Implementation of Supplemental Instruction at the Department of Astronomy - A preparatory study.

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Preface

This report describes a plan to implement Supplemental Instruction (SI) as a new pedagogical tool at the Department of Astronomy in Stockholm. The report is written for the second phase of the course *Universitetspedagogik i Teori och Praktik* (University pedagogics in theory and practice), given by the unit for pedagogical development at Stockholm University.

We aim to set the stage for the implementation of SI at the department by clarifying how SI can improve the current learning situation. As a continuation we intend to apply to the council for renewal of higher education to achieve the economical resources to initiate such a programme and to demonstrate its potential advantages. An important step in the implementation of SI is to inform the faculty about what SI proposes to do.[1] This report is an attempt to do so.

Although this project specifically aim at the Department of Astronomy at Stockholm University, we are convinced that similar circumstances apply at many other departments, and that many of the considerations in this report can be more generally applied.

SI is now used at many universities around the world, but not much is actually published about this method. We have therefore chosen to include many references to the World Wide Web (WWW), where a lot of information about this method is available. These URLs were all alive in November 2002. A lot of electronically published material can also be found on the homepage of the Center for Supplemental Instruction, UMKC.[2]

Stockholm, January 2003

Jesper Sollerman & Magnus Näslund

[1] Ainsworth, Garnett, Phelps, Shannon, & Ripperger-Suhler (1994) *Supplemental Instruction: Steps in Starting* - www.umkc.edu/centers/cad/si/sidocs/jbstrt94.htm
[2] www.umkc.edu/cad/SI/Index.htm

Contents

Abstract

We propose to implement a version of Supplemental Instruction (SI) at the Department of Astronomy at Stockholm University. The department offers introductory courses in astronomy but also more advanced courses where background studies in mathematics and physics are required. Most students are found in the introductory courses, where we believe that a substantial improvement in learning quality will result from student-led out-of-class activities.

Such a SI programme would, as a complement to ordinary lectures, provide sessions during which introductory students will be encouraged to discuss topics guided by advanced students. We believe that SI will facilitate deeper learning by students at introductory courses in astronomy, while at the same time give advanced students, acting as SI leaders, a possibility to put their astronomical knowledge in a wider context. Furthermore, our SI programme will provide feed back to lecturers, and will keep the SI instructors better connected to the daily work at the department.

1 Introduction

Astronomy is a subject for everyone, attracting people of all ages and backgrounds. During the last decade this large interest has increased even further, among other things due to the large coverage by media. Almost every week, we can read about new discoveries e.g., by the Hubble Space Telescope. Organizations like NASA[3] and ESA[4] have become increasingly aware of the importance of Public Relations. As a result, the number of students attending the introductory courses at Stockholm Observatory[5] (Department of Astronomy, Stockholm University) has increased to 100-200 per course. Although the department benefits from this, it also raises new demands.

The Swedish Government has as one of its main educational goals that 50 % of every age group should have begun university studies at the age of 25.[6] As this goal is achieved, an increasing number of students with a greater diversity in their backgrounds will attend the university in the coming years, and the demand for new pedagogical methods will become stronger.

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[3] www.nasa.gov

[4] sci.esa.int

[5] www.astro.su.se

[6] *Den öppna högskolan, Sammanfattning av regeringens proposition 2001/02:15* - http://utbildning.regeringen.se/ansvarsomr/universitet/publikationer.htm; http://utbildning.regeringen.se/publikationerinfo/pdffaktabl/2001/u01_015.pdf

1.1 Astronomy - a fascinating field

Astronomy, in a sense, contains everything, from the Universe as a whole to the tiniest particles which may be the dominating mass constituent in our Universe. Vast distances, huge celestial bodies and powerful explosions far beyond our experiences in daily life, are just a few things that attract people to astronomy. Astronomy is also open to almost everyone; who has not looked up at the night skies and wondered about what is going on in outer space? Few other fields of natural science are as accessible as astronomy; all you need is a dark location and a clear sky.

1.2 Astronomy as a gateway to science

Most people are able to relate to astronomy. However, astronomy is still considered by many to be a very special subject, isolated from other sciences. The reason for this misconception is probably that astronomy is believed to deal with outer space, while e.g., physics, chemistry and biology take care of what is happening on Earth. Astronomical research during the last decades have clearly shown that almost every field of physics has an application in astronomy. Furthermore, astrochemistry and astrobiology are two fields of increasing interest. Astronomy also connects to other disciplines, such as philosophy and the humanities. Questions about our place in cosmos are raised also by many people outside the astronomical community.

The popularity of astronomy is attracting people/students to science. For many, this is a gateway to continued scientific studies. The large introductory astronomy classes thus act as a science magnet for recruiting students to the natural sciences. For others yet, the introductory astronomy class may be their only contact with science and the scientific method. Hence, astronomy could be the subject in favour to increase the interest in natural sciences in general, and physics in particular, while SI could be the tool to accomplish the desired outcome.

2 What is Supplemental Instruction?

Supplemental Instruction was originally developed by Dr. Deanna C. Martin at the University of Missouri-Kansas City.[7] SI is a academic student assistance programme. It consists of supplementary and voluntary sessions for students where they can discuss difficult concepts and topics in the course. These sessions are regularly scheduled, out-of-class, and facilitated by peers. They can be seen as informal seminars in which students discuss and penetrate the course literature and lecture notes. In this way they will learn how to integrate course content and reasoning skills. The SI sessions are directed by "SI leaders," usually

[7] www.umkc.edu/centers/cad/si/

students who have previously and successfully taken the course. Professional staff train the SI leaders in learning strategies and theory.

