

Critical mass and the dependency of research quality on group size

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The notion of critical mass in research is one that has been around for a long time. It has been described as some kind of threshold group size above which research standards significantly improve. However no evidence for such a threshold has been found and critical mass has never been measured - until now.

We develop a new, simple, sociophysical model which explains how research quality depends on research-group structure and in particular on size. Our model predicts that there are, in fact, two critical masses in research, the values of which are discipline dependent. Research quality is, on average, linearly dependent on group size, but only up to a limit termed the upper critical mass. Beyond this limit, a phase transition reduces the dependency of quality on quantity. The upper critical mass is interpreted as the average maximum number of colleagues with whom a given individual in a research group can meaningfully interact. Once the group exceeds this size, it tends to fragment into sub-groups and research quality no longer improves significantly with increasing size.

Our theory is tested using empirical data on the quantity and quality of scientific research groups, for which critical masses are determined. For theoretical and experimental physics, the lower critical masses are estimated to be about 6 and 13, respectively. Research groups should strive to achieve these sizes for stability. The upper critical masses, beyond which research quality does not significantly improve with group size, are about twice these values.

[1] R. Kenna and B. Berche, *The extensive nature of group quality*, EPL 90 (2010) 58002.

[2] R. Kenna and B. Berche, *Critical mass and the dependency of research quality on group size*, Scientometrics 86 (2011) 527-540.