And I thought there is no point in not accepting it. I should give it a go and see what I think of it. So it wasn't until the last minute that I had been offered that I thought I will give it a go. It was very last minute (interview #9).*

It was found that the support of a secondary maths or physics teacher or mathematics tutor was also critical for encouraging students to submit applications for the scholarship.

• **Financial means of surviving on the scholarship:** All of the Hypatia students found that summer vacation work was an important contributor towards their financial viability while in the program. One student even managed to make this income last all of the academic year. Other means of financial support included paid tutoring or supervision work, Austudy, the government youth allowance, parental contributions, and other part-time work. One student, who was financially supporting herself as a full time student, indicated that this engendered difficulty in coping with her studies, and that, despite the scholarship, she still experienced difficulties in purchasing books and other living expenses.

Some students found that it was not financially viable for them to participate in an overseas exchange program, despite some financial assistance. In one instance, this issue was compounded by the costs of being a rural student studying in the city:

*I just wasn't financial enough. I know they provided scholarships to go over, but it was still a bit too hard because being from the country I have to rent a place here, and it was a case of 'what would I do with where I was living here while I was over there'? I mean I would have loved to ... (interview #4).*

• **Collaborative learning environments:** The social resources provided by the scholarship, both in terms of access to academic staff and interactions with fellow Hypatia scholars were more highly valued by the participants than the material ones. This was particularly notable among those scholarship recipients who came from rural areas. One of these identified the transition to the city 'was a big step' (interview #1), while another stated that:

*Student: Yeah it was pretty tough ... if it wasn't for the lecturers here in the maths department ... a couple in particular, if it wasn't for them I still wouldn't be studying here. The first six months especially are really, really tough.*

*Interviewer: What was really tough about it then?*

*Student: For me there was only one other friend of mine from high school who moved up here ... she was the only other person that I knew here in Adelaide when I first moved up. And she's gone home now. ...So [I left my] whole group of friends. ... I went from a situation of being in work and earning money to then having to try and financially survive at uni and yes, other personal problems, with family and stuff being down there, so yeah definitely the first six months is tough. But once I got past that it was good (interview #4).*

Another student identified the Hypatia social network as important in overcoming her concerns about the value of the course content, and dealing with her anxiety about making the transition to the workforce:

*And I also think the scholarship is great because you have your feelings of 'oh am I leaning much in this course'? Because you know toward the end of the course you don't feel that you have learnt enough to be going out to into the workforce. Which is good to have other people to chat to about that and realise that they are sort of feeling the same feelings, which makes you feel better about what you are doing (interview #4)*

The same student also indicated that this was an area in which the program could be further developed:

*I know I met the first years once, and I didn't really get to know them that well. I think... if they had made us get together more often being in third year you could have helped ... the first years. Like you could have probably chatted to them about the subjects that they were doing and sort of said, 'you know if you need any help you could stop by and I could give you help.' but because you weren't sort of made to do that you didn't really think about it, you just went about doing your own work (interview #4).*

What emerged most strongly from the interviews was that, while there may be scope for an even more collaborative atmosphere, all of the scholarship program participants highly valued the support network established, the easy access to the academic staff, and the recognition of their abilities.

• **Other benefits of Scholarship program:** The students identified a number of additional benefits to participation in the Hypatia Scholarship program. The reputation of the scholarship and the summertime paid-work experience in industry both contributed to improving their confidence in their abilities to make the transition to fulltime paid employment.<sup>4</sup> Participation in the annual Mathematical-in-Industry Study Groups (MISG) provided the students with opportunities to apply mathematical theory to the solution of real world problems, exposed the Hypatia students to a variety of career possibilities and new research directions in mathematics, and helped several participants to overcome their ambivalence about the value of their program. Some of the students recognised that the benefits they enjoy in the program would also be beneficial to other students in mathematics.

