WSU Teaching Innovation Grant Proposal – Student Engagement and Alternative Delivery

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Flipping the Classroom:
Combining SCALE-UP and Distance Learning

The Department of Computer Science and Engineering is successfully pursuing multiple efforts to modernize the modes of delivery of its classes. In particular, this includes active learning using SCALE-UP classrooms, and distance learning sections for traditional classes. In this project, we will leverage existing infrastructure to create a class setting where a single teacher can provide, within a single class section, both an active learning experience and a distance learning setting, depending on student needs. This setting will, in particular, be realized for the CS2210 class "Logic for Computer Scientists".

Motivation

A traditional mode of delivery for university classes, in particular on formal mathematical or theoretical content, is that of a frontal lecture, accompanied by homework exercises which are graded and selectively discussed in lab sessions or the main class. Active learning in this mode of delivery is restricted to the homework, and possibly through interactions with tutors at help desks or in lab sessions. The most knowledgeable (and expensive) resource, namely the teacher, hardly interacts with the students, other than in form of a monologue.

This traditional mode of delivery, however, lends itself easily to adoption for a type of distance learning, in the sense that the frontal lectures are videotaped and made available to students which are unable to physically attend the classes, e.g. due to class conflicts or because they may be part-time students with day jobs. Homework can then be turned in electronically, graded, and handed back to the students with feedback. A class which is delivered in this way can thus be run as a combined class for both, distance learning students and physically attending students, with relatively small overhead. This mode of distance learning has indeed been installed successfully for many classes in the Department of Computer Science and Engineering. The PI has in fact conducted several classes in this combined online/offline mode, including CS2210 (Logic for Computer Scientists) in Fall 2013, Fall 2012; CS499/699 (Logic for Computer Scientists, quarter version) in Winter 2012, Winter 2011; CS2200 (Discrete Structures and their Algorithms) in Spring 2013; CS740 (Computational Complexity and Algorithm Analysis) in Spring 2012, Spring 2011; EGR199 (Introduction to Discrete Structures for Computer Science) in Fall 2011.

At the same time, the Department of Computer Science and Engineering has installed several so-called *SCALE-UP* classrooms to promote active learning. SCALE-UP stands for "Student-Centered Active Learning Environment with Upside-down Pedagogies", and it identifies a learning environment specifically created to facilitate active, collaborative learning in a studio-like setting. Spaces are carefully designed to facilitate interactions between teams of students who work on short, interesting tasks. The basic idea is that students are given something interesting to investigate. While they work in teams on these problems, the instructor is free to roam around the classroom, asking questions, sending one team to help another, or asking why someone else got a different answer. There is no separate lab class and most of the "lectures" are actually class-wide discussions. Of course, this mode of delivery does not lend itself to distance learning. Thus, for students who cannot physically attend class, separate class sections have to be set up where the class content is delivered by other means, e.g. either by dedicated online learning approaches, or by a distance learning mode accompanying a traditional frontal delivery of the class, as described above.

However, the SCALE-UP classrooms easily lend themselves to several different modes of delivery. The SCALE-UP teaching approach described above is only one example from a multitude of different possible approaches to active learning, and it is possible to find a setting which uses active learning components but which, at the same time, can be used for parallel distance learning.

The mode of delivery which we propose for this project is a classical *flipped classroom* approach. This approach is essentially an *inversion* of the traditional frontal mode of delivery described above, in that class time (and thus the time where the teacher is available for consultation) is used for solving exercises in groups, while the frontal teaching component is replaced by self-study by the students using book, articles, manuscript, or prepared video lectures.

In this project, we will install a flipped classroom approach for the CS2210 class "Logic for Computer Scientists" which at the same time can be used to serve distance learning students. The new mode of delivery will free the teacher's time for intensive interaction with the physically attending students, while the distance learning students will still enjoy a high-quality traditional mode of distance learning delivery.

The successfully installed approach can then serve as a model for other classes taught by the PI or by other teachers for other classes.