SI is meant to increase the students skill in comprehension, analysis, critical thinking, and problem solving. It will emphasize a deeper learning, as students will have to work with new concepts themselves. In that respect, SI provides a model of collaborative learning that can be used in a variety of learning environments.[8] SI targets traditionally difficult academic courses, those that have a high percentage of failures. In an improved learning environment, students will more likely pass assessments and the "throughput" will accordingly increase.

The key persons in the SI program are the SI leaders. They have been chosen by the course instructor to conduct peer-facilitated study sessions for the targeted course. The SI leader in a sense assumes the role of the "model student". Their task is to assist students in integrating course content and learning strategies. They themselves receive training in supervision of learning and study strategies.

The selection of a peer to facilitate the study sessions is meant to downplay the importance of the role of the content "expert" (e.g., the lecturing professor) while increasing the role of the facilitator. By limiting the role of the content expert, each student assumes a more active role in the group. The collective knowledge and wisdom of the group becomes the source for reconstructing whatever content has been presented by the course instructor. SI does not attempt to replace the role of the content expert, but rather to provide an alternative method for processing the information. Because SI leaders are not presented as experts but only as "model students" they are under no pressure to answer all questions about the course content. In fact, the SI leaders should really not answer questions at all. Instead, questions are redirected for the group to answer. This is an attempt to develop the student's ability to independently think critically about issues as they unfold. All students should attempt to answer questions and clarify information. In this way the accuracy of answers and factual information are ultimately accomplished by the collective self-correcting nature of the process itself. It should also not be overlooked that when students are answering each others questions, they become engaged, and engagement is the first step toward critical thinking and away from the passiveness that characterizes learning dependency. Engagement, in this case, is not the result of a contrived attempt to get students to do critical thinking as much as it is the desirable outcome of removing the temptation to ask the expert.[9]

Peer-facilitated study sessions may also encourage students to go beyond blindly accepting presented material as unquestioned "truth." Since scientific researchers only rarely can make a definite statement in unequivocal terms about

[8] Wilcox & Koehler (1996) *Supplemental Instruction: Critical Thinking in Context of Academic Assistance* - www.umkc.edu/centers/cad/si/sidocs/kwcrit96.htm

[9] Wilcox & Koehler (1996)

the implications of their findings, educators are no less responsible to the same standard.

The goal of SI is to tap the otherwise natural and uninterrupted processes of inquiry. Inquiry begins when some aspect of the subject matter is unsettling, problematic, or just not understood. Critical thinking skills must necessarily be employed when knowledge is uncertain.[10]

3 SI in Sweden

SI has been used in Sweden since 1994. The Institute of Technology and the Faculty of Mathematics and Natural Sciences at Lund university made an early implementation of the idea, with support from The council for the renewal of undergraduate education.[11] Lund now hosts a Centre for Supplemental Instruction.[12] Two persons at Lund have undertaken training at the National Center for SI,[13] University of Missouri-Kansas City, and now titulate themselves Supplemental Instruction Certified Trainers. They provide regular courses for SI-instructors in Sweden. One single training event has been reported to have had participants from 11 different Swedish universities.[14] The initial SI programmes in Lund have been reported to be very successful.[15] Although it was not possible to measure the success in a truly experimental way, due to the lack of control groups, it was seen that about half of the students participated in the SI sessions and that the students themselves state that they have achieved a deeper understanding of the subject.[16] The students were most happy with the possibility to participate in small group discussions. The same investigation reports that also the SI leaders acquired a deeper understanding of the subject.

SI is also implemented at Uppsala university, both in Mathematics[17] and in Medicin.[18] It is available at Chalmers university in Gothenburg, where it has been very successful at for example the school for electrical engineering,[19] as well as at the institute of computer sciences at Umeå university.[20] This is by no means intended as a comprehensive list of institutes which apply SI, but will guide the reader to various SI centres around the country. It is clear that

[10] Wilcox & Koehler (1996) *Supplemental Instruction: Critical Thinking in Context of Academic Assistance* - www.umkc.edu/centers/cad/si/sidocs/kwcrit96.htm

[11] www.hgur.se/activities/projects/financed_projects/a-b/bryngfors_leif_94.htm

[12] www.lth.se/english/si/default.html

[13] www.umkc.edu/cad/SI/Index.htm

[14] Wilcox (1996) *Supplemental Instruction in Sweden: An Interview with Marita Bruzell-Nilsson and Leif Bryngfors*, Supplemental Instruction Update, 1,3

[15] Bryngfors & Bruzell-Nilsson (1997) *SI Supplemental Instruction, An experimental Project with the Method of Supplemental Instruction*

[16] Bryngfors & Bruzell-Nilsson (1997)

[17] www.it.uu.se/edu/si/info.shtml

[18] hgur.hsv.se/activities/projects/financed_projects/m-p/muhr_carin_2_97.htm

[19] www.ee.chalmers.se/externt/si/si.htm;www.ee.chalmers.se/externt/si/enrf.htm

[20] www.cs.umu.se/education/SI/

SI has mostly been used in mathematics, programming and engineering, where some of the focus is on learning how to do different tasks, or how to achieve certain skills. SI is however also used in humanities, for example in courses in Ethnology at Lund.[21]

Recently (Autumn 2001) SI was also implemented at KTH Syd in basic programming and mathematics courses. The implementation of this has been well documented in a report by Gustavsson & Lundberg (2002).[22] This report, written in Swedish, gives a very practical view of implementing the method at a new university, including preparations, schedules, and comments from the students and the SI-leaders. To our knowledge, there is still no implementation of SI at Stockholm university.