Perhaps the greatest associated benefit of the program was the excitement amongst the students about their future opportunities; several have indicated a desire to work with the defence organisation that sponsors the scholarship, and another has discovered an interest in the newly emerging field of sports mathematics. Three Hypatia students have had the to opportunity to get "a taste of what it is like to do postgraduate study (interview #3)" by working with PhD candidates on topics related to their research projects. Students identified the expectations set for them by the scholarship as improving their motivation levels:

*This (the scholarship) kinds of helps you, because you have it in your mind you have to do pretty well. It immediately encourages you. You've got the motivation to go and stay focussed, and do your assignments and get up in the morning and get down here by eight o'clock in the morning. So I think without the expectation of getting good grades I would have in another degree fallen back a bit and drifted into the mentality that, 'this is uni. I don't really have to go to uni'. It helps you to stay focussed (interview #9).*

For some students, their greatest perceived achievements were the academic grades they had achieved. For one it was gaining permanent employment before completing her honours degree. For another, who had moved to the city to take up the scholarship, it was simply the fact of having been able to make a successful transition from a rural area to the city. One student's response focussed on the development of ideas for her future:

*I've been able to settle into one thing, and get a focus on where I want to be and so that's pretty much a big thing. Because I know what I want to do. I've got a future plan mapped out. I've got this plan for going overseas at the end of fourth year, and I really want to do that. I've got everything planned out that is probably the biggest thing I've achieved so far (interview #9).*

• **Limitations of the program:** All of the students interviewed praised the Hypatia Scholarship program, and expressed high levels of satisfaction with their experiences. There were only two areas where students identified scope for the program's improvement. The first was that the scholarship only applies to two academic programs, and does not include the double maths-finance degree or pure mathematics. The other was part of the recurring theme of the value of social

---

<sup>4</sup> The relationship between girls' interest in mathematics and confidence levels has been well documented, e.g. Rogers, P. & Kaiser, G., (eds) (1995). *Equity in Mathematics Education*, Falmer Press, London. Walkerdine, V., & The Girls and Mathematics Unit (1989), *Counting Girls Out*, Virago Press, London. Willis, S. (1989). *Real Girls Don't Do Maths: Gender and the construction of privilege*, Deakin University, Geelong, Victoria.

networking, with one Hypatia student indicating that she felt her interactions with non-Hypatia students were constrained:

*I mean I guess in one way it does sort of restrict you from everyone else other than with the people who are on the scholarship, because you don't spend any time just sitting around the ground of the uni (interview #4).*

Another problem that emerged from the interviews was students' uncertainty over the relevance of a degree in mathematics. Despite Hypatia applicants being required to submit in an essay on why they want to study mathematics, at least one was unclear during the first year of the course as to how she could apply knowledge gained in the program to future employment. "What I thought this course was going to be and what it is, is completely different (interview # 9)" This relates directly to the problem the School of Mathematics has experienced in marketing the program.

• **Discussion of emergent themes:** Two interrelated key themes have emerged from the analysis of the interview text. These are the value of the social resources provided in an affirmative action scholarship program; and how the Hypatia students perceive their gendered identities in the program.

This study indicates that the students place the greatest value on the social dimension of the scholarship experience, while the financial payment of HECS fees in the scholarship program is even less valued than the other material resources of shared office space and provision of a computer. Uncertainty and anxiety over where the degree may lead them appear to be reduced by the scholar's shared social network. The social interaction with academic staff is also of critical importance; all of the students interviewed mentioned that being able to easily liaise with academics was important to learning and enjoyment of the program. Contextualising this last point within the typical undergraduate student experiences, where resource constraints mean that students gain little access to academics, reinforces the significance of this element of the scholarship program.

