References

[1] A. Aberdein, U. Martin, and A. Pease. An empirical investigation into explanation in mathematical conversations. Unpublished Draft

This paper develops a taxonomy of explanation in mathematics in based on data from the minipolymath projects. Since online blogs and forums are quite conducive to quantitative and empirical research, the authors develop paricular indicators to test their hypotheses. The first hypothesis to be rejected is the assertion that "there are no explanations in mathematics." The hypothesis, on the contrary, that "all explanations are answers to why-questions" was found to be strongly supported by evidence. The authors, then, go into more detail, as to the eplanations themselves: these have been found to be *trace explanations*, that is, explanations that point to the sequence of inferences that led to the conclusion, as well as *strategic explanations*, that is, explanations that demonstrate the solving strategy. An important aspect of explanations in mathematics is the sociality factor. Here the authors demontstrate that explanations are related to the following people-centred elements: abilities; knowledge; understanding; values. Moreover, the social context involved in explanations is, as well, varied: inquiry; pedagogical; persuasion; information-seeking., 2012.

[2] M. S. Ackerman, J. Dachtera, V. Pipek, and V. Wulf. Sharing knowledge and expertise: The CSCW view of knowledge management. *Computer Supported Cooperative Work*, 22(4):531–573, August 2013.

This paper is has a historical focus: it examines how the CSCW viewpoints on knowledge and expertise sharing developed over time. Originally CSCW research developed over knowledge sharing, or, what the authors call, 1st generation of CSCW research: the focus was on the role that the externalisation of knowledge plays in the form of computational and information technology artefacts and repositories. Later on, 2nd generation of CSCW research, focused more on expertise sharing based on discussions among knowledgable actors. In CSCW terminology, 1st generation dealt with the *organisational memory*, of communities and groups of experts, while 2nd generation focused more on *expertise sharing*.

[3] J. Adams. Collaborations: The rise of research networks. *Nature*, 490(7420):335–336, 2012.

This is a 2-page article that simply acknowledges the increase in internation scientific collaborations, especially during the last decade. The author considers collaboration as measured by co-authorship and as advantages of international collaboration he mentions more frequent citation of coauthored articles, which also can very well become tools of international diiplomacy. The main problem, though, according to the author, is that shared international, national and institutional research agendas could push researchers to work only on topics that peer consensus defines as the most interesting, and neglecting other research areas.

[4] A. Amin and P. Cohendet. *Architectures of Knowledge: Firms, Capabilities and Communities.* Oxford University Press, 2003.

[5] H. Andersen and S. Wagenknecht. Epistemic dependence in interdisciplinary groups. *Synthese*, 190(11):1881–1898, 2013.

This paper deals with trust in science: an individual scientist in an interdisciplinary research group depends on the scientific knowledge of his or her colleagues. The authors distinguish *unilateral epistemic dependence*, i.e. when an individual scientist trusts the testimony/testimonies of other scientists, with whom he or she is not necessary collaborating; and *multilateral epistemic dependence*, i.e. when a group of collaborating scientists trust each others' scientific testimonies in order to continue with their research activities. In a research collaboration group, in other words, there is complementary knowledge distributed among the individual members of the group. The the authors raise the question of how to *integrate* the group's distributed knowledge in an optimal way. The problem arises due to the fact that each member can have *interactional expertise* on the fields of his or her fellow researchers. i.e. has a superficial knowledge of the subject that helps him or her to discuss subjects outside his or her field, but *contributory expertise* only on his or her own field, i.e. can deep knowledge of the subject and can produce new knowledge. The authors propose for different ways of *cognitive integration* within the group, depending on the type of epistemic dependence and the type of expertise distributed among the research group members. In the case of unilateral, or bilateral, epistemic dependence, integration can be done by the group leader, who possesses the "full expertise" to connect with each group member. When each member has only limited interactional expertise of areas beyond his or her own, then the members form a group of multilateral epistemic dependence to teach each other, and at the end the group may dissolve. When there is an overlap of expertise between group members, again a case of multilateral epistemic dependence, usually the case is one of *negotiation among experts.* And finally, in the case that each member has a substantial level of interactional expertise in the areas of his or her collaborators, then, according to the authors, this will be a case of *joint integration.*

[6] J. C. Baez. Math blogs. *Notices of the AMS*, 57(3):333, March 2010.

This is an article by a mathematician surveying the maths blogosphere in 2010.

[7] M. J. Barany. Polymath1 and the modalities of 'massively collaborative mathematics'. In *Proceedings of the 6th International Symposium on Wikis and Open Collaboration.* Association for Computing Machinery, 2010. Article No. 10

The paper discusses the negotiations between the participants in the polymath project and the materiality of the blogging platform. A blog was already a familiar form of online practice for many participants before the announcement of polymath. In the beginning there was much of reflective thinking about the blog, and the author describes how the blog evolved through collective self-observation. Probably the most important aspect in the experience of reading a blog is its temporal presentation of discussion threads. That posed a problem in following sub-threads of discussions, since everything was presented in a linear narrative. Gowers's role, the originator and administrator of the blog, was pivotal on this: he activated the threaded comments feature of the blog, and threads could now branch into sub-threads presented again in a temporal way. Another important factor was the LaTeX typeset feature, part of the modern common culture of every the mathematician all over the world. Another feature of the blog platform was the ability to use LaTeX markup, although this had to be adapted to the new blog environment: many users not acquainted with the particularities of LaTeX on the blog platform quite often made mistakes in their postings, and commented on them.

[8] M. J. Barany and D. MacKenzie. Chalk: Materials and Concepts in Mathematics Research. In C. Coopman, J. Vertesi, M. Lynch, and S. Woolgar, editors, *Representation in Scientific Practice Revisited*. MIT Press, 2014.

This paper attempts to demonstrate the deeper relationship between advanced and abstract mathematical concepts and the practices and instruments, especially chalk and blackboards, that act as a material platform that render them material form. It is an ethnographic study of mathematics as a laboratory, rather, than as a science proper. Blackboards are mainly found in seminar rooms and lecture theatres: they define the audience's orientation and mark the visual territory of the lecture. Blackboards can be big, or small, and available; slow, and loud; common and ostentatious. Blackboards define the performance accompanying writing with chalk; they become a theatrical prop, or a scene backdrop. The lecturer can erase by hand a formula, putting a semicolon on the performance; he, or she, on the other hand can erase the whole surface, putting a full stop, or changing a paragraph, on the proving performance. The chalk's shape, on the other hand, limits its writing abilities with respect to certain markings, but its manual manipulation can condense or disperse complicated formulas. Chalk writing itself narrates the proof in a revealingly unfolding path uncovering bit by bit the deeper mathematical meaning. Blacboard and chalk combined on the fly can translate "complex, symbol-intensive ideas into a manipulable, surveyable form." This "blackboard" way of writing is not limited to "vertical" board writing, but extends to "horizontal" board writing: piles and piles of paper covering a mathematician's desk. Scrap paper writing is as well, quite akin to chalk writing. The author of the paper stresses quite a few times in a rather subtle way that blackboards, chalk, and piles of scrap paper make certain types of mathematical argumentation materially more feasible than others.

[9] B. Barnes. *Interests and the Growth of Knowledge.* Routledge & Kegan Paul, 1977.

[10] T. J. Barnes. A history of regression: Actors, networks, machines, and numbers. *Environment and Planning A*, 30(2):203–223, 1998.

