Capturing consensus through Adaptive Comparative Judgment: Building the foundations of a concept inventory for graphics

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Abstract

One of the most significant challenges for curriculum development is to comprehensively position a program of study that is both current and relevant. This challenge requires balancing the perspectives of the role of education that serve both the individual and the wider society. Engaging all stakeholders is critically important so as to ensure that the program of study is fit for purpose and serves the necessary agendas.

Reaching consensus on the content to teach makes explicit the foundations of the program of study. The core concepts and principles that govern a discipline area will determine the focus, tasks, activities, competencies, and assessment and associated pedagogical practices that define teaching and learning.

This paper explores the potential of the Adaptive Comparative Judgment (ACJ) method in aggregating the professional opinions of experts and stakeholders as a method of reaching consensus on what is important. The method is considered as an alternative to the Delphi method and presents a number of specific advantages over the more established research approach.

Introduction

The need to develop a concept Inventory for Engineering Design Graphics has been well established by Sadowski and Sorby (2015). Their work highlights the potential of a Concept Inventory to enhance educational practices and inform future developments. The importance of defining a concept inventory in engineering graphics is not argued in this paper; instead the focus is on the method of reaching consensus. The need for expert opinion and multiple perspectives to ensure a robust outcome requires a means of aggregating converging and diverging views of what is important to teach students with respect to Engineering Design Graphics. The perspective, experience and foresight of stakeholders are a product of context and situation and often the result is variability in the ranking of what is of value.

The Delphi Technique and Associated Limitations

The Delphi technique is a group approach utilized to gather data relating to the opinions of experts on a specified area or subject matter (Yousef 2007). It has been applied in several educational areas and some of its uses have included: cost-effectiveness, cost-benefit-analysis, curriculum and campus planning, and educational goals and objectives (Green 2014). It is an extremely useful research approach in complex ill-defined areas that rely on the informed judgement of subject experts. According to Rowe and Wright (1999) there are a number of key characteristics of the Delphi technique, namely:

1. Anonymity of the research participants to encourage free expression of personal views
2. Regulated feedback from the researchers in order to inform the participants' views from round to round
3. Iteration to facilitate evaluation, clarification and modification of their views
4. Aggregation of the responses that allows for interpretation by the researchers

Although the Delphi technique has been applied successfully in past research, there are some inherent limitations in using the method. Linstone and Turoff (1975 cited in Yousef 2007) suggest some limitations of the technique including the potential for the researcher to impose a view upon the participants in the structuring of the study. Another limitation that can be associated with the technique is the inability of participants to see the overall picture or vision with which they are involved and as discussed in Green (2014) this can lead to sanitized or lowest common denominator type agreement occurring. Achieving an acceptable level of consensus from experts on an ill-defined issue is one of the mantras of the Delphi method. However, given the iterative nature of the process, where responses are analyzed and presented back to participants during subsequent rounds, there is potential to suppress diverging opinions. This issue has led to variants of the classical Delphi that emphasize divergence of opinion by concluding a study with a focus group where experts can meet and discuss their perspectives (vanZolingen and Klaassen 2003). This still holds potential issues of validity though as the anonymity factor has now been removed from the process. Also, gathering qualitative feedback from the participants is extremely difficult and often occurs at a much later date whereas the researchers could benefit from this data if it were more immediately available (vanZolingen and Klaassen 2003). It is therefore prudent to explore alternatives to the Delphi approach that provide a statistical reliability for achieving consensus while protecting the internal constructs of the individual participants.

Adaptive Comparative Judgment as a Research Tool for Achieving Consensus

Adaptive comparative judgement (ACJ) has been implemented as a tool for assessing student work in areas such as design and graphical education (Seery et al. 2011, Seery and Delahunty 2013, Seery et al. 2017). The approach allows for consensus to be achieved through a number of rounds of judgements where experts select the "best" option between two pairs of student work. The process appraises the position of items while judgments are being made by the individuals. This begins with a rough sorting of work and as rounds progress items begin to group until the system determines a statistically reliable rank. Pollitt (2012) summarizes a number of key advantages associated with this system of assessment including validity, reliability and the ability to identify the misfit judges whose internal constructs manifest differentially from the overall group.

Applying ACJ

This paper considers the potential of ACJ as a method of robustly informing the Concept Inventory and focuses on the capacity of the software to enhance the outcomes and insure quality. The ACJ process facilitates participants making judgments on the most important concepts comparatively. Unlike the Delphi method, ACJ will run as one round with a series of comparative judgments (dependent on the number of concepts and judges). This is an immediate practical advantage as it reduces the overall research timeline compared to the Delphi method. The holistic nature of the judgment is an important aspect as participants are not worried about a rating scale and the error that can occur due to the order of concepts presented. In other words Concept A was rated on the Likert scale at point 4, subsequent concepts where then deemed to be more important and this causes a *calibration uncertainty*. ACJ focuses on the comparison with another concept directly and will adapt to the concepts based on the need to affirm its position on the rank. This process is a sophisticated calculation of the direct decisions of the participants, coupled with their 'proxy' decisions and aggregated with the decisions of all other participants. This approach to reaching consensus ensures that participants make absolute decision and that all decisions are captured in the system for further consideration, if required.

The significant difference in the process is that the pairwise comparisons are conducted simultaneously and not sequentially. This simultaneous judging session means that all participants can see the breadth of concepts randomly and are not influenced by the decision of others (as possible with the sequential rounds) thus preserving the integrity of their personal constructs. Additionally, the decisions made by the group are tracked by *probability parameters* that record the degree of alignment between participant decisions, this can highlight the level of consensus reached (*Inter-rater Reliability*) between the group and produces a ranked order of the core concepts. Together with the capacity of the parameter values to determine level of agreement, it

can also predict the likelihood of a participant's decision when presented with a comparison relative to the decision of the remainder of the expert group. Therefore, a participant (or even a concept) can be identified by the 'misfit' statistic, highlighting the need for further investigation.

Conclusions

Using ACJ to determine a Concept Inventory in Engineering Design Graphics has the potential to ensure the anonymity of the participant, aggregate judgment without compromise, identify areas of divergent view, capture qualitative data and statically determine reliability.

Although initial pilots have supported the use of ACJ, further research is required to run the method in parallel to a live Delphi to establish an absolute benchmark comparison.

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