Statement of Purpose

The goal of this project is to develop and realize, in the setting of CS2210, a way to improve the mode of delivery of classes with theoretical content by switching to a flipped classroom active learning experience for the physically attending students, while at the same time catering for students which cannot physically attend the class. The new setting has two main benefits. First, it improves the learning experience by physically attending students. Secondly, it also provides a cost-efficient way to offer a distance learning option for the same class, without the need to establish a separately taught online section.

Course Enhancement

The course chosen for this project is CS2210, Logic for Computer Scientists. It is a fundamental class which was newly introduced by the PI into the curriculum on the occasion of the semester conversion. Every computer science student has to take either this class or the alternative CS3200, Theoretical Foundations of Computing. In Fall 2012, class attendance at CS2210 maxed out at the room capacity of 35 students, with several requests to lift the limit, which could not be accommodated. For Spring 2013, attendance was 40 students. In Fall 2013 attendance was 45 students, of which 30 had signed up for the distance learning section. So far, the class has always been delivered in the traditional, frontal style, accompanied by graded homework, with additional offering of help desk hours. Like many theory-oriented classes in the Computer Science curriculum, the content of CS2210 is very stable over time, in fact, classes with identical content have been taught world-wide for 20 years or more, i.e., the content is foundational and will not be in any need of updates in the near future. The PI uses a low-cost required textbook [Sch08] as basis, with some content aligned with [Ben93] which is optional for the students. The PI furthermore recasts the selected material into a self-contained typeset manuscript which is provided to the students [Hit13].

The new mode of delivery will be installed in two subsequent stages.

In Fall 2014, the PI will teach the class in traditional frontal mode, including a distance learning option using the existing videotaping and video delivery infrastructure. However, care will be taken to ensure that the recordings can be reused for future installments of the class, i.e., significantly higher quality control will be in place regarding content delivery and video quality. Content which does not apply to future installments will be omitted or cut from the tapes. If required, parts of the class will be re-taped to ensure high quality. The recordings will be suitably edited, cut, and combined to logical chunks which reflect the structure and content of the class. Students will be given homework exercises, which will subsequently be graded and handed back to the students with feedback, and a help desk will be installed as usual.

In Spring 2015, the PI will reuse the edited recordings from Fall 2014 to deliver the class in both a distance learning and a flipped classroom mode. Distance learning students will receive the edited recordings and will engage in homework exercises as before. However, the physically attending students will also receive the edited recordings and will prepare for class sessions by watching the parts which will be further discussed in the class session. They will furthermore be given a few preparatory exercises to assist them in digesting the recorded material before the class sessions. The class sessions themselves will be driven by group discussions and by problem solving in teams, with the PI available for agile interaction with the students. These class sessions will require separate careful preparation by the PI. After the class sessions, each student will furthermore be required to provide a clean write-up of

the solution drafts created during class – this is important because the ability to produce formal written solutions is a central learning outcome but cannot be practiced during class. These written solutions will subsequently be graded and handed back to the students with feedback, thus providing another iteration loop for improvement.

Assessment

The project will be assessed qualitatively by means of questionnaires through which students will anonymously report on the effectiveness of the mode of delivery, compared with traditional modes which they have encountered throughout their studies.

Sustainability

The successfully conducted project will not only improve the PI's delivery of the CS2210 class in the next academic year and in subsequent years. The recordings established during the project can furthermore be reused by other teachers of CS2210 for a flipped classroom approach. The experience gained by the PI in this project will furthermore enable him to adopt the new delivery mode for suitable other classes he frequently teaches with a distance learning option, such as CS2200. The PI will furthermore be available in the future for consultation by other faculty members who wish to transfer to a similar mode of delivery.