This paper traces the history of correlation and regression analysis back in the 19th century. Francis Galton, the statistician who formulated, in the first place, correlation and regrassion analysis did so out of a social interest: he believed in the possibility of eugenics and was interested in studying the variation around the mean. The use of mathematical inscriptions were equally important while Galton created a new tier of reality: his various measurements of pea sizes, human heights, and body parts were meticulously recorded and then transformed and reshuffled on paper as he applied his statistical techniques. The correlation coefficient and the regression line emerged as new "bits of being." At the same time Galton involved a whole network of allies in developing his new theory: his own money; his use of the bean machine, a device demonstrating that the normal distribution is approximate to the binomial distribution; his involvement with a number of scientists and scientific societies; and his reliance on a particular body of contemporary ideas. This netowrk of regression analysis allies was extended to include: the institutionalization of statistics; the spreas of immutable mobiles in the form of scholarly periodicals; and in the treatment both by governments and by academic disciplines of their respective subjects. Then regression analysis for similar reasons spread to the human geography studies in the 20th century. The general argument of the article, in other words, is that that numbers are not eternal perfect forms but have very particular social and cultural biographies, and as correlation and regression analyses became black boxes, they moved out of biometrics and into other fields, including eventually human geography in the mid-1950s.

[11] P. L. Berger and T. Luckmann. *The Social Construction of Reality: A Treatise in the Sociology of Knowledge.* Anchor Books, 1966.

[12] D. Bloor. Wittgenstein and Mannheim on the sociology of mathematics. *Studies in History and Philosophy of Science Part A*, 4(2):173–191, 1973.

This paper attempts to establish the *strong programme* of the sociology of [scientific] knowledge with the aim of explaining how peoples beliefs are brought about by the influences at work on them. The author sets up four requirements for this new sociology: it must locate causes of belief, that is, general laws relating beliefs to conditions which are necessary and sufficient to determine them; no exception must be made for those beliefs held by the investigator who pursues the programme; it must explain its own emergence and conclusions; and, finally, not only must true and false beliefs be explained, but the same sort of causes must generate both classes of belief. According to the author there is a generally held belief that mathematics and logic are seen as being about a body of truths which exist in their own right independently of whether anyone believes them or knows about them. The author, on the contrary, in accord to his strong programme, holds that mathematics and logic are collections of norms, and their ontological status is the same as that of a social institution. In other words, the activities of calculation and inference, in the author's opinion, are amenable to the same processes of investigation, and can be explained by the same theories, as any other body of social norms.

[13] D. Bloor. Polyhedra and the abominations of Leviticus. *The British Journal for the History of Science*, 11(3):245–272, 1978.

This paper attempts to apply Mary Douglas's grid/group theory to Lakatos's data, connecting, in other words, mathematical knowledge, with social structure. According to the author, Lakatos treats mathematical 'kinds' as being our creations; classification is our achievement and our problem. Lakatos, in the author's opinion, asserts that theorems are conjectures, and as such they need testing; and proofs are attempts to test them. A proof procedure does not have a set of preordained implications outside the immediate context of use: it begins with an invention of a technique or procedure, a process which can be repeated a finite number of steps. Still, though, simple ideas can always be turned into complex ones and the whole problem started again. In this way mathematical concepts can be 'stretched,' and counterexamples are being 'recognised.' The recognition of a counterexample, i.e. the renegotiation of the boundaries that circumscribe a mathematical concept, when this very concept is being negotiated is a social process, and not an absolute one. To get the whole story, in the author's opinion, we need to know if there are any general patterns in these endlessly necessary negotiations, and what the currency is in terms of which profits and losses are calculated. Then the author turns to Mary Douglas's group/grid theory: the boundary which separates the members of a social group from strangers is called simply the group boundary, and its strength is said to vary from low group to high group; while the pattern of roles and statuses is thought of as a grid of internal boundaries. The unifying idea of the group/grid theory, according to the paper, is that the response to anomaly, and hence the drawing of intellectual boundaries, will be negotiated into alignment with the pattern of social group/grid boundaries.

[14] L. M. Brown and H. Rechenberg. Paul Dirac and Werner Heisenberg: A partnership in science. In B. M. Kursunoglu and E. P. Wigner, editors, *Reminiscences about a Great Physicist: Paul Adrien Maurice Dirac*, pages 117–157. Cambridge University Press, 1987.

This is a paper presenting Paul Dirac and Werner Heisenberg both as research partners and personal friends. It is based on the correspondence between Dirac and Heisenberg, and personal interviews of them. The author covers their partnership during years that quantum mechanics was being mathematically formulated and completed, then when quantum electrodynamics appeared, and then when it became quantum fields and particle theory. The author devotes a section to their friendhip as travel companions. It is an interesting paper from another respect: it points to a period in physics when the theoretical physics community was uncertain to which mathematical framework would be more appropriate to formulate a new theory based both on epxperimental results as well as on the personal intuition of the researchers themselves.

[15] J. C. Brunson, S. Fassino, A. McInnes, M. Narayan, B. Richardson, C. Franck, P. Ion, and R. Laubenbacher. Evolutionary events in a mathematical sciences research collaboration network. *Scientometrics*, 99(3):973–998, 2013.

This is quite a quantitative paper. It draws on data from the *Mathematical Reviews* database between 1985 and 2009. Its objective is to trace evolutionary trends during that period. It translates the raw data into graphs, and then uses time-series methodology to analyse collaboration networks. After their (technically demanding) analysis the authors reach some quite interesting conclusions. Both papers having three or more authors as well as researchers having three or more collaborators increased at a high rate. The authors of the paper formulate three alternative and parallel explanations of these trends. One is that as researchers become better connected, i.e. expand their collaboration network, more avenues of potential research arise, leading into an increase of contributions per paper overall. An additional explanation is that there are collaborators, not professional mathematicians themselves, who joined mathematics research groups rather infrequently. A third possible explanation, according to the paper, is that as the subnetworks of pure and applied mathematics have grown more cohesive, the overall scientific literature is becoming more cohesive. In the applied mathematics network the paper observes a surge in one-time authors, and one-time collaborations, while the pure mathematics subnetwork demonstrates greater productivity, as regards to individual researchers and collaborative pairs, as well as greater interdisciplinarity, as measured by the number of assigned subject classifications.

[16] A. Bundy. The interaction of representation and reasoning. *Proceedings of the Royal Society of London A: Mathematical, Physical, and Engineering Sciences*, 469(2157):1–18, 2013.

This paper deals with automated reasoning as representation of knowledge, as well as representation of methods of knowledge reasoning. Failures of reasoning leads to changes of representation which can be automated. The author illustrates his argument by drawing on applications of automated reasoning: multi-agent planning, physical theories and experiments, and mathematical proofs. According to the author, failures of reasoning can be diagnosed and repaired by repairing the representation language. The paper also discusses the “reformation algorithm”: a general-purpose algorithm under development, at the time of the paper, with the aim of dignosing and repairing faulty representation languages.

[17] A. Bunt, M. Terry, and E. Lank. Challenges and opportunities for mathematics software in expert problem solving. *Human–Computer Interaction*, 28:222–264, 2013.

This article studies the use of Computer Algebra Systems and matrix-based mathematics packages which offer sophisticated functionality for problem solving. The authors conducted ethnographic research based on semi-structured interviews with professional experts, and found that both engineers and mathematicians had liitle trust on computational tools. Five main factors were identified for this lack of trust. The first was a lack of transparency with respect to the derivation of results: the intermediate steps conducted by the system were not clear. As a result there was a lack of clearly defined operational boundaries: when the computer operates strictly on the input from the user, and when it adds its own steps? The third problem identified was the need for two-dimensional input: the systems were not conducive for researchers in moving between informal notes, sketches, mathematical formulae, and mathematical arguments. A result of this was a potential for transcription problems when switching from physical to computational media, and vice versa. A final factor was that computer systems had limited support for collaboration among experts, which is quite important, especially in the early stages of research: a shared computer console requires coordination of physical input devices, as opposed, for example, to the use of blackboard. Collaboration through physical media, on the other hand, was much easier.

[18] E. A. Carlson. *The Unfit: A History of a Bad Idea.* Cold Spring Harbor Laboratory Press, 2001.

[19] B. Carrascal. Proofs, mathematical practice and argumentation. *Argumentation*, 29(3):305–324, 2015.