4 Teaching at the Department of Astronomy

Undergraduate teaching at the Department of Astronomy in Stockholm is done at two quite different levels. Most students have no previous background in astronomy and take our introductory courses. These courses require no previous university studies, and we list some examples here (translations by the authors)[23]

Introductionary Astronomy.
Planets and life in the Universe.
The Sun and other Stars.
Astronomy, image and art.

These courses are characterized by a large number of students (60-200), with a very diverse background. Often, the lectures are given in the evenings, to allow also non-traditional part-time students to participate. Teaching resources admit mainly normal lecturing for these large groups, and thus allows very little discussion and feed-back for the introductory students (InS), see Figure 1.

The other, much smaller, group is the advanced students (AdS) with at least 2.5 years of university mathematics and physics as background knowledge. These take specialized and very advanced courses, as for example:[24]

Astrophysical radiation processes.
The physics of the interstellar medium.
Galaxies and galactic dynamics.
Stellar atmospheres.

[21] www.etn.lu.se/kurs/

[22] Gustavsson & Lundberg (2002) *Kursrapport avseende Supplemental Instruction*, KTH Syd

[23] www.astro.su.se/utbildning/utbildning.html#oversikt

[24] www.astro.su.se/utbildning/utbildning.html#grund

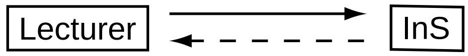

Figure 1: Traditional lecturing is almost a one-way communication. Only a minor fraction of available time is spent in discussions and similar events.

Advanced courses are lectured, but also contain a number of exercises. After one year of astronomy courses, and a one-semester master thesis, the student get a degree and can then apply for the PhD-programme in astronomy. Due to the small number of students, there is more available time per student for lecturers of these courses. The groups of students are also relatively homogeneous. Students discuss with each other and seem to find time to meet out of class more easily compared to students of introductory courses.

5 The case for SI at the Department of Astronomy

By having the advanced students (AdS) mentoring the introductory students (InS) we expect to achieve the following advantages. For the InS there will now be a forum for discussion of the multitude of relatively advanced concepts present in astronomy. A deep understanding of these concepts requires some elaboration and digestion beyond the classical lecture. The SI-instructors (i.e., the AdS) will also be able to provide feed-back to the normal lecturer of the specific course about which concepts that are viewed as problematic by the students. Today this is often only realized in a negative way on the exams, when it is too late. The AdS, on the other hand, will have to lead the discussions on a large variety of astronomical subjects, and will therefore constantly have to review the introductory astronomy literature. We believe this will greatly improve their ability to put their advanced astronomy courses into context. There is no better way to learn a given subject than to have to teach it oneself. We therefore believe that a Supplemental Instruction programme will help both groups of students. The SI-instructors will be given an introduction to the pedagogical SI ideas, and will get experience in teaching and explaining difficult concepts to other people. This is a valuable merit that is currently not well developed within our astronomy programme.

Midterm course evaluations, an example of important feed-back, could be performed efficiently during SI sessions. In fact, these evaluations could be improved if included in some of those sessions. By working in small groups, students tend to stimulate discussions, and administrative tasks are reduced substantially, while not significantly altering the outcome of evaluations.[25] Course

[25] Casey & Slater (2002) *A Comparison of Group and Individually Completed Course Evaluations in Introductory Astronomy*, Astronomy Education Review, Vol. 1, Issue 2 -

evaluations, being important in every course, would be especially valuable in the context of SI. A continuous monitoring of progress of students' learning is of utmost importance.

5.1 What would be unique in our approach to SI?

5.1.1 Course selection

SI traditionally targets difficult academic courses, to increase the throughput of students. This is a problem-based approach, with a clear, and often very economical aim. We see the concentration of pedagogical effort in the astronomy introductory courses more as a vision. There is not really an alarming problem to be tackled, and the courses are not traditionally extremely difficult. But we do believe that teaching can be more efficient, and that the understanding of the astronomical concepts can be deepened with the implementation of SI. Enhancing critical thinking and promoting open discussions are at the heart of this vision.

What is unique in terms of SI in this programme is that students from different introductory courses can in principle, at least occasionally, meet in the same SI-session. We believe that the subjects of discussion will be relevant for most students at that level, independent if they take the courses on Modern Cosmology, Planets and Life or the classical Introduction to Astronomy.

5.1.2 Leader competence

SI-leaders are traditionally students who have previously and successfully completed the target course. This will not be the case in our implementation of SI. The more advanced students have in general not taken these introductory courses. The reason is simply the way the curriculum is put together. Students who want to do advanced astronomy start with mathematics and physics before they reach the advanced astronomy courses. They do not attend introductory, popular courses that assume no prior knowledge in mathematics. Part of the reason for not requiring any introductory astronomy for the advanced astronomy courses is to enable students from different universities, in particular the institutes of technology, to enroll in the advanced astronomy programme if they have the right mathematics and physics background. In practice, many of the students who start the advanced astronomy programme already master the introductory material through self-studies. This is not surprising either. Most students choosing astronomy do so because they are genuinely interested in the subject.

With the special set-up of our department, the SI effort will mainly be given between advanced and introductory students. We believe this is one of the potential strengths in our programme, because the gain for the AdS is greater

http://aer.noao.edu/AERArticle.php?issue=2&section=2&article=3

than normally accomplished in the SI-setup, when the AdS instruct the very same course they took the previous semester. Here, the AdS and InS will truly study the courses together, and the AdS' greater experience in terms of study-techniques and perspective will be utilized. The AdS will be able to broaden their knowledge in astronomy and put their advanced studies into context. Our programme will, in this respect, be in between the traditional SI and the mentor-variation of SI, developed in Texas Austin, where the SI-leaders are enrolled PhD-students.[26] .