PI Qualifications

The PI has a PhD in mathematics which he acquired before transitioning to computer science, and thus has an intimate and in-depth understanding of the theoretical underpinnings of computer science, including the material taught in CS2210 and CS2200. He also has extensive teaching experience which ranges from freshmen to graduate courses, and includes teaching for classes with up to 1,000 students. He has taught several classes which included a distance learning section, including CS2210 in Fall 2013, Fall 2012; CS499/699 in Winter 2012, Winter 2011; CS2200 in Spring 2013; CS740 in Spring 2012, Spring 2011; EGR-199 in Fall 2011. Throughout his career, he has taught in different capacities at departments of Computer Science, Mathematics, Economics, and Computational Linguistics. He has co-authored several textbooks, one of which [HKR10] received an award as "Outstanding Academic Title 2010" by the American Library Association's *Choice Magazine*, and indeed it was one out of only seven titles in "Information and Computer Science" thus honored. The book has been translated to Chinese and German. The PI has a considerable track record in engaging and advising undergraduate and Master students in such a way that it yields internationally competitive research results (see e.g. [BH04, CH12, CJH12, CKH12, CHH07, HW05, Kro06, LH08a, LH08b, TH06]—in all cases the primary author is either an undergraduate or a Master student). In 2011 and 2012, the PI acquired a total of $32,000 in NSF funding in the *Research Experiences for Undergraduates* program.[1] The PI received a Wright State Teaching Innovation Grant in 2012 for the project "ImproMat – Improving the Retention Rate of Computer Science Students which are Underprepared in Mathematics."

Budget and Budget Justification

The PI requests $6,000 for a partial Graduate Teaching Assistant (GTA) over two semesters ($750 per month) to assist in the development and conduct of the class. During the first semester, the GTA will do proofreading of the manuscript provided by the teacher, will do additional quality control for the videos, will provide a student help desk for class participants, and will do homework grading and assist with exam grading. During the second semester, the GTA will provide a student help desk for class participants, will do homework grading for the distance learning section of the class, and will assist with exam grading.

Funds are requested for a GTA because changing the class to the combined delivery modes laid out in the proposal requires significant additional effort by the teacher, i.e., the PI. The GTA will thus absorb some of the total workload for the conduct of the class.

For subsequent installations of this class, i.e. beyond the runtime of this project, a GTA will no longer be required since all class material will already have been prepared.

References

[BH04] S. Bader and P. Hitzler. Logic programs, iterated function systems, and recurrent radial basis function networks. Journal of Applied Logic, 2(3):273–300, 2004.

[1] $16,000 as PI, $16,000 as co-PI.

[Ben93] M. Ben-Ari, Mathematical Logic for Computer Science, Springer, 1993.

[CH12] D. Carral Martinez and P. Hitzler. Extending description logic rules. In E. Simperl et al., editors, The Semantic Web: Research and Applications – 9th Extended SemanticWeb Conference, ESWC 2012, Heraklion, Crete, Greece, May 27-31, 2012. Proceedings, Lecture Notes in Computer Science, pages 345–359. Springer, 2012.

[CHH07] N. Cherchago, P. Hitzler, and S. Hölldobler. Decidability under the well-founded semantics. In M. Marchiori, J. Z. Pan, and C. de Sainte Marie, editors, Proceedings of the First International Conference on Web Reasoning and Rule Systems, RR2007, Innsbruck, Austria, June 2007, volume 4524 of Lecture Notes in Computer Science, pages 269–278. Springer, 2007.

[CJH12] D. Carral Martinez, K. Janowicz, and P. Hitzler. A logical geo-ontology design pattern for quantifying over types. In: I. F. Cruz et al., editors: SIGSPATIAL 2012 International Conference on Advances in Geographic Information Systems (formerly known as GIS), SIGSPATIAL'12, Redondo Beach, CA, USA, November 7-9, 2012. ACM 2012, pp. 239-248.

[CKH12] D. Carral Martinez, A. A. Krisnadhi, and P. Hitzler. Integrating OWL and rules: A syntax proposal for nominal schemas. In P. Klinov and M. Horridge, editors, Proceedings of OWL: Experiences and Directions Workshop 2012, Heraklion, Crete, Greece, May 27-28, 2012, volume 849 of CEUR Workshop Proc. CEUR-WS.org, 2012.