This paper focuses on argumentation as a creative process and uses mathematics as an illustration of it. Mathematics, according to the author, is conducted in an informal manner, and mathematical proofs, in practice, arise in dialogical contexts under the presence of uncertainty, usually during the period of discovery. As a result, rhetorical elements might be employed to convince each particular audience to the proof, and collaborative work ,additionally can advance comprehension and solution of a problem. This is easily visible both in classroom settings, as well as in contexts of more advanced mathematics. The Minipolymath projects are a good example of collaborative work and argumentaion processes in analyzing and evaluating a proof.

[20] J. Chambers. *Software for Data Analysis: Programming with R.* Springer, 2008.

[21] F. Close. *Antimatter*. Oxford University Press, 2009.

This is a book explaining the history and interpretaion of antimatter. It's only included as a reference for a reader who would like to learn more on the subjects, rather than as a reference on a particular type of collaboration. It has also some history of the research on antimatter.

[22] R. Cowan, P. A. David, and D. Foray. The explicit economics of knowledge codification and tacitness. *Industrial and Corporate Change*, 9(2):211–253, 2000.

[23] J. Cranshaw and A. Kittur. The polymath project: lessons from a successful online collaboratiolan in mathematics. In *Proceedings of the International Conference on Human Factors in Computing Systems*, pages 1865–1874, 2011.

This is a paper that presents a more quantitative approach to polymath, commenting that deduction in mathematical proofs is collaborative by default: every proof is always based on previous proofs from other authors. The paper focuses their attention on polymath1. The authors distinguish two types of commenting on the blog: *numbered comments*, which contribute to the proof; *meta-comments* which refer to the process of the proof, and do not contribute something. They treat numbered comments as quantitative data, and meta-comments as qualitative data. An interesting result is that out of 39 participants in the proof, the top ten commenters made almost 90% of the comments. Also 29 of the participants did not hide their identity. The authors also note the role of leadership, Gowers and Tao, in particular, especially in grouping and summarizing progress of threads. Finally it is acknowledged that newcomers to the project might have a problem in joining in, and as a solution to that is proposed that there should be some mechanisms that identify important content, as well as pending tasks that need to be tackled.

[24] M. K. D. Cross. Rethinking epistemic communities twenty years later. *Review of International Studies*, 39(1):137–160, 2013.

[25] P. Darch. *When Scientists Meet the Public: An Investigation into Citizen Cyberscience*. University of Oxford, 2011. Doctoral Dissertation

This thesis presents two qualitative ethnographic case studies of the communities that have formed around two Citizen Cyberscience projects (CCP): climateprediction.net and Galaxy Zoo. CCPs are projects mediated through the Internet, in which teams of scientists recruit members of the public (volunteers) to assist in scientific research, typically through the processing of large quantities of data. By considering these social actors in the broader contexts in which they are situated (historical, institutional, social, scientific), the author discusses the co-shaping of the interests of these actors, the nature of the relationships amongst these actors, and the infrastructure of the projects and the purposes and nature of the scientific work performed. The author focuses on two relationships in particular. The first is that between scientists and volunteers, finding that, although scientists in both projects are concerned with treating volunteers with respect, there are nevertheless considerable differences between the projects. These are related to a number of interconnecting factors, including the particular contexts in which each project is embedded, the nature of the scientific work that volunteers are asked to undertake, the possibilities and challenges for the future development of the projects as perceived by the scientists, and the tools at the disposal of the respective teams of scientists for mediating relationships with volunteers. The second is amongst the volunteers themselves. This thesis argues that volunteers are heterogeneous, from disparate backgrounds, and that they sustain their involvement in CCPs for very different purposes. In particular, they seek to pursue these through the way they negotiate and construct their relationships to other volunteers, drawing on particular features of the project to do so.

[26] G. de la Flor, M. Jirotka, P. Luff, J. Pybus, and R. Kirkham. Transforming scholarly practice: Embedding technological interventions to support the collaborative analysis of ancient texts. *Computer Supported Cooperative Work*, 19(3):309–334, 2010.

This paper overlaps quite extensively with [34].

[27] G. de la Flor, P. Luff, M. Jirotka, R. Pybus, J. Kirkman, and A. Carusi. The case of the disappearing ox: Seeing through digital images to an analysis of ancient texts. In *Proceedings of the 28th International Conference on Human Factors in Computing Systems*, pages 473–482, 2010. This paper presents the detailed ways in which classicists work with digital image processing technologies and visualisation techniques. This study is based on video-based ethnograpic data. The initial software prototype is controlled through a mouse and keyboard and provides a orkspace where classicists can select high-resolution digital images, manipulate these in various ways and view them alongside other images, texts and annotations. The system can magnify detailed areas of an image as well as provide an overhead view of an image so that it can be seen in its entirety. The system also includes an annotation feature, making it possible for classicists to comment on and enter translations of letters, words and phrases. The authors, in addition, provide some suggetstions on the improvement on the system, based on comments from the scholars, as well as drawing on their own analyses.

[28] R. A. De Millo, R. J. Lipton, and A. J. Perlis. Social processes and proofs of theorems and programs. *Communications of the ACM*, 22(5):271–280, 1978.

This paper argues that insofar as it is successful, mathematics is a social, informal, intuitive, organic, human process, a community project. In the authors' opinion, while the aim of program verification, an attempt to make programming more mathematics-like, is to increase dramatically one's confidence in the correct functioning of a piece of software, in the case of proof in mathematics it is the social process that determines whether mathematicians feel confident about a theorem.

[29] S. Dick. Aftermath: The work of proof in the age of human–machine interaction. *Isis*, 102(3):494–505, 2011.

This paper narrates the story of AURA (Automated Reasoning Assistant). Its purpose was to assist humans in reasoning. AURA was developed at the Argonne National Laboratory. The group that built it believed that mathematical proof involved human insight which could not be automated, and what was left was to automate the parts of a proof that could be, in their opinion, automated. After the input of programmers' instructions, the results were unpredictable to a high degree, and the proofs were needed an excessive amount of time to be elicited. A first modification of their method was to put human intuition into the machine. This was done by a special module in the program, the SYSIN file. The SYSIN file read a *weighted information* file compiled by the programmers, which restricted the order of inferences according to the researchers' intuition as to which inferences mattered the most. A second mechanism, the Set of Support Strategy, received input from human users which restricted the the inference sequences that AURA could make. In between all of these steps the researchers were experimenting and checking the output of these experiments, and were also building models of problems to be solved. This, in the author's opinion, demonstrates a negotiation of proof between humans and machine, a nonhuman, which was, in general, quite successful in its final results.

[30] S. Dick. Machines who write. *IEEE Annals of the History of Computing*, 35(2):85–88, 2013.

The paper proposes a "history of computer-as-writing." This kind of new writing started with Turing: the "tape" of the Turing machine was, in fact, the corresponding paper. The historian's gaze, in other words, is being directed now to the *materiality* of data. In the early 50s computers were used, among other things, to prove mathematical theorems. These proofs were inspired by Whitehead and Russel's *Principia Mathematica*. *Principia Mathematica*, though, was written on paper, theorems proven by computers were coded onto magnetic drums and core magnetic storage systems. Paper-oriented mathematical notation, in other words, was translated into magnetic-storage-oriented expressions-as-linked-lists. And while Russel and Whitehead's paper-oriented expressions had two operations for generating and manipulating expressions, magnetic-storage-oriented expressions, as implemented for example on the RAND Johnniac computer between 1955 and 1957, had 44 variations of such operations. These operations constituted a new grammar of magnetic-storage-oriented writing. Writing about computers also led to the development of new forms of writing. Such examples are Knuth's famous proposal for "literary programming," as well as the many manuals, tutorials, instruction sets, and references by practitioners "promoting" computer skills through their pages.

[31] M. Douglas. *Natural Symbols: Explorations in Cosmology.* Routledge, 1970, 1996.