5.2 Potential Benefits

Our main goal is to provide the students with a deeper understanding of astronomical phenomena as well as the methods of scientific research. Learning may be defined as a change in the understanding or in the view of the world around us.[27] Although we try to achieve this during lectures, it is non-trivial to succeed with more than 100 students in the classroom. SI can improve these conditions. Not only will the students get more time to discuss, but peer-facilitated sessions probably also result in more open-minded discussions.[28] Peer tutoring can send important signals; in traditional teaching performed by a 'professional teacher', students may more easily adapt to a role as sole receivers of facts, while the SI idea assumes active participation of the InS, which is vital for the learning process. The intentions are that the students will have this in mind already at the start of the SI sessions, and that the mere presence of an advanced student as SI leader will enhance the view of InS as the main actors. In addition, instructors will obtain a better overview of astronomy and feel that they are participating in departmental activities, as visualized in Figure 2.

5.2.1 Critical thinking

The concept of critical thinking is of great importance in science, and can really be understood by the students only through discussions, rather than classical lectures. SI-sessions will give students time to think about astronomy and to discuss it with their peers. Our large introductory courses are often the first meeting point with university science for these students, and therefore a great attractor to science. But a large fraction of the students will not meet scientific ideas elsewhere, and the importance of open critical discussions of scientific ideas should not be underestimated.

[26] Fest, Beauchamp, Holladay, & Sparks (1999) *The Use of Graduate Students/Experienced Supplemental Instruction (SI) Leaders as SI Supervisors* - www.umkc.edu/cad/si/sidocs/bfgrad99.htm

[27] Ramsden (1992) *Learning to Teach in Higher Education*, p. 4

[28] Biggs (1999) *Teaching for Quality Learning at University*, p. 111 and references therein

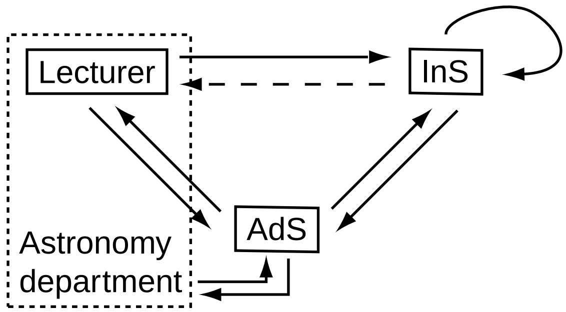

Figure 2: By using SI, the Introductory Students (InS) will get opportunities to experience deeper learning. A continuous interaction with Advanced Students (AdS), who serve as SI leaders, and their fellow students will provide an improved learning environment for the InS. The AdS will also give feedback to the lecturer, who in turn will be able to develop his/her lecturing further.

5.2.2 SI leaders as *Amanuenser*

The largest benefit of this SI programme may well be for the AdS. They are likely to mature and take their own studies much more seriously after the promotion and training to SI leaders. There have been investigations showing that SI leaders gain most; students who were asked to read a subject with the purpose to teach it performed better in tests, compared to students who made the reading part only.[29] Engaging the AdS in the teaching will also tighten their connection to the rest of the faculty. The AdS students have recently complained that they do not feel part of the department, and SI will also be an effort to tackle this problem and thus to make the AdS feel appreciated. The AdS will of course be paid for their efforts, just as other lecturers. The not-so-hidden agenda is to enroll more of the AdS to our PhD-programme. The strategy of engaging AdS as "amanuenser" to help with basic teaching can of course be used at many different departments in Sweden.

5.3 Potential Problems

5.3.1 Involvement of Introductory Students (InS)

One particular item to address, based on previous experience with SI, is how to include all InS. Less motivated students, which may need SI most, are less likely to come to the non-compulsory SI-sessions. Because students' way of learning are influenced by previous educational experience,[30] those who are used

[29] Topping (1998) "The Effectiveness of Peer Tutoring in further and higher education: A Typology and Review of the Literature", in *Mentoring and Tutoring by Students*, edited by Goodlad, Koogan Page Ltd, London, p. 53, and references therein

[30] Ramsden (1992) *Learning to Teach in Higher Education*, p. 83

to surface methods of learning will most certainly need to devote a substantial time to SI sessions in order to achieve a deeper understanding of the subject. Based on a poll among the students on our introductory astronomy course, there seems to be a great interest in SI in astronomy. This will be discussed in detail below (Section 6). We have discussed making one session per student compulsory, but many of the students have quite full schedules anyway. (See also discussion in Allen, Kolpas & Stathis, 1992.[31]) Active participation in the sessions could also be rewarded in the exam, for example by letting active SI-students have a shorter exam at the end of the course. The main goal of this effort is, however, not primarily to increase the throughput of students, but to enhance the understanding of the subject, and encourage critical thinking, among those who participate in the sessions. After every course we will evaluate the response from the InS by special forms, and hope that positive response will also spread to make the courses even more popular. For the involved AdS we will make deeper interviews to evaluate their experiences.

5.3.2 How do we find SI leaders?

One potential problem is of course to find SI leaders. These are the crucial persons that actually make the whole concept work. At our department, the number of AdS are relatively few, although we hope this will soon change. From experiences made in Lund[32] and at KTH Syd[33] it appears that attracting good SI-leaders has been relatively easy. In the small classes at the level of the AdS, lecturers have a good contact with students, which facilitate the selection of suitable candidates. There is also the option to engage PhD-students from the department, or students from the Modern Astronomy course, where the latter are at an intermediate level between the introductory and the advanced students.

We must also be aware of the possibility that the AdS can feel a pressure from their task in general or from some InS. Other potential problems in mentoring are e.g., lack of experience and competence, lack of time for preparations and being unable to let the students make their own mistakes.[34]

Encouragement and continuous support from the lecturer are of utmost importance. It might well be the case that the AdS, like the InS, have to be reminded about the role of SI leaders, i.e., to lead discussions and to convey viewpoints to the lecturer, and *not* to provide another set of lectures.