[Hit13] P. Hitzler, Logic for Computer Scientists. CS 2210 Lecture, Fall Semester 2013. Available from http://www.pascal-hitzler.de/teaching/f13/index.html

[HKR10] P. Hitzler, M. Krötzsch, S. Rudolph, Foundations of Semantic Web Technologies. Textbooks in Computing, Chapman and Hall/CRC Press, 2010

[HW05] P. Hitzler and M. Wendt. A uniform approach to logic programming semantics. Theory and Practice of Logic Programming, 5(1–2):123–159, 2005.

[Kro06] M. Krötzsch. Generalized ultrametric spaces in quantitative domain theory. Theoretical Computer Science, 368(1–2):30–49, 2006.

[LH08a] J. Lehmann and P. Hitzler. Foundations of refinement operators for description logics. In H. Blockeel, et al., editors, Inductive Logic Programming, 17th International Conference, ILP 2007, Corvallis, OR, USA, June 2007, Revised Selected Papers, volume 4894 of Lecture Notes in Artificial Intelligence, pages 161–174, 2008.

[LH08b] J. Lehmann and P. Hitzler. A refinement operator based learning algorithm for the ALC description logic. In H. Blockeel et al., editors, Inductive Logic Programming, 17th International Conference, ILP 2007, Corvallis, OR, USA, June 2007, Revised Selected Papers, volume 4894 of Lecture Notes in Artificial Intelligence, pages 147-160. Springer, 2008.

[TH06] T. Matzner and P. Hitzler. Any-world access to OWL from Prolog. In J. Hertzberg, M. Beetz, and R. Englert, editors, KI 2007: Advances in Artificial Intelligence, 30th Annual German Conference on AI, KI 2007, Osnabrück, Germany, September 2007, Proceedings, volume 4667 of Lecture Notes in Computer Science, pages 84–98. Springer, Berlin, 2006.

[Sch08] U. Schöning, Logic for Computer Scientists, Birkhäuser, 2008.

Budget

Item	Description and Justification	Amount
Graduate Teaching Assistant	Partial GTA over two semesters ($750 per month) to assist in the development and conduct of the class. During the first semester, the GTA will do proofreading of the manuscript provided by the teacher, will do additional quality control for the videos, will provide a student help desk for class participants, and will do homework grading and assist with exam grading. During the second semester, the GTA will provide a student help desk for class participants, will do homework grading for the distance learning section of the class, and will assist with exam grading. Funds are requested for a GTA because changing the class to the combined delivery modes laid out in the proposal requires significant additional effort by the teacher, i.e., the PI. The GTA will thus absorb some of the total workload for the conduct of the class. For subsequent installations of this class, i.e. beyond the runtime of this project, a GTA will no longer be required since all class material will already have been prepared.	$6,000
TOTALS		**$6,000**

Outcomes of Previous Award

The PI has received a Wright State Teaching Innovation Grant in 2012 for the project "ImproMat – Improving the Retention Rate of Computer Science Students which are Underprepared in Mathematics." The project installed the new CS1200/CS2200 sequence which was targeted at students intending to study Computer Science but which are underprepared in Mathematics.

Evaluation of the project was done quantitatively, by measuring the retention rates and comparing them to retention rates for similar students before the installation of the new sequence.

At the end of the two-course sequence conducted and installed as part of the project, 15 students from the PI's CS1200 section registered for CS2200, and 10 of these passed with a grade of C or better. Of the remaining 5 students 4 had had a C in CS1200, while only one had had a B. Of the 10 students with C or better in CS2200, 3 had had a C in CS1200. Thus, a total of 67% of students advancing from the PI's CS1200 section to CS2200 obtained a C or better in CS2200, allowing them to advance. The success rate of the students from the an adjunct lecturer's CS1200 class, taught in parallel, was not quite as good, with only 30% of the advancing students obtaining a C or better in CS2200.

Overall, 46% of students (16 out of 35) advancing from CS1200 in fall 2012 obtained a C or better in CS2200 in spring 2013. Of the students attending CS2200 who had not previously attended CS1200 (due to better math preparation in high school), 50% (10 out of 20) obtained a C or better in CS2200. This shows that CS1200 was indeed highly successful in leveling the field for CS2200, as those students who had taken CS1200 generally had much less math preparation from high school.