[32] P. Dowling. A sociological analysis of school mathematics texts. *Educational Studies in Mathematics*, 31(4):389–415, 1996.

[33] W. H. Dutton. The wisdom of collaborative network organizations: Capturing the value of networked individuals. *Prometheus*, 26(3):211–230, 2008.

This papers proposes a taxonomy of collaborative network organisations, based on how a particular network reconfigures information and communication flows. Following the disctinctions between Web 1.0, 2.0, and 3.0 the author proposes a similar taxonomy of collaborative networks. 1.0 category, or *sharing*, is the network's ability to create and distribute linked objects and documents. 2.0 category of networks, or *contributing*, are networks with the ability to employ social networking applications, and facilitate group communication. 3.0 networks, or *co-creating*, are networks which facilitate cooperative work toward shared goals.

[34] G. Eden and M. Jirotka. Digital images of medieval music documents: transforming research processes and knowledge production in musicology. In *Proceedings of the 45th Hawaii International Conference on System Sciences*, pages 1646–1655, 2012.

This is a paper presenting findings on how digital image archives of medieval music manuscripts transform research in medieval musicology. The authors conducted qualitative research that consisted of in-person and phne interviews, one focus group, and observational fieldwork sessions. Digital image archives offer a zoom feature, a ruler and a colour patch to assist scholars in the analysis of a document's physical properties, such as its decorative elements, size, binding, and areas where it is deteriorated. Moreover, paleographic practices focus on the content of documents where scholars are interested in deciphering and reading words and musical notes as well as trying to identify the scribes who wrote them. The authors found that scholars required two computer monitors to compare documents archived in two different digital image archives. Another interesting finding is that some digital archives create functionality that prevents them from saving online images on to the user's desktop, thus protecting the images from being copied. In other cases, the researcher must acquire permission from the manuscript holder to access the digital image.

[35] C. Franzoni and H. Sauermann. Crowd science: The organization of scientific research in open collaborative projects. *Research Policy*, 43(1):1–20,

2014.

This paper examines three examples of crowd science: the Foldit project in biochemistry, the Gallaxy Zoo in astronomy, and the Polymath project in mathematics. The authors identify two common characteristics in all three of them: participation to the project is virtually open to a wide pool of contributors; intermediate contributions to each project are publicly open and available to everyone to see. The authors see three potential benefits from croud science: open participation can be complementary to lead researchers and save more money and resources than traditional scientific research projects; the publicly available contributions from each individual crowd science participant can "spill over" to other research projects; and finally crowd science projects, due to their organisational nature, can increase the public understanding of science.

[36] H. Furstenberg and Y. Katznelson. A density version of the Hales-Jewett theorem. *Journal d'Analyse Mathmatique*, 57(1):64–119, 1991.

This is the original proof of the Hales-Jewett theorem based on ergodic theory. Both authors are well known mathematicians in ergodic theory.

[37] F. Galton. Eugenics: Its definition, scope, and aims. *American Journal of Sociology*, 10(1):1–25, 1904.

[38] Y. Gao, J. Kinoshita, E. Wu, E. Miller, R. Lee, A. Seaborne, S. Cayzer, and T. Clark. SWAN: A distributed knowledge infrastructure for alzheimer disease research. *Web Semantics: Science, Services and Agents on the World Wide Web*, 4(3):222–228, 2006.

This paper analyses SWAN – a Semantic Web Application in Neuromedicine – which is a project to develop an effective, integrated scientific knowledge infrastructure for Alzheimer Disease (AD) researchers. Although researchers over the past 20 years have made significant progress in understanding AD and related neurological disorders, there is still no clear agreement on the etiology of AD: citation analysis from the Alzheimer Research Forum estimates that there are more than 40,000 citations in the PubMed database of relevance to neurodegenerative diseases, and 150200 new studies are published each week. SWAN is an attempt to develop a practical, common, semantically-structured, web-compatible framework for scientific discourse using Semantic Web technology in the search for a cure for Alzheimer disease. The community members in SWAN are principally concerned with advancing their own research program. The most important aspect of SWAN, in the authors' opinion, is that it provides semantic interoperability of digital resources based on a common set of software and a common ontology of scientific discourse.

[39] A. Gazni, C. R. Sugimoto, and F. Didegah. Mapping world scientific collaboration: Authors, institutions, and countries. *Journal of the Association for Information Science and Technology*, 63(2):323–335, 2012.

This is a paper attempting to describe collaboaration as measured by coauthorship across institutions and countries. Its evidence is based on indexed documents from Thomson Reuters's Web of Science, and its results came from network analysis. One interesting finding is that he life sciences have the highest degrees of collaboration, whereas the social sciences have the lowest. Disciplines such as physics and mathematics favored international teams, whereas disciplines in the health sciences favored within-country institutional collaborations. U.S., U.K., Germany, France, Italy, and Canada account for 82% of the world's multinational publications. The authors' analysis of the top 20 institutions provided evidence that these high-impact institutions had higher levels of collaboration across all fields and all collaboration types.

[40] A. Geraschenko, S. Morrison, and R. Vakil. Mathoverflow. *Notices of the AMS*, 57(6):701, June/July 2010.

This paper has been written by the two students who developed MathOverflow, an by the researcher whose research funding originally supported the project. It has some of the history and explains some of the rationale behind the MathOverflow project.

[41] S. Gherardi and A. Strati. The 'texture' of organizing in an italian university department. *Journal of Management Studies*, 27(6):605–618, 1990.

This paper is based on an empirical study of a department of mathematics in an Italian university and aims at illustrating the social processes that underlie the construction of *organisational texture*. The authors define organisational texture as collective construction of the organizational processes whereby a shared understanding of organizational life is achieved. The themes around which the authors conducted their empirical research were the following: *activity*, which must be approached from the organisational actor's standpoint; *ownership*, that is, the motional bond that ties actors to the social artefact that they build; *link*, that is, the purpose, meaning and design as revealed in actors' (empirically detectable) relationships with various audiences; *reputation*, which brings out the actors' feelings of participation in organizational life and their symbolic contribution to the social construction of organisational texture; *typification* and the *mirror game* –by which various groups first form images of each other and then reflect them back and forth among themselves– are processes weaving together the organization's texture and its members' sense of belonging to it. The authors, though, acknowledge that their approach has both a strength and a weakness: it highlights those features of an organization that make it unique and special; on the other hand, it is an approach that focuses on those aspects that are least susceptible to comparison with those of other organizations.

[42] E. Gomart and A. Hennion. A sociology of attachment: Music amateurs, drug users. *The Sociological Review*, 47(S1):220–247, 1999.

[43] G. Gonthier, A. Asperti, J. Avigad, Y. Bertot, C. Cohen, F. Garillot, S. Le Roux, A. Mahboubi, R. O'Connor, S. O. Biha, I. Pasca, L. Rideau, A. Solovyev, E. Tassi, and L. Théry. A machine-checked proof of the odd order theorem. In S. Blazy, C. Pauline-Mohring, and D. Pichardie, editors, *Interactive Theorem Proving*, volume 7998 of *Lecture Notes in Computer Science*. Springer, 2013.

The paper focuses on the six-year collaborative effort to formalise the Feit-Thompson Odd Order Theorem for the Coq proof assistant. The proof of this Theorem filled an entire issue of the Pacific Journal of Mathematics. Later work in the group thery community focused on simplifying and clarifying the argument. The problem with this particular theorem is that it makes formalisation extremely difficult due to a great combination of theories involved in describing the the same mathematical object. The collaborators involved in formalising the proof had to develop many various techniques with each technique specialised for particular tasks. The authors conclude that because of the combined success of the great number of techniques involved in proving the Odd Order Theorem, the proof assistant community is now ready for "theorem proving in the large.".

[44] T. Gowers and M. Nielsen. Massively collaborative mathematics. *Nature*, (7266):879–881, 2009.