However, it is also well known that mentoring can have positive effects for the mentors, like improved self-esteem, regained interest in the work/studies, and a chance to evolve in the career.[35]

[31] Allen, Kolpas, & Stathis (1992) *Supplemental Instruction in Calculus I using mandatory and optional attendance in SI sessions* - www.umkc.edu/centers/cad/si/sidocs/nlmth196.htm

[32] Bryngfors & Bruzell-Nilsson (1997), page 13

[33] Gustavsson & Lundberg (2002), page 3

[34] Murray & Owen (1991) *Beyond the Myths and Magic of Mentoring*, Jossey-Bass Inc.

[35] Murray & Owen (1991)

5.3.3 Economics

An obvious potential problem is economics. Although it is clearly possible to run an SI programme on a fairly limited budget, SI leaders have to get paid and at least one lecturer has to supervise the programme. The economical situation at the university departments is tight and any extra efforts have to be justified. We are aware that similar programmes, although fairly successful, have been closed at other departments due to budget reasons.[36] We aim to apply for money for the initial phase of this programme from outside the department, and hope to show that the programme is well worth the effort for the future. Several key persons at the department have already communicated their favourable attitude to this project. The potential problem is instead the difficulty to clearly show positive results that can be measured in a quantitative way. It is easy to show positive replies from the involved students and teachers, but more difficult to show concrete results.[37]

Although the success on the throughput for SI has been demonstrated in the past, we hope that our SI programme will survive as it:

- Becomes a invaluable resource of feed-back for the lecturers.
- Motivates the involved AdS to such an extent that this is clearly communicated to the faculty.
- Increases the quality of learning for the introductory courses in such a way that these courses gain even more in popularity.

6 Questionnaire

In order to investigate the demand for SI as seen by students, we undertook a questionnaire at the Introductory Astronomy course *(Översiktskurs i astronomi, 5 credits)* during spring 2002 (VT2002) and summer 2002 (ST2002), two semesters when one of us (MN) teached the course. In both cases the questionnaire was filled out during lecture 10 out of 12. During spring the course was lectured one evening every week from February to April, while the summer course corresponded to a full-time course, e.g., five weeks during day time. Our SI concept was briefly outlined and the students were asked to indicate whether they would like to attend such SI sessions or not. An SI session was suggested to be given once a week or once every second week as a complement to regular lectures. It was also clearly stated that SI sessions would not be in lecture form, but a forum partially directed by the InS themselves. The result was clear; for

[36] e.g., Arwidsson et al. (1976) *Utvärdering av försök med äldrekursare som handledare i svenskundervisningen*, PU-enheten Linköpings universitet, Rapport nr 1976:6, page 10

[37] Arwidsson et al. (1976); Bryngfors & Bruzell-Nilsson (1997); Gustavsson & Lundberg (2002)

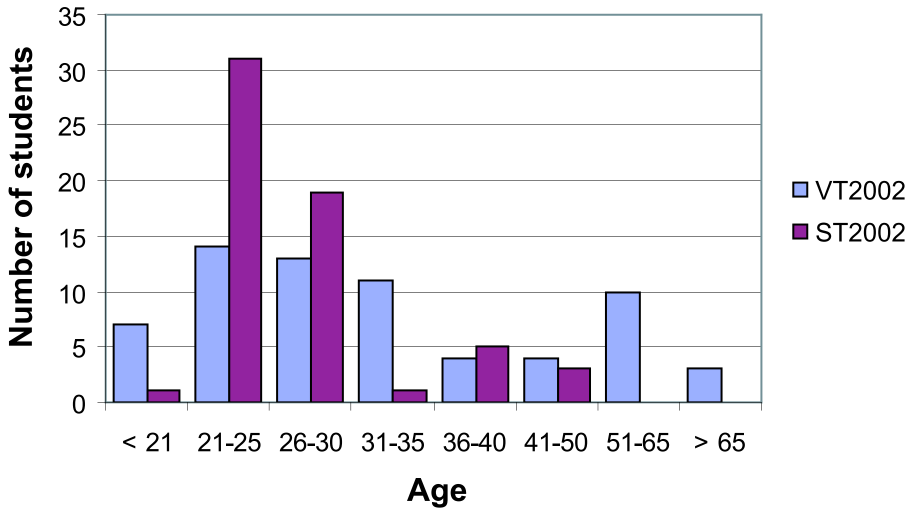

Figure 3: Age distribution.

VT2002 70% of a total of 67 answered that they would attend ("Yes"), while the corresponding figures of ST2002 were 68% out of 62 answers.

The students were also asked to state their age and level concerning background studies. Using this information we were able to look for possible correlations. The age distribution differs somewhat between the two semesters; the distribution of the summer course has a sharper peak at younger ages, i.e., between 20 and 30 (Fig. 3). However, in both courses a majority of the students were below 35 years old. Although a background in university studies is not required, most of the students turned out to have such an experience. Figure 4 shows the "highest" educational level of students in the two courses.

6.1 Different attitudes toward SI

We looked for correlations between educational level and point of view regarding SI. In the VT2002 course, the trend is clearly that the largest demand comes from the students with only high school education. There seems to be a decreasing interest in extra SI sessions with increasing level of prior education (Fig. 5).

Here we have presented only the fraction of the students that have replied positively and negatively in each educational bin. The actual number of students can be read from Figure 4. It is clear that the results are based on poor statistics, and no firm conclusions should be drawn from this limited study.