The more important measure, though, is the ratio of students who successfully complete the CS1200/CS2200 sequence within a year. Of those students who enrolled in CS1200 in fall 2012, 20% (16 out of 80; PI's section: 24%; adjunct's section: 15%) received a C or better in CS2200. If we restrict the analysis only to those students attempting the final exam in CS1200 (i.e. those who did not drop the class), then the success rate is 24% (16 out of 68); PI's section: 31%; adjunct's section: 17%).

This compares very favorably with the system which was in place before the introduction of the CS1200/C2200 sequence. In fact, in the 2009/2010 academic year, only 10% (7 out of 73) of students entering with an MPL of 3 or 4 (which corresponds to the entry requirements for CS1200) completed MTH 257 with C or better within a year. For the 2008/2009 academic year, in fact, only 1.7% (1 out of 59) of students entering with an MPL of 3 or 4 completed MTH 257 with C or better within a year.

Overall, the success rate of the new CS1200/CS2200 sequence was 24% (16 out of 68 of students with insufficient math preparation from high school), while the success rate of the previous system was only at 6% (8 out of 132 for both reported years combined).

Investigator Profile

Pascal Hitzler, Department of Computer Science and Engineering, Wright State University, Dayton, OH.
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Professional Preparation

Universität Tübingen, Germany	Mathematics	Diplom	1998
National University of Ireland Cork	Mathematics	PhD	2001
TU Dresden, Germany	Computer Science	Habilitation	2005

Appointments

since 2012	Associate Professor (early promotion), Computer Science & Engineering Department, Wright State University, Dayton, OH
since 2012	Director of the Discrete Structures Program, Computer Science & Engineering Department, Wright State University, Dayton, OH
2009 –2012	Assistant Professor, Computer Science & Engineering Department, Wright State University, Dayton, OH
2004 – 2009	Assistant Professor, AIFB, University of Karlsruhe (TH), Germany
Oct – Dec 2003	Research Associate, Department of Electrical Engineering and Computer Science, Case Western Reserve University, Cleveland, OH
2001 – 2004	Postdoctoral Researcher, Artificial Intelligence Institute, Computer Science Department, TU Dresden, Germany

5 Publications Related to Teaching

Pascal Hitzler, Markus Krötzsch, Sebastian Rudolph, Foundations of Semantic Web Technologies. Textbooks in Computing, Chapman and Hall/CRC press, 2009. (Textbook for undergraduate and graduate teaching; *Outstanding Academic Title* of the American Library Association's Choice Magazine; Chinese translation in progress)

Pascal Hitzler, Markus Krötzsch, Sebastian Rudolph, York Sure, Semantic Web. Grundlagen. Springer, 2008. 2nd edition planned for 2013. (Textbook for undergraduate and graduate teaching)

Steffen Hölldobler, Sebastian Bader, Bertram Fonhöfer, Ursula Hans, Pascal Hitzler, Markus Krötzsch, Tobias Pietzsch, Logik und Logikprogrammierung Band 2: Aufgaben und Lösungen. Synchron Verlag, Heidelberg, 2011. (Textbook for undergraduate and graduate teaching)

Pascal Hitzler, Anthony K. Seda, Mathematical Aspects of Logic Programming Semantics. Studies in Informatics, Chapman and Hall/CRC Press, 2010. (Research monograph for graduate teaching)

Pascal Hitzler, Henrik Schärfe, Conceptual Structures in Practice. Studies in Informatics, Chapman and Hall/CRC Press, 2009. (Collection for graduate teaching)

5 Other Significant Publications (out of over 250 publications)

Markus Krötzsch, Sebastian Rudolph, Pascal Hitzler, Complexity of Horn Description Logics. ACM Transactions on Computational Logic 14(1), 2013.

Frederick Maier, Yue Ma, Pascal Hitzler, Paraconsistent OWL and Related Logics. Semantic Web 4(4), 2013, 395-427.