The authors of the paper organised the first polymath project and they recount their experiences, especially the general enthusiasm that embraced the project. They also not some problems that arise from this type of massive scientific collaboration. Authorship can be a problem, since it could cause contention and discourage participation. The transparency and public character of polymath could counter the problem of authorship. Preservation can be another potential problem: what happens if someone or something pulls the plug of the servers that hold the projects? The Library of Congress, in fact, is financing some projects of preserving legal blogs. Scaling up could also be a problem: late entrants would have to spent considerable time in deciding which thread of the attempted solution they would be interested to pick up; the blog is presents the threads in a linear narrative, and can be confusing to select a thread from the start. In the end, the authors attempt to promote an open-source-like model of scientific research.

[45] W.T. Gowers. Polymath and the density Hales-Jewett theorem. In I. Bárány, J. Solymosi, and G. Sági, editors, *An Irregular Mind*, volume 21 of *Bolyai Society Mathematical Studies*, pages 659–687. Springer Berlin Heidelberg, 2010.

[46] R. L. Graham, B. L. Rothschild, and J. H. Spencer. *Ramsey Theory*. John Wiley & Sons, Inc., 2nd edition, 1990.

[47] J. Grcar. Mathematics turned inside out: the intensive faculty versus the extensive faculty. *Higher Education*, 61(6):693–720, 2011.

This paper asserts that United States research universities have an "intensive" mathematics faculty inside a department of the same name, and an "extensive" mathematics faculty spread across other departments. The intensive and extensive faculties teach lower or upper division students, respectively, and they conduct research in mathematics subjects either unrelated or relevant to upper division students, also respectively. In the author's opinion, US research university have not been successful in aligning the teaching and research responsibilities of their mathematics department faculties, whereas the mathematics research conducted by faculty outside the mathematics department is aligned with the vocational interests of undergraduate students.

[48] C. Greiffenhagen. The materiality of mathematics: presenting mathematics at the blackboard. *The British Journal of Sociology*, 65(3):502–528, 2014.

This paper promotes the idea that, although mathematics is generally seen as a purely mental activity, it is, in fact, a deeply material activity. During a lecture the lecturer is writing on on the blackboard a mathematical proof explaining it, while he moves back and forth. Visualising a proof on the blackboard is a *directed* activity; moreover the lecturer can provide, in summary form, the *architecture* of the proof, before he goes into greater detail. He can also use a side of the blackboard as a *helper* for the proof which can contain comments, mentioning another theorem etc. The author goes into great detail by presenting successive snapshots of a lecture combined with transcripts.

[49] C. Greiffenhagen, M. Mair, and W. Sharrock. From methodology to methodography: A study of qualitative and quantitative reasoning in practice. *Methodological Innovations Online*, 6(3):93–107, 2011.

This paper characterises itself as a report on *methodography*, that is, an empirical study of research methods in practice. It is a small-scale investigation on the working practices of two groups of social scientists: one group with a predominantly qualitative approach, and another involved in statistical modelling. The main part of the paper presents two episodes: one between two researchers analysing and drawing conclusions from an interview transcript; and another betwenn two collaborators working out an agreed final version of a statistical model which combines temporal and spatial data. The activities that the authors report are ones that are *not on the record*, meaning that they are not normally recorded in the study materials of social research, nor are referenced in published journals. The inferences the researchers make in the course of their exchanges begin at different points, are leveraged in different ways and lead them in very different directions because they belong to distinct lines of inquiry into quite distinct problems each with their own local and disciplinary histories.Still though, in both cases, it was found that the way the researchers reasoned their problems through was entirely logical and systematic (or mechanical), as well as, entirely intuitive and interpretive (or undisciplined) – contrary to the picture according to the worst stereotypes in the literature.

[50] C. Greiffenhagen and W Sharrock. Does mathematics look certain in the front, but fallible in the back? *Social Studies of Science*, 41(6):839–866, 2011.

This paper focuses on the *front stage* of mathematics, i.e. lectures and textbooks, and on the *back stage* of mathematics, i.e. meetings of supervisor and doctoral student (as well as informal conversations between mathematicians, one could add. The authors try to promote the idea that there is a continuum between the *front* and the *back* of mathematics, and not just a jump from the certainty of the proof on the 'front stage' to the alleged fallibility on the *back stage*. Moreover familiarising oneself with the 'back stage' does not lead a new kind of reasoning and insight different from that appearing to the certainty of the *front*.

[51] C. Greiffenhagen and W Sharrock. Sources for myths about mathematics. on the significance of the difference between finished mathematics and mathematics-in-the-making. In K. François, B. Löwe, T. Müller, and B. Kerkhove, editors, *Foundations of the Formal Sciences VII: Bringing together Philosophy and Sociology of Science*. College Publications, 2011.

This paper attempts to show that the view of mathematical knowledge as the very paradigm of certainty, universality, objectivity, or exactness, is mostly a myth, rather than an acurate description proper. When attention is turned to *mathematics-in-the-making*, according to the authors, the view that emerges is quite different. The authors use Goffman's theatrical metaphor of the backstage and frontstage of social activities in segragating the setting of mathematics presentaion. Having conducted two ethnographic studies, one by attending graduate lectures, and another one by attending meetings between a supervisor and his doctoral students, they propose a new view, their view, of mathematics: the formal lecture as the *front* of mathematics, and the informal supervisor-students meetings as the *back* of mathematics.

[52] D. J. Griffiths. *Revolutions in Twentieth-Century Physics*. Cambridge University Press, 2013.

[53] A. Guerragio and P. Nastasi. *Italian Mathematics between the Two World Wars*. Birkhäser Verlag, 2000.

[54] P. M. Haas. Introduction: epistemic communities and international policy coordination. *International Organization*, 46(1):1–35, 1992.

[55] J Habermas. *Knowledge and Human Interests*. Beacon Press, 1972.

[56] E. Hecht. How Einstein confirmed $E_0 = mc^2$. *American Journal of Physics*, 79(6):591–600, 2011.

This paper asserts that although Albert Einstein demonstrated repeatedly the validity of the mass-energy equivalence formula, he never, in fact, managed to mathematically prove it from some fundamental principles. This situation, according to the author, occurs also with Newton's second law of motion.

[57] M. Hoare, S. Benford, R. Jones, and N. Milic-Frayling. Coming in from the margins: amateur musicians in the online age. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1295–1304, 2014.

This paper focuses on how online distribution and promotion is transforming the world of the amateur and especially of the amateur musician. The authors present, in particular, a study of how a community of amateur musicians is using online distribution channels and social media to promote their music, how they employ digital but also material practices to distribute this music to small fan bases, locally and internationally, and how they wrestle with diverse online services to promote themselves. This study was conducted through interviews, and revealed that amateur musicians are, in fact, serious about their music and are an important class of users quite distinct from the professionals as well as from the novices and hobbyists.

[58] R. Ihaka and R. Gentleman. R: A language for data analysis and graphics. *Journal of Computational and Graphical Statistics*, 5(3):299–314, 1996.

This is the paper that made the R programming language known to the scientific community.

[59] S. J. Jackson, D. Ribes, A. Buyuktur, and G. C. Bowker. Collaborative rhythm: temporal dissonance and alignment in collaborative scientific work. In *Proceedings of the ACM 2011 conference on Computer supported cooperative work*, pages 245–254, 2011.

This paper asserts that joint scientific work is organized around four separate registers, or *rhythms*: organisational; infrastructural; biographical; and phenomenal. Organisational rhythms are related to temporal structures embedded in the organizations and institutions, such as local academic calendars, deadlines and review processes, or submission and other important event dates. Infrastructural rhythms are dictated by the extensive assemblage of equipment and infrastructure, such as the time of software upgrades, hardware replacement schedules, and the time it takes to build adoption of a new protocol, instrument or standard within a research group or across a field, or the time it takes for a spacecraft to get to Mars. Biographical rhythms have to do with the life choices and circumstances of scientific workers themselves, such as timing of children, illness and recovery, divorces and new relationships, births and deaths.

