

A Pattern Approach to Increasing Enrollment and Retention of Female Students in Computer Science and STEM Education

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MOTIVATION

The problem of low enrollment and retention of females in computer science (CS)—and other STEM disciplines—has been researched, but much of this research is focused on the status quo; describing what goes wrong and the reasons for it. Some practices and approaches for changing the situation have been described too, e.g. in [5].

However, these descriptions are in many cases hard to translate to other situations or are not applicable there. This is even more because the ways the approaches are described differ—sometimes significantly—in style and level of detail. And when applied as described, the results were in some cases not as intended. We assume that one of the reasons is that the success of the described approaches is in many cases dependent on many factors and that they work only in certain contexts. Information about these factors and contexts often is lacking in the description.

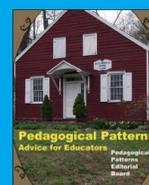
What is needed is to get hold of the *essence of what works* and a description of this knowledge in a way that is concrete enough for easily understanding and applying it, yet general enough to be widely applicable. To support such way of knowledge description it should consist of

- support for a deep analysis of the significant aspects of working approaches, helping with understanding *why* and *when* they work and
- a uniform description of working approaches for improving dissemination and sharing of this knowledge.

The intention of this work is to propose (design) patterns as a possible way of describing the knowledge in an easily accessible way. We hereby introduce patterns (in general and for education), offer an example (taken from [3]) and summarize our proposal, including options for future work.

EDUCATIONAL PATTERNS

Patterns have been used successfully in (CS) education, mainly triggered by the work of the *Pedagogical Patterns Project*. These patterns address different levels of education, ranging from small classroom interactions (like QUESTION BOOMERANG [4]) to constructivism-based general approaches (like ACTIVE STUDENT or PEER FEEDBACK [6]). Other aspects covered are organizational issues and technology-enhanced learning. However, patterns on institutional level are still scarce and need to be described.



(DESIGN) PATTERNS

Patterns originate in architecture and were introduced by Christopher Alexander et al. in [1]. They are described as a formulae that “describes a problem which occurs over and over again, and then the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice”.

Patterns are commonly described using a special format. This includes at least these elements (or variations of these):

- (C) Context - The situation in which the problem can occur and the pattern offers a solution.
- (P) Problem - The problem which the pattern solution addresses.
- (F) Forces - Describing what shapes the problem and leads towards the solution.
- (S) Solution - The generic and generative aspects that help with solving or at least minimizing the problem.
- (CI) Consequences and Implementation Tips - Describes the resulting context, including both benefits and liabilities, and tips for the pattern implementation.
- (E) Example/s - Concrete examples of how the pattern was applied in different situations.
- Related Patterns (not shown in example) - Which other patterns can be applied after this one or in combination with it.

Describing knowledge on how to improve situations in the form of patterns offers various advantages:

- the elements enforce a thorough analysis and understanding of the working aspects,
- the knowledge is easily accessible because of a common structure, and
- the approach has been proven valuable in various fields.

EXAMPLE PATTERN

APPLICABILITY HIGHLIGHTING

(C) Your institution is preparing advertising material for your computer science programs. This includes flyers, presentations and other kinds of material.

(P) *Mainly focusing on the technical and functional aspects of computer science when communicating about it reproduces its masculine image and is likely to not attract many female students.*

(F) Computer science comprises much more than technique, but people often become aware of these aspects when studying CS and not before. Because CS is often presented as being highly technical it is often perceived as being masculine, as in most cultures technique as such is mainly masculine gendered. Values that are of influence on the girls' choices are creativity, service, autonomy, and entrepreneurial. Interviews with (Dutch) female CS students also indicate that especially the possibility to express their creativity attracted the girls, even though this was not explicitly addressed in the institutions' advertising activities [2].

The typical language used when representing CS often uses metaphors which originate in—and therefore are associated with—the building industry, like “building a program” or “the architecture of a system”. The usage of such metaphors often connotes a male image of the discipline.

(S) **Therefore: Develop and utilize a language for communicating about CS that includes and highlights the possible applications of CS. Beside the technical aspects emphasize also values as creativity and entrepreneurship and show how CS relates to the application and use of technology in the world.**

(CI) This language removes a part of the dual view of CS being connoted as mainly male or female, and is therefore more gender inclusive. It comes closer to how female students see the discipline themselves without removing the (important) technical aspects. Female CS students stated in interviews that they like CS because they learn “new languages there” and that they can “express their creativity by e.g. solving security problems related to cybercrime” [2].

The solution does not suggest to replace the old descriptions in the advertising material, but to enhance them. Add for example showcases of real-life applications and how they fit into societal environments. Explain how creativity forms an essential part of computer science (innovative student projects can be used for this) and how good software can make a change. Present both aspects of computer science—techniques and applicability—as equally important.

(E) *One implementation related to this pattern, although not directly, is an activity at the Harvey Mudd College. They take young women who are about to choose their major to a Gracehopper Convention, which exposes the female students to a variety of non-technical aspects (beside meeting female role models too). The effect on the girls' choices was measurable and is, partly, also changed by the way computer science is presented as whole at these conventions through using a more inclusive language.*

CONCLUSION & FUTURE WORK

(Design) Patterns can be a valuable approach for analysing the working approaches for improving enrollment and retention of females in disciplines where they are underrepresented. They help with finding and describing the essence of what works in a very standardized, yet open and adaptable way, which supports the exchange and sharing of this knowledge.

As patterns are well known and accepted in Computer Science, we expect that they will—for this reason—as approach for describing knowledge also likely be more easily accepted in CS departments specifically and STEM departments in general. Furthermore, the combination of the knowledge itself—more located on an organizational and institutional level—and the approach—coming from computer science— makes this research interdisciplinary. This might help with building a bridge between all involved parties, increasing the chance of success.

In [3] we started with describing these four patterns, based on research findings and experience reports:

- APPLICABILITY HIGHLIGHTING (described in this work),
- INCLUSIVE REPRESENTATION (use pictures of male and female students, avoid stereotypical representations),
- EXPERIENCE CLASSES (place students in classes based on their prior experience), and
- INCLUSIVE APPROACH (offer activities that address female students, but include males too).

Our intention is to continue with mining such patterns from literature and concrete experiences of people involved in alike projects. Collaborations with other institutions are hereby highly welcome.

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