Sebastian Rudolph, Markus Krötzsch, Pascal Hitzler, Type-Elimination-Based Reasoning for the Description Logic SHIQbs Using Decision Diagrams and Disjunctive Datalog. Logical Methods in Computer Science 8 (1:12), 2012.

Matthias Knorr, Jose Julio Alferes, Pascal Hitzler, Local Closed-World Reasoning with Description Logics under the Well-founded Semantics. Artificial Intelligence 175(9-10), 2011, 1528-1554.

Jens Lehmann, Pascal Hitzler, Concept Learning in Description Logics Using Refinement Operators. Machine Learning Journal 78(1-2), 203-250, 2010.

Synergistic Activities (selection)

- 15 years of involvement in enhancement programs for highly skilled high-school students (in Germany): 10 summer schools and contests organized; lecturing (10 courses); publication of course material, reports, edited books (25 publications); setting of contest exercises; community service as treasurer and assistant treasurer for associations and as editorial board of a book series (in German) in this area.
- Journal involvement: Editor-in-chief of the IOS Press journal Semantic Web. Editorial board (4 journals). Journal reviewing (selection): ACM Trans. on Internet Tech., Data and Knowledge Engineering, Fund. Inf., IEEE Trans. on Neural Networks, Int. J. on Semantic Web and Inf. Systems, J. of Artificial Intelligence Research, J. of Automated Reasoning, J. of Logic and Computation, J. of the ACM, J. on Web Semantics, Theory and Applications of Categories, Theory and Practice of Logic Programming, IEEE Trans. on Data and Knowledge Engineering.
- Further Reviewing (selection): Project applications for NSF, for the Portuguese FCT, for the Deutsche Forschungsgemeinschaft (German Research Foundation, DFG), for the Austrian Fonds zur Förderung der wissenschaftlichen Forschung, for the Dutch Nederlandse Organisatie voor Wetenschappelijk Onderzoek, NOW, for the Natural Sciences and Engineering Research Council of Canada, NSERC, for the Chilenian Fondo NAcional de Desarrollo Cientifico y Tecnologico, FONDECYT, and for INRIA, France. Book proposals and book manuscripts for Springer.
- Conference involvement (selection): Steering Committee member (RR, as vice-president 2007-2012, OWLED, ICCS); PC Chair (AIMSA2014, ODBASE2011, RR2010, AGI-09, ICCS06), General Chair (RR2012), Area Chair (ESWC2013, ESWC2011, ISWC 2010, KI 2009), Workshops/Tutorials Chair (K-CAP 2013), Senior PC Member (ISWC2013, AAAI-13, ISWC2012, IJCAI-11), Sponsor Chair (ISWC2013, ESWC2009, RR2009). Ca. 20 workshops organized. PC member (selection): ISWC2014, Hypertext 2014, KR 2014, ESWC 2014, ISWC2013, IJCAI-13, PODS 2013, WWW2013, Hypertext 2013, WWW2012, AAAI-12, ISWC 2012, ECAI 2012, ISWC2011, AAAI-11, WWW2011, IJCNN-11, ECAI2010, AAAI-10, ESWC2010, ISWC2009, IJCAI-09, IJCNN 2009, ISWC 2008, KR-08, ECAI 2008, ESWC2008, WWW2008.
- Participant in the W3C standardization working group “Web Ontology Language” (OWL). Co-author of the W3C Recommendation “OWL 2 Web Ontology Language: Primer”.

Current students:

David Carral Martinez (PhD student)
Michelle Cheatham (PhD student)
Amit Krishna Joshi (PhD student)
Adila Alfa Krisnadhi (PhD student)
Raghava Mutharaju (PhD student)
Stella Sam (PhD student)
Kunal Sengupta (PhD student)
Cong Wang (PhD student)

Manoj Kasyap (Master student)
Ali Kerbasi (Master student)
Kylyn Magee (Master student)

Kyle Bayes (undergraduate student)
Christopher Lamp (undergraduate student)

Current co-supervised students:

Pavan Kapanipathi (PhD student; supervisor: Amit Sheth)
Sarasi Lalithsena (PhD student; supervisor: Amit Sheth)