The abovementioned trend could not be seen in the ST2002 course (Fig. 6)

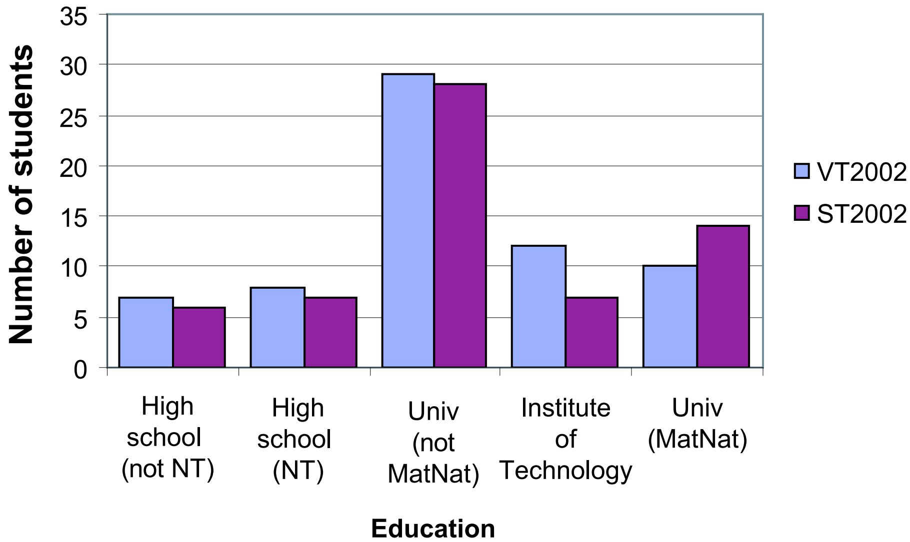

Figure 4: Educational level. It is not obvious how to grade the last two bins with respect to each other. *Question: Which is your 'highest' educational level?* NT = Natural sciences or technical high-school programme. Univ = University studies. MatNat = Studies at Faculty of mathematics and natural sciences at the university.

where the age distribution peaked in the 20-30 year interval, but to improve the statistics we have added the two courses as shown in Figure 7. Although a weak correlation seems to be present, it depends on the last bin, which represents students with a background from mathematics/science faculty at the university. Finally, we made a coarser binning by dividing students into two groups. Among those without prior university studies (bin 1-2 in Figures 5-7) 79% answered that they would attend SI sessions. The corresponding fraction among those with (bin 3-5) prior university studies was 66%.

One possible interpretation of these numbers is that less educated students are more in favour of SI, because they probably experience difficulties of the course content at an earlier stage. On the other hand, an SI approach could frighten younger students in its demand of activity from each participant, while older students could be in favour because they might previously have experienced the benefits of similar activities. Furthermore, students with no prior knowledge of science may hesitate to join groups containing science students.

One should keep in mind that some students who would both be interested in and benefit from SI are missing in the present statistics. The questionnaire

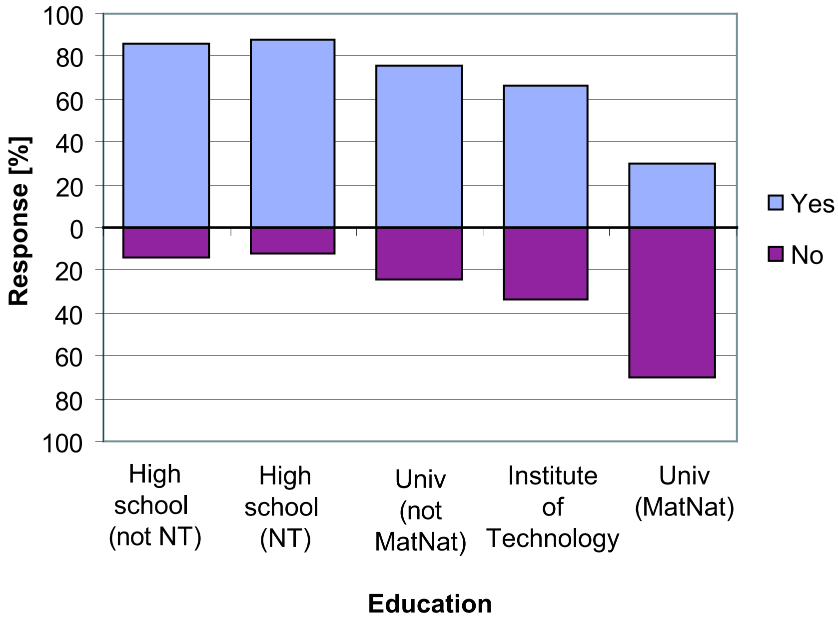

Figure 5: Response to the SI idea for different educational backgrounds (spring course, VT2002).

was handed out late in the course and a number of people quit these courses at an early stage. Reasons for leaving are several, but among the most common are lack of time and an experience of the course content as being difficult.

While students quitting a course because of lack of time at a first glance appear to be unreachable by the SI approach, which by definition involves more time spent in class, a thorough investigation might show that this is not the case. If deeper learning would be accomplished in connection with SI sessions, students may experience that, in the end, less time needs to be devoted to their studies when traditional, surface learning is abandoned. In addition, the conception of a subject to be difficult is exactly what SI is meant to overcome. It may very well be that a substantial fraction of those students who quit a course would have continued their studies if SI was offered. If a student feel that the topic is becoming more and more difficult, the motivation to continue will most likely diminish. However, the reasons for leaving a course, as well as the possible improvements due to SI, remain to be investigated for this particular group of students.