Phenomenal rhythms are related to the rhythms emanating from the objects of study themselves: in the cases of ecology and earth studies, for example, there are the seasonal rhythms of animals mating, snow melting, and vegetation growing, budding, maturing, and declining according to distinctive and sometimes inconvenient patterns.

[60] M. Jirotka, C. L. Lee, and G. M. Olson. Supporting scientific collaboration: Methods, tools and concepts. *Computer Supported Cooperative Work*, 22(4):667–715, 2013.

[61] P. Johnson, J. May, and H. Johnosn. Introduction to multiple and collaborative tasks. *ACM Transactions on Computer-Human Interaction*, 10(4):277–280, 2003.

This paper is an introductory article to a special issue dealing with challenges to HCI with respect to multiple and collaborative tasks. Multiple tasks are frequently carried out in parallel, with various levels of interleaving and interruption, and people perform the same task with the same technological support in different ways, depending upon their social context, and the degree of cooperation and collaboration. Moreover collaboration introduces overheads for managing the collaboration, which have to be traded off against gains in efficiency of the task itself. The articles that follow this introcduction, according to the editors, attempt to promote multi-disciplinary research for HCI, bridging the boundaries of sociology, psychology and computer science.

[62] J. S. Katz and B. R. Martin. What is reasearch collaboration? *Research Policy*, 26(1):1–18, 1997.

This paper attempts to formulate a definition of research collaboration challenging the following established assumptions: that the concept of 'research collaboration' is well understood; that we are dealing with essentially the same phenomenon, whether we are concerned with collaboration between individuals, groups, institutions, sectors or nations; that we can in some way measure the level of collaboration and hence determine whether or not it is changing as a result of a particular policy; that more collaboration is actually better, whether for the advancement of knowledge or for exploiting the results of our scientific endeavours more effectively. The authors conclude that hat constitutes a collaboration therefore varies across institutions, fields, sectors and countries, and very probably changes over time as well. Among the factors which motivate collaboration the authors cite: funding agencies' need to save money, the growing availability and falling (real) cost of transport and communication; the desire for intellectual interactions with other scientists; the need for a division of labour in more specialised or capital-intensive areas of science; the requirements of interdisciplinary research; and government encouragement of international and cross-sectoral collaboration.

[63] J. Keller. Beyond Facebook: How the world's mathematicians organize online. *The Atlantic*, 28 September 2010.

This is one of the earliest newspaper articles on MathOverflow.

[64] A. Kittur, J. V. Nickerson, M. Bernstein, E. Gerber, A. Shaw, J. Zimmerman, M. Lease, and J. Horton. The future of crowd work. In *Proceedings of the 2013 conference on Computer supported cooperative work*, pages 1301–1318, 2013.

This paper examines major challenges so that future crowdwork will become complex, collaborative, and sustainable. Future stakeholders of crowdwork, according to the authors, need to focus on 12 organisational research challenges: workflow, task assignment, hierarchy, real-time response, synchronous collaboration, quality control, crowds guiding AIs, AIs guiding crowds, platforms, job design, reputation, and motivation.

[65] M. J. Klein. Max planck and the beginnings of the quantum theory. *Archive for History of Exact Sciences*, 1(5):459–479, 12 June 1962.

[66] D. Kleppner and R. Jackiw. One hundred years of quantum physics. *Science*, 289(5481):893–898, 2000.

[67] A. Koyré. An unpublished letter of Robert Hooke to Isaac Newton. *Isis*, 43(4):312–337, 1952.

[68] H. Kragh. The names of physics: plasma, fission, photon. *European Physical Journal H*, 39(3):263–281, 2014.

[69] L Krieger. Stanford and UC Berkeley create massively collaborative math. *San Jose Mercury News*, 8 August 2010.

One of the earliest newspaper articles on MathOverflow.

[70] I. Lakatos. *Proofs and Refutations: The Logic of Mathematical Discovery.* Cambridge University Press, 1977.

[71] P. Landri. The paragmatics of passion: A sociology of attachment to mathematics. *Organization*, 14(3):413–435, 2007.

This paper introduces a sociology of passion and attempts to connect it to scientific practice, and, in particular, to understand which practices sustain and nurture passion, preparing for it to emerge within an epistemic community. The author views mathematics as a *situated practice*, that is, taking place in schools of mathematics within epistemic communities (analysis, algebra, geometry, etc.), where it actively contributes to the making of mathematical *objects of knowledge*; additionally, he defines passion as a *collective attachment* to an epistemic community. The paper draws on a research program on Renato Caccioppoli, a famous Italian mathematician, and the group of mathematicians he used to work with. The author's research followed a qualitative methodology and focused on interviews and documents (letters, books, movies analysis, newspapers' articles) on historical and contemporary accounts of schools of mathematics and epistemic communities. The following practices were identified as the pragmatics of passion, i.e. the set of situated practices that sustains, supports and nurtures collective scientific passion: celebrating talent; writing argumentative papers; construction of the beauty of mathematical objects; distribution of competencies; and memory work.

[72] W. Leeds-Hurwitz. Social construction of reality. In S. Littlejohn and K. Foss, editors, *Encyclopedia of Communication Theory*, pages 891–894. SAGE Publications, 2009.

[73] L. Leydesdorff and C. S. Wagner. International collaboration in science and the formation of a core group. *Journal of Informetrics*, 2(4):317–325, 2008.

This paper suggests that international collaboration in science, as measured by co-authorship, can be considered as a communications network that is different from national systems and has its own internal dynamics; that is, it shares features with other complex adaptive systems whose order arises from the interactions of hundreds of agents pursuing self-interested strategies. During the 1990s, according to the authors, the "eco-system" was disturbed by changes in the political system such as the fall of the Soviet Union and the reunification of Germany, and during the period 2000–2005 the network of global collaborations appears, in the authors' opinion, to have reinforced the formation of a core group of fourteen most cooperative countries. The paper concludes that the order arises from rules embedded at the level of the researchers themselves, and self-organizes through collective action.

[74] B. Macfarlane and M. Cheng. Communism, universalism and disinterestedness: Re-examining contemporary support among academics for Merton's scientific norms. *Journal of Academic Ethics*, 6(1):67–78, 2008.

This paper examines whether there is empirical data supporting the adherence of modern scientists to three of the Mertonian norms of scientific ethos: communism, universalism, and disinterestedness. The authors conducted a web-based survey which elicited responses to a series of value statements and were analysed using the weighted average method and through cross-tabulation. The authors find strong support for communism as an academic norm defined in relation to sharing research results and teaching materials as opposed to protecting intellectual copyright and withholding accessi, but more limited support for universalism as defined by the belief that academic knowledge should transcend national, political, or religious boundaries. Disinterestedness, as defined in terms of personal detachment from truth claims, was found to be least popular contemporary academic norm, and the authors connect this finding with the high impact of a performative culturewhich is linked to the need for a large number of academics to align their research interests with funding opportunities. The authors conclude by proposing an alternate set of contemporary academic norms: capitalism, as a belief in maximising individual financial return on academic endeavour in a market economy; particularism, that knowledge is individually constructed on the basis of social experiences and political forces; and interestedness, closely related to the belief that academic enquiry can never be a value-free, dispassionate analysis of the observed 'facts'.

[75] D. MacKenzie. Statistical theory and social interests: A case-study. *Social Studies of Science*, 8(1):35–83, 1978.

