

# Strategies for Teaching Students with Heterogeneous Prior Knowledge

Emma Fitzgerald\*

Michael Lentmaier\*

**Abstract**—In this paper we investigate teaching of students with heterogeneous prior knowledge in the context of the international Masters in Wireless Communications program at LTH. To analyse the problem, we conducted a survey and interview study with teachers in the program. Our survey results confirm a wide spread in prior knowledge among students and provide examples of strategies currently used by teachers to deal with this issue. We then explore, in the context of the existing literature, two strategies in particular for teaching students with heterogeneous prior knowledge: group-based teaching and learning activities that encourage exchange of knowledge among students, and online learning tools to allow students to independently assess and complement their prior knowledge.

**Keywords:** prior knowledge, heterogeneous backgrounds, international students, Masters program

## I. INTRODUCTION

In an increasingly globalised academic system, classes are made up of a diverse student body with heterogeneous backgrounds and prior knowledge. This is especially true in international programs, such as the Masters in Wireless Communications program at LTH, which is the focus of this paper. Students in this program are recruited from around the world and as such have a diverse array of prior studies and workplace experience. The common requirement for students to enter the program is a Bachelors degree in electrical engineering or a related field, however the content of this degree varies from institution to institution and country to country, leaving some students lacking in assumed knowledge for the program. Many students have worked for a number of years between completing their Bachelors degree and enrolling in our Masters program, meaning that some prior knowledge may have lain unused for some time and thus not be readily available to the student. On the other hand work experience can provide students with valuable prior knowledge of other kinds, such as skills in teamwork and communication. In this paper, we conduct surveys and interviews of teachers within the program, and examine two practical solutions to address this issue: group-based teaching and learning activities, and online learning tools.

## II. RELATED WORK

Prior knowledge is critical to students' success, in fact, it is "the most important student variable in learning" [1]. Students with better prior knowledge perform better and are more likely to adopt deep learning approaches ([2], cited in [3]). Halikar et al. [4] give a model for how prior knowledge affects following studies. According to this model, students with more prior knowledge have a distinct advantage, and the deeper and better integrated is this prior knowledge, the

greater the advantage. A more comprehensive review of prior knowledge and its effect on learning can be found in [5].

In order to assist students lacking in prior knowledge, teachers often adapt courses to those with less prior knowledge (the "lowest common denominator"), causing other students to lose motivation [6]. However, catering instead only to better-prepared students is just as problematic, as the course then becomes too difficult for those students without the needed prior knowledge. In [6], advanced students were taken out of the class to do activities tailored to their needs. Beichner et al. [7] propose instead a new teaching method, named SCALE-UP, intended to include more group work and problem solving even in large classes, which can assist students with lower levels of prior knowledge. However, while these methods were successful, they can be difficult to implement, requiring more teaching hours, or a re-design of course materials or teaching spaces. Another key ingredient in teaching students with heterogeneous prior knowledge is to accurately determine what prior knowledge the students have, for example by using a web or classroom test [8].

International students also face other problems that interact with and exacerbate those caused by insufficient prior knowledge. Many of these problems relate to academic culture: the types of assessments and learning activities encountered, the expectations teachers have of students and vice versa, and the academic attributes or skills that are valued. Teachers are therefore encouraged to acknowledge the students' background and consciously teach the academic culture of the host institution [9]. Course objectives, expectations, and instructions should be explicit and clearly formulated [9, 10]. Since expectations for assessment may be different than what students are used to, there should be opportunities to practice what will be assessed without penalty, and there should be multiple opportunities for assessment — no "sudden death" moments [10].

International students' peers can also play a role in assisting them adapt to a new academic culture. Opportunities to receive feedback from peers is helpful, as is working in diverse groups [10]. Diverse groups have benefits not only for international students but for all students, as they need to meet new ways of thinking in order to learn [11]. However, people tend to form groups with others who are similar to themselves in a range of characteristics, including ethnicity, gender, age, and religion [12]. This is no less true of students in an international environment, who tend to form groups with homogeneous background [13, 9]. Diverse groups, therefore, need to be engineered by the teacher, as they will rarely occur otherwise. Moreover, cross-cultural groups often function less effectively than monocultural groups, so it is important to remove or minimise "assessment threat": the fear that students' marks will suffer adversely through working in a heterogeneous group instead of their preferred homogeneous one [9].

\*Emma Fitzgerald and Michael Lentmaier are with the School of Electrical and Information Technology, Lund University, SE-221 00, Lund, Sweden  
Email: *firstname.lastname@eit.lth.se*

Item 1:	Which topics are required as prior knowledge in your course?
Item 2:	In your experience, to what extent do students have the required prior knowledge when they enter your course?
Item 3:	Please give more details or comments about students' prior knowledge in your course.
Item 4:	Have you observed differences in prior knowledge between students in your course? (level of prior knowledge and/or topics covered)
Item 5:	What measures, if any, have you taken in your course to deal with differences in students' prior knowledge? Have these measures been effective?
Item 6:	Do you think it would be helpful to have online tools for students to complement any missing prior knowledge?
Item 7:	What would you like to see included in these online tools? (topics, types of exercises, etc)
Item 8:	Would you be willing to participate in a short interview about your experiences teaching in the Masters in Wireless Communications program? If so, please enter your email address below.

