Comparative evaluation of parametric design systems for teaching design computation

Robert Aish and *Sean Hanna*, The Bartlett School of Architecture, University College London, Gower Street, London WC1E 6BT, UK

Three parametric design systems were tested by the authors to assess their suitability for undergraduate teaching. We used criteria taken from the 'cognitive dimensions' literature and an exercise of typical geometric operations in ascending order of complexity. For each system the cognitive barriers associated with the sequence of operations were plotted to create a 'learning curve'. Different parametric systems presented distinctly different learning curves. The test exercise had to be completed in its entirety to assess the potential challenges which students with different educational levels, skills and abilities might encounter, so a single expert user conducted the tests. This research is intended to develop methods, both design exercises and evaluative criteria that could be used in future empirical studies.
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Keywords: architectural design, design education, human–computer interaction, parametric design, evaluation

Digital media and working methods are considered to have a pronounced influence on design thinking (Oxman, 2008), therefore understanding the way parametric systems support parametric design thinking is of critical importance for both students and educators. Students will develop their parametric design ability through the use of these applications. Indeed, the way the selected system presents its functionality may well be taken by students as the definition of parametric design. Therefore the influence of parametric design systems on the students and responsibility which goes with this means that it is essential that the available applications are systematically evaluated. Often the choice of parametric system is influenced by other extraneous factors such as the 'platform' or the application software associated with the parametric system, where the platform or application might have already been selected by the user's institution. Similarly students with partial knowledge of parametric design may be influenced to select tools with which they are already familiar even if these systems may not be best suited to later learning stages. In this study we have deliberately excluded these extraneous factors and focussed exclusively on a systematic evaluation of the different parametric design systems.

Corresponding author:
Robert Aish
robert.aish@ucl.ac.uk

Learning rates may differ between students. Different parametric software may be more or less suited to different parametric modelling tasks and to

www.elsevier.com/locate/destud
0142-694X *Design Studies* ■■ (2017) ■■–■■
http://dx.doi.org/10.1016/j.destud.2017.05.002

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Please cite this article in press as: Aish, R., & Hanna, S., Comparative evaluation of parametric design systems for teaching design computation, Design Studies (2017), http://dx.doi.org/10.1016/j.destud.2017.05.002

different students. All these differences interact. While it may be possible to observe this type of parametric design learning informally in a classroom setting, it will be challenging to design controlled empirical tests for students learning to use parametric design software for the first time, sufficient to provide a statistically valid description of the learning progress. Additionally, there are the considerable challenges inherent in coordinating sufficient resources and appropriate student volunteers to make investigation of non-trivial skill learning practical. Further, such observations may not directly explain the underlying reasons for ease or difficulty in learning, which are of interest both to software designers and educators. For these reasons we propose an alternative approach, which establishes a set of relevant criteria by which the software can be evaluated, aiming both to limit the subjectivity of different users and to correspond to particular cognitive factors which explain potential learning challenges. This is intended to equip a single user, often an expert, most probably with some existing bias, to make this evaluation with sufficient objectivity. These two approaches, expert evaluation and empirical studies, can ideally inform one another, but at least the first should be explored before the second and it is the first which is the topic of this paper.

The purpose of this evaluation is to explore the cognitive issues involved with parametric design software which would be experienced by a novice user rather than the subjective experience of students with particular backgrounds or levels of skill. This evaluation involved constructing the same abstract parametric geometry model with the different systems and evaluating the model building process with nine criteria developed from the 'cognitive dimensions' literature. The design of the test exercise, the development of the evaluative criteria, the model building activity with the different systems and the review of the different model building processes with the evaluative criteria has been done by the authors. The authors have a background in developing, using and teaching parametric design and design computation. They also have similar levels of *unfamiliarity* with the current interfaces and functionality of the three systems tested. Experts associated with the three software developers were consulted by the authors to ensure equal knowledge for each system.

In many applications of parametric design for example to architecture, parametric modelling involve operations which create and use collections. Therefore how collections are presented by a parametric design application to the designer is crucially important. The model building exercise involves:

1. Creating of a 2D array of points
2. Creating a surface using the 2D array of points
3. Creating a set of curves through the points
4. Creating a set of curves through the transpose of the array of points
5. Creating a single curve by making an arbitrary selection of points from the 2D array

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