We could summarize our results by noting that even though there is a difference in response depending on educational background, the overall attitude

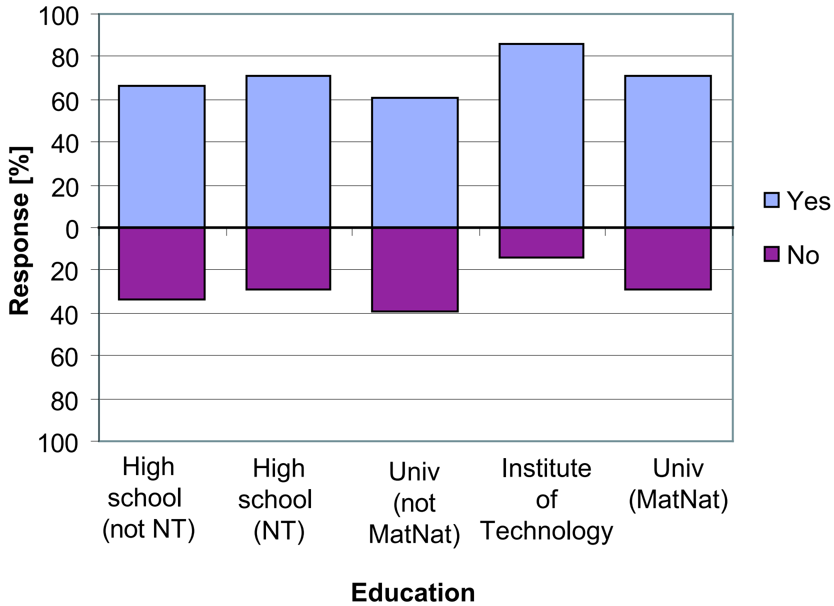

Figure 6: Response to the SI idea for different educational backgrounds (summer course, ST2002).

towards SI is clearly positive regardless of educational background.

6.2 Specific comments

The questionnaire also included some space for comments. Some students with a non-science background are anxious about group dynamics when science and non-science students are mixed. This could be avoided by dividing InS into two groups based on these different backgrounds. However, this would be in conflict with the basic ideas of SI; students of different backgrounds are important for the enrichment of discussions. It will accordingly be the task of the AdS to encourage active InS to stay active, but at the same time to ensure that they will not dominate on expense of their fellow students. Compared to 'traditional SI' we may face a more diverse group of students in our introductory courses, and this fact has to be taken into account. A gap between experienced and first-time students, whether it has to do with expert knowledge or study techniques, can easily turn into a dominant- submission structure as mentioned above.

Other students are worried about the skills of the AdS; although it is important that the AdS are suited for their tasks, some students may still believe that the AdS should provide all answers rather than to lead discussions and

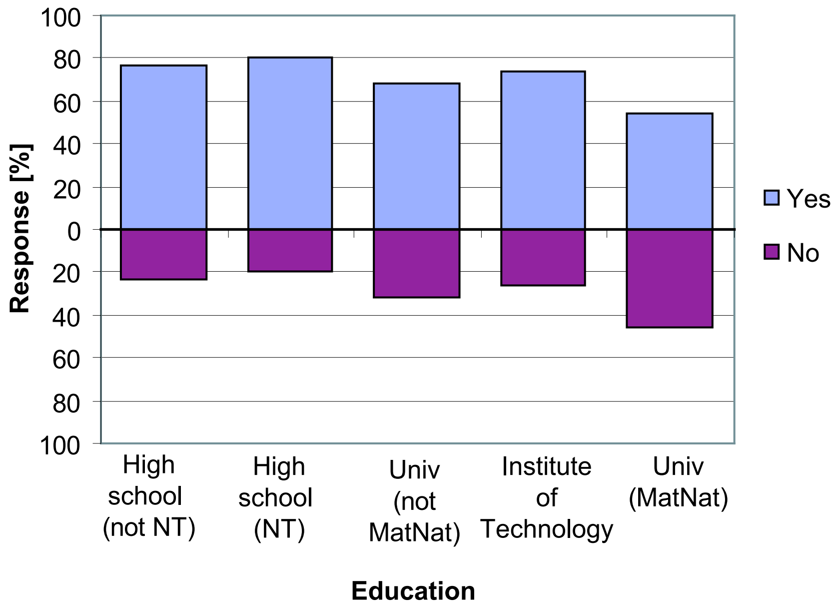

Figure 7: Response to the SI idea for different educational backgrounds (courses combined).

encourage students to participate in them. Consequently, both lecturers and AdS have to stress the point that InS themselves influence and direct activities during SI sessions.

Even comments given by those who claim that they would not attend SI sessions are positive regarding the basic idea. The dominating reason giving "no" for an answer is simply lack of time. We have collected some comments in Figure 8.

6.3 Conclusions

Based on the result of the questionnaire and previous discussions with students, we are convinced that a substantial number of the InS would participate in, and benefit from, our planned SI programme. Quantitatively, 2/3 of students with a background in university studies, and 4/5 of those without, are in favour of our SI idea, in the sense that they claim that they would participate during out-of-class sessions. This positive response was beyond our expectations. By offering SI on trial for a period of one or two semesters we would gain experience and knowledge about how to create a smoothly working programme. We therefore plan to apply for financial support for such a programme.

Among "yes" answers

"For people to attend SI, I think the group size has to be small so that all students can participate in discussions."

"Discussion groups would be very useful, where one could ask questions without making a fool of oneself in front of students of natural sciences who already know it all."

"Whatever topic you are studying, it is very important to be able to discuss what you learn/are taught. It makes it easier to absorb and understand, and to discover how much you really understand."

"Yes, I would attend IF the AdS would be skilled enough to explain clearly, in a pedagogical way, which may be questionable if he/she is 'only' a student."

".......and one gets inspired to know more even when it comes to physics!"