TABLE I

LIST OF SURVEY ITEMS PROVIDED TO THE TEACHERS.

### III. TEACHER SURVEY AND INTERVIEW STUDY

To improve our understanding of the problem of heterogeneous prior knowledge in our particular case of the Masters in Wireless Communications program, we conducted a survey of teachers in the program, as well as interviews with selected survey respondents. The list of items in the survey is given in Table I. The survey was filled in by 13 individuals and three of them were interviewed in order to provide further insight into their experiences.

Looking at the responses to item 2, *Do students have the required prior knowledge?*, shown in Figure 1, there is no strong tendency towards either a poor or a good level of prior knowledge. Most teachers report a medium prior knowledge of the students in their classes, and only a few tend slightly towards either side. However, this result should be considered in conjunction with the comments given in response to items 3 and 4. Here all respondents reported a clear difference between the students: some students appear to have a much better prior knowledge than others. This observation was also confirmed in the interviews. While it is encouraging to see that most students appear to have sufficient prior knowledge for our courses, it also seems to be a fact that there commonly exist a number of students who lack elementary skills, e.g. in mathematics or programming, that we normally take for granted in a Masters level program. In item 5, *What can we*

To what extent do students have the required prior knowledge when they enter your course?

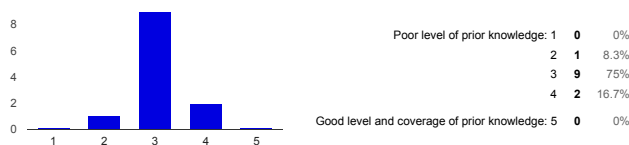


Fig. 1. Responses to survey item 2.

*do about differences in prior knowledge?*, the teachers could describe how they dealt with the gaps in prior knowledge within their courses. The measures taken differ from case to case. Some teachers refer to course books that cover the prior knowledge while others have extended their lecture notes with some additional material (e.g. mathematical background) or provided some specially designed tutorial materials (e.g. programming examples). Some have adapted parts of their

teaching time in lectures or exercise classes and provide more basic knowledge in order to help those students having difficulties.

When asked about online tools for students to complement missing prior knowledge (survey item 6), 75% of the respondents believe that such tools can be helpful or very helpful, as shown in Figure 2. Some further comments and suggestions were provided in the free text responses and within the interviews. A few teachers are more critical, pointing out that it may be difficult to cover the wide range of topics and that the outcome may not be worth the required effort. For some courses, the teachers believe that the provided background material already should be sufficient, and that the difficulties some students have can be explained by the little effort they spent within a course. In order to identify the scope of general, course independent online tools we can get some inspirations from the list of suggestions given in the teachers' survey responses. Several teachers recommend general material on basic mathematics and programming, which seem to be the most critical elements for which a large gap among the students can be observed.

Would it be helpful to have online tools for students to complement any missing prior knowledge?

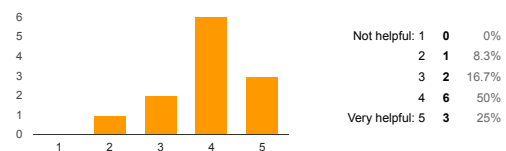


Fig. 2. Responses to survey item 6.

### IV. STRATEGIES FOR TEACHING STUDENTS WITH HETEROGENEOUS PRIOR KNOWLEDGE

In the following section we will examine two approaches to teaching students with heterogeneous prior knowledge that have been proposed for development within the Masters in Wireless Communications program, namely group-based teaching and learning activities, and online tools. We will discuss these strategies in the context of the literature and evaluate how they can best be applied in the program.

#### A. Group-based teaching and learning activities

One method to mitigate the problem of heterogeneous prior knowledge among students is to use group-based teaching and learning activities, with a format aimed at helping students to complement their prior knowledge. The structure of a group task as well as how groupwork is rewarded can have profound effects on the functioning of a group [11]. Steiner's typology gives a way to categorise different types of group tasks and how the group must work to complete them. In order to improve students' prior knowledge, it is advisable to avoid disjunctive group work, in which a solution to a problem is found by one group member, as such tasks encourage an approach in which each problem is solved by the student with the best knowledge about that area already. Conjunctive tasks, in which the overall group performance is determined by the worst performance of any of its members, should also be avoided as they are liable to demotivate the students with greater prior knowledge. Instead, the focus should be on compensatory tasks, in which the group collectively comes to a consensus.

Student groups with heterogenous prior knowledge are often diverse in other ways as well. Diversity in a group can be both a liability and an asset, with creativity and problem solving typically better in a diverse group, while efficiency and solidarity suffer [11]. Thus group tasks will benefit from having a creative, problem-solving focus. To counteract some of the negative effects of group diversity, group solidarity can be built through activities that help develop a group identity. This could be as simple as each group choosing a name and logo, or could involve more complex teambuilding activities.