This paper examines the controversy that took place between 1900 and 1914 about how best to measure statistical association of categorical variables and is based on archival research. Karl Pearson, one of the founders of he emerging community of mathematical statisticians in Britain, and George Udny Yule, his best-known pupil, found themselves opposed to each other in an increasingly acrimonious debate. The underlying basis of this debate, according to the author, could be locationg on conflicting *social interests*. The author defines *cognitive interests* as referring to those aspects of the actual or potential scientific applications of theories which 'feed back' into theoretical development by structuring scientists' construction and judgment of theories. The natural sciences typically embody cognitive interests in technical prediction and control. In providing measures of association, both Pearson and Yule were attempting to extend the scope of statistical analysis into a field where no reliable techniques of inference were available. Pearson's approach was structured by the analogy between the association of nominal variables and correlation employed as a tool for interval-level prediction. Yule's methods, on the other hand, were structured by a cognitive interest in prediction using nominal data as phenomena in their own right; the nominal/interval analogy had for him no direct force. Their concepts of 'measuring association', in the author's opinion, were different: for Pearson it meant seeking to estimate an underlying correlation; for Yule, seeking in a looser sense to measure the dependence of the given nominal data. Pearson's eugenically-oriented research programme was one in which the theories of regression,correlation and association played an important part. Yule, on the other hand, had no commitment to eugenics; although Yule's early statistical work was pauperism, considered a symptom of hereditary degeneracy by eugenics, he concentrated on the way administrative reforms, notably the abolition of out relief, reduced the observed rate of pauperism. The author suggests that two distinct constellations of interests could be seen in the British intelligentsia in the Victorian and Edwardian period. One was grounded in the situation of those professional occupations that were growing in importance with modernization: it found expression in technocratic ideologies such as Fabianism, and in the eugenics movement; the other was grounded in the situation of those disparate members of the traditional elite (for example, downwardly-mobile offspring), to whom modernization posed a threat: this constellation of interests found expression in various forms of conservatism, but not in scientistic ideologies such as eugenics.

[76] D. MacKenzie. Negotiating arithmetic, constructing proof: The sociology of mathematics and information technology. *Social Studies of Science*, 23(1):37–65, 1993.

This paper focuses on floating-point arithmetic, as performed by computers and advanced digital calculators. The author asserts that different computer arithmetics have been proposed, and the nearest approximation to a consensual computer arithmetic, the Institute of Electrical and Electronics Engineers' standard for floating-point arithmetic, had to be negotiated, rather than deduced from existing human arithmetic. A second theme the paper focuses on, is mathematical proof of the correctness of programs and hardware designs demanded for systems crucial to safety or security. The author mentions the case of the VIPER microprocessor as an instance that formal proof in computer systems is, in fact, much more controversial than floating-point arithmetic. The VIPER microprocessor was funded by the UK Ministry of Defence, was intended for use in safety-critical systems. When the VIPER was commercialised the High Court was almost called upon in order to decide on whether the formal proof behind VIPER was indeed a proof or not.

[77] D. MacKenzie. Slaying the Kraken: The sociohistory of a mathematical proof. *Social Studies of Science*, 29(1):7–60, 1999.

This paper chronicles the four-colour conjecture, the first attempts at a mathematical proof of it, and the computerized version of the proof in 1976. A debate, then, emerged as to whether the computerized version was a mathematical proof proper or not. Finally the computer-assisted proof gained acceptance from a great part of mathematicians in the community, although a minority still held that it was not a mathematical proof, but the debate was never resolved: published discussion simply petered out, as scientific interest moved on to other topics.

[78] D. MacKenzie. *Mechanizing Proof: Computing, Risk, and Trust.* The MIT Press, 2001.

[79] D. MacKenzie. Computers and the sociology of mathematical proof. In R. Hersch, editor, *18 Unconventional Essays on the Nature of Mathematics*, pages 128–146. Springer, 2006.

In this article proofs are classified as proofs *about* computers, and proofs *using* computers. This classification is sociological, in the sense that, the demonstration of a proof can be convicing to some scientific quarters, while unconvincing to other ones. Proofs *about* computers are related to the practical limitations of exhaustive software testing. In commercial computing, empirical testing, no matter how imperfect, is considered an inescapable necessity. In academic computing, on the contrary, software verification with mathematical theoretical models, that covers all possible cases, is deemed irreplaceable. Proofs *using* computers, on the other hand, have to do with (machine) proof checkers, and automated theorem provers: proofs made by hand, according to the mainstream opinion in the field of computer science, are of limited use. The author, then, distinguishes between formal proof, and rigorous argument. A formal proof is a finite sequence of formulae produced by mechanised inference rules. Rigorous arguments, on the other hand are are all those arguments accepted by mathematicians as mathematical proofs, but are not necessary formal proofs. In other words, formal proofs can be machine-produced, while rigorous arguments are human-produced, but not necessarily machine-produced, and this is an instance of a disciplinary divide.

[80] M. Mair, C. Greiffenhagen, and W.W. Sharrock. Statistical practice: putting society on display. *Theory, Culture & Society*, Published online before print, January 6, 2015.

The paper deals with how statistical practice is a negotiation between statisticians and the users of statistical methods and results. The authors focus especially on Bayesian statistics, which locates probability to the *beliefs* of statisticians, in contradistinction to the *frequentist* interpretation of probability as an *objective* property of "chance set-ups." The users of statistical methods and results have an important role, as well. Since statistical research involves "efforts to catch meaning," instead of "evacuating" it, the models, as communicators of meaning, "have to do the talking" with the users of statistical research. When the models become understandable to the users, then, automatically, they become successful.

[81] V. Mamadouh. Grid-group cultural theory: an introduction. *GeoJournal*, 47(3):395–409, 1999.

[82] U. Martin. Computational logic and the social. *Journal of Logic and Computation*. Advance Access published June 16, 2014.

[83] U. Martin. Stumbling around in the dark: lessons from everyday mathematics. In A.P. Felty and A. Middeldorp, editors, *Automated Deduction – CADE-25*, volume 9195 of *Lecture Notes in Computer Science*. Springer, 2015.

This paper deals with how software technology is being used in the everyday practice of mathematics. The author examines four cases. The first is the *polymath* project: a specially organised blog with important, and difficult to solve, mathematical problems, set up initially by the Fields medallist Timothy Gowers. The result was a journal collective publication. Later on, another key figure for later *polymaths* joined the blog, the Fields medallist Terence Tao. The blog moderators encouraged participation by proposing ideas of solutions, or pointing to errors in a proposed solution step. In later *polymaths* a blog leader occasionally summarised together discussion threads and sub-threads, and created new threads. One major principle behind the design of the blog was not to intimidate new participants, or hamper existing ones. There was a widespread enthusiasm among the participants due to the high-profile problems to be solved, and the sense of participation in solving it. There were concerns as to the time commitment to the project, as well as to the public visibility of errors, both especially for new researchers not established in their fields. The second case the author examines are the *minipolymath* series: series of problems implementing the *polymath* model drawn from the International Mathematical Olympiad. One of these problems, posted at 8am on July 19th, 2011, had been solved by 9.50pm. The author developed a typology of comments on the blog: concept, example, conjecture, proof, example & conjecture, other. By far the most instrumental in the discussion threads were the *examples.* The third case of computer software use in mathematics everyday research that the author examines is the *mathoverflow* forum. In *mathoverflow* users post questions on research-level mathematics, and they receive answers from other users. This forum uses, in addition, a reputation system based on ratings from the users. The author, after studying the "group theory" questions developed a typology of questions: conjecture, what is this, example, formula, different proof, reference, perplexed, motivation, other. About 90% of the questions received a response. The last case the author examines is the GAP open-source software: a computer algebra system supporting research and teaching. The author examined 49 papers in google scholar citing GAP Version 4.7.5, 2014. After eliminating a number of items, such as duplicates or slides, the remaining 37 were subsumed under the following main groupings: explicit computation as part of a proof; examples and counter-examples; new algorithms; computation with explicit primes; applications in other fields; other. The author, in the end, draws some interesting conclusions: conjectures, concepts and examples play a key role in the creation of a proof; examples are used in a great variety of ways; leadership plays an important role in recruiting and channelling the labour of the crowd; and, finally, innovation is deeply affected by institutional factors.