"I have previously studied at other departments, among them the Department of education, and I strongly suggest that you invite them to show how to provide good teaching!"

"I miss exercises to be solved in smaller groups. It would force people to cooperate."

"I really believe in discussion groups!!!"

"Discussion groups seem to be a good solution because they can give extensive explanations, and thereby reduce the time for refreshing our minds during lectures."

Among "no" answers

"I would probably attend if fewer occasions."

"I would perhaps attend once or twice."

"The idea is superb. If I were a full-time student I would most likely attend, but my current work doesn't give me time."

"The idea is splendid, but due to lack of time I would probably not attend."

"I'm a writer, not a talker."

"I am a lazy student. I don't want to come here more often than what is absolutely needed. However, SI seems to be a good idea for more ambitious students."

Figure 8: Specific comments given in questionnaire. Translations by the authors.

7 Extensions

7.1 Astronomy related pedagogical themes

Mentoring by students, where SI is a special subclass, is a rich pedagogical field, which is widely studied in the international literature.[38]

The use of interactive teaching is also not new in astronomy education. Learning in an active mode is preferred since understanding of many of the mind-boggling concepts can come only when the student actively turns the information around conceptually to view it from different angles. The concept of peer instruction in astronomy, a pedagogical theme closely related to SI, is outlined by Green (2003).[39] This book also contains, as a primary tool for implementation of peer instruction in astronomy, a large library of conceptual questions that serve to gauge comprehension of scientific principles and to foster student engagement. These tools could easily be used also during SI sessions.

One of the fruitful pedagogical themes used in these questions is the many misconceptions about astronomy among the general public. These have been studied by Comins (2001)[40] and are also used in many introductory astronomy textbooks to enhance critical thinking and deeper understanding. (e.g., Comins & Kaufmann III 2000).[41]

It is important, however, that the misconceptions are not simply abandoned for an authorative 'scientific truth'. Understanding can only be achieved if the misunderstood concepts can be discussed and elaborated upon, and if the scientific arguments for abandoning the old beliefs are thoroughly highlighted. This is again more easily accomplished during an SI session than in a normal lecture. Discussing misconceptions by InS during the course may be an important tool in the process of learning. Such activities can lead to a better understanding of the subject itself, but also of the way InS learn *how* to achieve understanding and different ways of interpretation. Without a climate allowing mistakes to be made and penetrated, this will be impossible to accomplish. It is thus crucial that lecturers and AdS act clearly to define a learning environment of this kind.[42]

7.2 Relevance for other departments

We believe that the SI concept outlined above could be easily and fruitfully implemented also at other departments. Besides other astronomy departments, a nearby example is the relatively large physics department that now offer large

[38] see e.g., the reviews by Topping (1998) and by Goodlad (1998)

[39] Green (2003) *Peer instruction for astronomy*, Pearson Education Inc

[40] Comins (2001) *Heavenly Errors: Misconceptions About the Real Nature of the Universe*, New York: Colombia University Press

[41] Comins, & Kaufmann III (2002) *Discovering the Universe 6th ed.*, W. H. Freeman and Company

[42] Biggs (1999) *Teaching for Quality Learning at University*, p. 75

introductory courses on popular themes for students without prior background in science.[43] The number of such courses are likely to increase at Swedish universities, both due to *tredje uppgiften*[44] and to a demand for *håpar*.[45] A yet unknown number of InS takes several courses, sometimes mixing physics and astronomy courses, and these students would of course benefit from similar study environments.

It should be possible to improve the quality of all such courses within the proposed SI-strategy.

7.3 Recruitment

The proposed project could also have implications for the more general problem of recruiting students to higher education, and in particular to the science educations. One of us (MN) is active in the *SkolAstro* project to inspire young students to study science by using astronomy. Within *Vetenskapens Hus*[46] this project will be able to supervise high-school students for their diploma thesis. We are confident that this research interaction will boost these students interest in natural sciences. *SkolAstro* has already produced several applicable tasks for high-school students, and JS has participated in producing easy research tasks within the ESA/ESO educational project.[47] The tutors we train for the SI-project could be used also in the drafting process, to broaden their experience. Furthermore, within *Vetenskapens Hus* we may find students working as assistants who are well suited as AdS and SI leaders.

[43] www.physto.se/utbildning/orientering.html

[44] The University's commitment to Public relations and contacts with the society

[45] The way the Swedish universities gets funded by the state, depending on how many students that pass exams

[46] www.vetenskapenshus.org; www.houseofscience.org

[47] www.eso.org/outreach/eduoff/

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A list of used WWW-links (alive in November 2002-January 2003):

http://www.vetenskapenshus.org
http://www.houseofscience.org
http://www.eso.org/outreach/eduoff
http://www.physto.se/utbildning/orientering.html
http://www.umkc.edu/centers/cad/si/sidocs/nlmth196.htm
http://www.umkc.edu/cad/si/sidocs/bfgrad99.htm
http://aer.noao.edu/AERArticle.php?issue=2&section=2&article=3
http://www.astro.su.se/utbildning/utbildning.html#oversikt
http://www.astro.su.se/utbildning/utbildning.html#grund
http://www.it.uu.se/edu/si/info.shtml
http://hgur.hsv.se/activities/projects/financed_projects/m-p/muhr_carin_2_97.htm
http://www.ee.chalmers.se/externt/si/si.htm
http://www.ee.chalmers.se/externt/si/enrf.htm
http://www.cs.umu.se/education/SI/
http://www.etn.lu.se/kurs/
http://www.hgur.se/activities/projects/financed_projects/a-b/bryngfors_leif_94.htm
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http://www.umkc.edu/centers/cad/si/sidocs/nlswed96.htm
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