### B. Online Learning Tools

Online learning tools can offer students a system for self-evaluating their prior knowledge as well as for self-training. For this purpose a database of modules needs to be developed, whose content ideally should reflect what is expected from students in their courses. Teacher surveys such as the one we presented in Section III can be used to identify key topic areas to include. Each learning module should target a specific subject area and provide some tools for diagnostic testing as well as some references to material that may help the students to improve their skills in that area.

While there is a risk that teachers lack the time to help setting up or improving the system, once established, online tools have a number of attractive features. Instead of forcing teachers to adapt the course contents to students with less prior knowledge and lower the motivation of others [6], the tools can allow students to spend their own time in order to fill their knowledge gaps. Furthermore, the time spent by the teacher does not have to increase with the number of students if some automatic feedback is implemented. Online tools may also allow students to get started even before the beginning of the course, and a voluntary online assessment can reduce stress for students. Students get a chance to get used to teachers' expectations, which may be quite different from those in their home country, and hence can avoid "sudden death" moments [10]. In addition to enabling student self-assessment, online tools can also support teachers by providing an effective means for monitoring the students' activities. The resulting extended loop of continuous testing, monitoring and improving the test material is in line with the formative assessment model presented in [14].

### V. CONCLUSION

In this paper we have examined teaching of students with heterogeneous prior knowledge in the context of the Masters in Wireless Communications program at LTH. We have investigated the problem using a survey and interview study of teachers in the program. The teachers' responses in the survey and interviews confirmed that there is a wide spread

in prior knowledge amongst the students and teachers were positive towards the idea of establishing online tools to help address this problem.

We have examined two strategies to address the issue of heterogeneous prior knowledge within the program: group-work, and online tools for student use. We have discussed how to design group-based teaching and learning activities geared towards increasing interaction between students, especially those who might not otherwise be inclined to work together, so that students can learn from each other in topics where they lack prior knowledge. Meanwhile online learning tools provide a means for each student to individually assess and complement their prior knowledge in their own time. Both of these strategies are currently being developed in the program and will be implemented during 2017.

### REFERENCES

- [1] F. Dochy, C. De Rijdt, and W. Dyck, "Cognitive prerequisites and learning how far have we progressed since bloom? implications for educational practice and teaching," *Active learning in higher education*, vol. 3, no. 3, pp. 265–284, 2002.
- [2] E. Hazel, M. Prosser, and K. Trigwell, "Student learning of biology concepts in different university contexts," *Research and Development in Higher Education*, vol. 19, pp. 323–326, 1996.
- [3] M. Prosser and K. Trigwell, *Understanding learning and teaching: The experience in higher education*. McGraw-Hill Education (UK), 1999.
- [4] T. K. Hailikari and A. Nevgi, "How to diagnose at-risk students in chemistry: The case of prior knowledge assessment," *International Journal of Science Education*, vol. 32, no. 15, pp. 2079–2095, 2010.
- [5] F. Dochy, M. Segers, and M. M. Buehl, "The relation between assessment practices and outcomes of studies: The case of research on prior knowledge," *Review of educational research*, vol. 69, no. 2, pp. 145–186, 1999.
- [6] R. Oliver, "Exploring a technology-facilitated solution to cater for advanced students in large undergraduate classes," *Journal of Computer Assisted Learning*, vol. 22, no. 1, pp. 1–12, 2006.
- [7] R. J. Beichner and J. Saul, "Student-centered activities for large-enrollment university physics (scale-up)," in *Proceedings of the Sigma Xi Forum on the Reform of Undergraduate Education*, 1999, pp. 43–52.
- [8] M. Elmgren and A.-S. Henriksson, *Academic Teaching*. Studentlitteratur, 2014.
- [9] J. Carroll, "Suggestions for teaching international students more effectively," *Oxford Centre for Staff and Learning Development Learning and Teaching Briefing Papers Series*, 2002, <http://www.uwplatt.edu/files/iss/teachinginternationalstudents.pdf> retrieved April 24 2016.
- [10] E. Jones and S. Brown, *Internationalising higher education*. Routledge, 2007.
- [11] E. Hammar Chiriac and A. Hempel, *Handbok för grupparbete: Att skapa fungerande grupparbeten i undervisning*. Studentlitteratur, 2008.
- [12] M. McPherson, L. Smith-Lovin, and J. M. Cook, "Birds of a feather: Homophily in social networks," *Annual review of sociology*, pp. 415–444, 2001.
- [13] J. Ryan, J. Carroll, and J. Ryan, *Teaching international students*. Oxford Centre for Staff and Learning Development, Oxford Brookes University, 2000.
- [14] D. J. Nicola and D. Macfarlane-Dick, "Formative assessment and self-regulated learning: a model and seven principles of good feedback practice," *Studies in Higher Education*, vol. 31, no. 2, pp. 199–218, 2006.