Identity as a Hypatia Scholarship student is highly valued by candidates, particularly when the candidates do not interpret gender as the focus of the scholarship. Most candidates believe the scholarship program is needed to assist more women to study mathematics, recognising some candidates would not have participated in it without the scholarship. Where gender is perceived as the focus of the scholarship, however, some candidates expressed ambivalence about the Hypatia program as an affirmative action strategy for women:

*I mean as much as I love the scholarship and praise it to bits, and think it is fantastic, I also know there is the case that you have to help yourself, and I don't think ... you should be disadvantaged being female, but at the same time I don't think you should receive any extra benefit just because you are. And so I think the scholarship is worthwhile at the moment because there aren't as many females doing it, and like I say I probably I wouldn't have done it if I hadn't got the scholarship. Yet at the same time, like I know for example when I've been out at DSTO I don't sort of enforce that fact that I've got this scholarship to people because of the fact that I don't want people treating me differently just because I am female, like I just want to be treated as an equal. Sometimes I think that people can go too far the other way and expect too many rights as females, but that is just my opinion (interview #4).*

Students expressed different interpretations of what an affirmative action strategy means in terms of creating a 'level playing field' between the genders:

*Yes, especially in DSTO. There is a real lack of females in every area. I think we bring a lot of different things to the field of science and research in terms of communication skills. I mean everyone brings different abilities, but you know it would be good to level the playing field and get a few more girls out there (interview #7).*

*I can see the advantage of promoting or encouraging women to take maths degrees. But at the start I was a little bit taken aback by the fact that it was only offered to women ...I thought it would be nice to compete on a level playing field, but I kind of got over that (interview #1)*

The first student demonstrates consistency between her understanding of the need for the scholarship program, her participation in it, and her hopes and desires for the contribution the program may make increasing women's participation in mathematical professions. Further, her gendered identity is based on a feminism of difference, demonstrating an understanding and affirmation of women as having different kinds of knowledges.<sup>5</sup> The second student, on the other hand, expresses a struggle to reconcile the need for affirmative strategies to encourage women's participation, and her own identity as a women participating in the program, with an egalitarian desire for people to be judged by their abilities regardless of differences. Another student expressed her belief in the potential for a broader social empowerment of women through her acceptance of the scholarship:

<sup>5</sup> Mura, R. (1995). Feminist Pedagogy in Mathematics Education in *Equity in Mathematics Education* (eds Rogers and Kaiser), Falmer Press, London, pp. 155 – 162.

Interviewer: *why did you accept the scholarship?*

Student: *Besides the benefits the scholarship afforded me, I was proud to be a female finding success in a traditionally male-dominated area. I felt as though I could, in a small way, set a positive example for other girls, and show them that they can pursue whatever interests they like (interview #3).*

This issue of social responsibility, the sense of 'setting a positive example' experienced by students who benefit from participating in scholarship programs for marginalised social groups, is clearly worthy of further investigation.

## 5. Recommendations and Conclusions

By any measure, the Hypatia scholarship program has shown itself to be a highly successful innovation to encourage women to undertake tertiary study in mathematics. The evaluation of the program, consisting of feedback from ten of the eleven Hypatia candidates, has confirmed that the program is achieving its aims. The participants indicate that they are extremely appreciative of the value of the resources provided by the scholarship, and enjoy being treated like research students, being welcomed, nurtured and respected as talented academic colleagues.

The relative values of the different aspects of the program can be most readily appreciated by comparing the reasons the students gave for having accepted the scholarship in the first place with the benefits they feel they have received from their participation in the program. The critical factors in acceptance were material resources and reputation. The greatest benefits, however, stemmed from the social networking within the program and with academic staff, the extra-curricular mathematical experiences of summer employment and MISG participation, and the confidence in their own abilities and enthusiasm about their work and their futures which they derived from the scholarship experience. The difference between these two sets of factors provides important lessons for two key questions: how to market programs targeted at encouraging enrollment of traditionally under-represented groups, and how to encourage students enrolled in such programs to achieve to their full capacities.

The Hypatia scholarship thus provides an extremely valuable model for providing an academic environment conducive for encouraging under-represented groups to achieve academic excellence. While the marketing aspect of the program is still in need of improvement, the testimony of the Hypatia candidates and the empirical evidence of the Hypatia students' grades and industry interest in recruiting them amply demonstrate its usefulness. We therefore strongly recommend the merits of the Hypatia model to other faculties that are interested in improving the balance of students in their academic courses.

**Acknowledgement:** The authors gratefully acknowledge Abigail Schweber for her assistance in editing this paper.