[84] U. Martin and A. Pease. Seventy four minutes of mathematics: An analysis of the third Mini-Polymath project. In A. Pease and B. Larvor, editors, *Proceedings of AISB/IACAP 2012, Symposium on Mathematical Practice and Cognition II.* The Society for the Study of Artificial Intelligence and Simulation of Behaviour, 2012.

This paper examines in detail the mini-polymath project No.3 held in July 2011. The project was hosted on three sites: a research thread, where the problem solving was happening; a discussion thread, where a meta-discussion about the project took place; and a wikipage, which would host a summary and a discussion of the problem. From its official announcement the problem was solved within 74 minutes. The authors developed a typology of comments: concept, example, conjecture, proof, and other.

By analyzing the various threads of attempted proof that developed until the final solution of the problem, they found that their analyses enriched the Polya and Lakatos's heuristic theoretical approaches. In the final section of the paper the authors propose to take into serious consideration the Turing test: if we want to develop machines that participate in an online polymath project and give off a sense of being human, we should should start analyzing automated proof in the same way as the typology of comments found in the polymath and mini-polymath projects.

[85] U. Martin and A Pease. Mathematical practice, crowdsourcing, and social machines. In J. Carette, D. Aspinall, C. Lange, and W. Sojka, P. Windsteiger, editors, *Intelligent Computer Mathematics*. Springer, 2013.

The paper identifies a new (scientific) paradigm in computer science: *social (computing) machines*. Social machines where first formulated by Berners-Lee who envisioned human creativity assisted by machines taking up the administrative part. The main examples cited in the case of mathematics are *polymath*, and *mathoverflow*. Polymath is an online project, in which a difficult mathematical problem is proposed online, and anyone with some good enough mathematical background can post suggested solutions, or improvements of suggested solutions. Mathoverflow, on the other hand, is an online platform where one can post questions, and receive answers from other members.The postings are considered as evidence of informal processes in a mathematical proof which are, in general, difficult to document in normal circumstances. Each posting then is analyzed based on Polya's and Lakatos's theories of mathematical proof. Mathoverflow deals with existing concepts in mathematics, and the questions posted were identified to be mainly of three types: conjectures, what-is-this questions, and examples. Polymath, on the other hand, deals with open conjectures. Then the authors focus on *minipolymaths* polymaths proposed in Olympiads which deal with solving problems deemed solvable with no need to use advanced mathematics. The main activity in one mini-polymath was classified into five categories: example, conjecture, proof, concept, other. Then the paper briefly examines other aspects of polymath and overflow, such as the presentation interface, or reputation ratings among the users. Finally the authors connect online collaborative projects of mathematics with the more broader context of social machines, mentioning, among others, design of social computations, accountability, provenance and trust, and others.

[86] U. Martin and A. Pease. Hardy, Littlewood, and *polymath*. In E. Davis and P.J Davis, editors, *Mathematics, Substance and Surmise: Views on the Meaning and Ontology of Mathematics*. Springer, 2016.

This paper follows a comparative view between polymath and Hardy and Littlewood's collaboration: their collaboration was legendary and they published both about 100 papers. They were both active as professional mathematicians, both in teaching classes in the university, being presidents in the London Mathematical Society, as well as organising meetings among mathematicians. They both viewed collaboration as something important in their professional lives, especially Hardy whose published special articles on collaboration and teaching. Then the paper explains their collaboration in more detail, describing the practicalities of the matter such as paper sheets to write, or rules of answering to suggested solutions. Then the authors narrate the start of the polymath project. Tim Gowers in January after an initial blog question on the possibility of collaborative mathematics, started officially the polymath project by posting a problem. After 7 weeks the problem was solved and the result was published in a journal. By 2015 nine polymaths were completed and mini-polymaths for mathematical Olympiads were organised in the same spirit. The authors focused their attention on polymath8, which was split itno polymath8a and polymath 8b. Both polymath8a and polymath8b were published in the arXiv files. One concern for the organisers was to attract people and not intimidate them by expanding too much the scope of the project. There was a shared enthusiasm. A problem that arose was that of the participants' time commitment, as well as the pace of progress which was too fast for some. This is considered in the paper as a special case of crowdsourcing, with the crowd being rather specialized in the sense that they had to know mathematics of a more advanced level.

[87] K. Marx. *Capital: A Critique of Political Economy. Vol. 1.* Penguin Books & New Left Review, 1976.

[88] T. McCarthy. *The Critical Theory of Jürgen Habermas.* The MIT Press, 1978.

[89] R. K. Merton. *The Sociology of Science: Theoretical and Empirical Investigations.* The University of Chicago Press, 1973.

[90] D. Mullins, N. Rummel, and H. Spada. Are two heads always better than one? Differential effects of collaboration on students' computer-supported learning in mathematics. *Computer-Supported Collaborative Learning*, 6(3):421–443, 2011.

This paper focuses on what kind of impact can have the type of knowledge presented during collaborative class instruction on learning. The authors distinguish between conceptual and procedural collaboration. In conceptual collaboration the learning outcomes are more increaed, since the students offer mutual elaborations and explanations. In procedural class collaboration, on the other hand, the authors observed a division of labour between the students, which reduced the opportunities for practice, which lead to ineffective learnig behaviour.

[91] D. Murray-Rust, J. Corneli, A. Pease, U. Martin, and M. Snaith. Synchronised multi-perspective analysis of online mathematical argument. In S. Jackson, D. Mohammed, L. Bermejo-Luque, and S. Oswald, editors,

Proceedings of 1st European Conference on Argumentation: Argumentation and Reasoned Action, 2015. To appear.

[92] N.F. Noy, J. Mortensen, M.A. Musen, and P.R. Alexander. Mechanical turk as an ontology engineer? Using microtasks as a component of an ontology-enineering workflow. In *WebSci '13 – Proceedings of the 5th Annual ACM Web Science Conference*, pages 262–271. Association for Computing Machinery, 2013.

This paper proposes the use of the Amazon Mechanical Turkers as ontology engineers in the evaluation and verification of ontologies. On particulaariousr tasks the authors found that the performance of the turkers were comparable to the performance of undergradutate students in a formal study, achived accuracy as high as 90% in verifying statements from common sense ontologies, and answered correctly up to 81% in domain-specific ontologies. As long as there are some qualification questions involved, to filter out spammers, and turkers unable to answer the particular questions of the ontology under construction, as well as to train and familirise the turkers with the tasks, nad as long as the questions are formulated in a simplified format, mechanical turkers can be very a very useful, as well as a financially feasible way to build a large ontology.

[93] G. Oleksik, N. Milic-Frayling, and R. Jones. Study of electronic lab notebook design and practices that emerged in a collaborative scientific environment. In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing*, pages 120–133, 2014.

This paper deals with *electronic lab notebook* (ELN) design, used for scientific record keeping, that emerged as scientists at the Nanophotonics Research Centre (NRC) appropriated commercial software and adapted it to their work, creating, thus, and using ELNs in their everyday work. NRC scientists, in particular, adopted tablet PCs and generic, commercial, off-the-shelf software for note taking and turned them into ELNs. By closely following scientists' activities, the authors analyzed the use of ELNs for conducting experiments, processing data, sharing insights, and coordinating work. It was found that the flexibility of digital media enables personalization and optimal support for needs of individual scientists while the conformity and consistency in the scientific record increases the capacity for sharing and leveraging each other's work. Additionally, most of the requirements related to interlinking, structuring, and aggregation of data, accessing and sharing of content, browsing, and history search were achieved through the adopted ELN.

[94] D. H. J. Polymath. The "Bounded Gaps between Primes" Polymath project: A retrospective analysis. *EMS Newsletter December 2014*, pages 13–23.

[95] D. H. J. Polymath. A new proof of the density Hales-Jewett theorem. *Annals of Mathematics*, 175(3):1283–1327, 2012.

[96] D. Robertson. A lightweight coordination calculus for agent systems. In J. Leite, A. Omicini, P. Torroni, and P. Yonur, editors, *Declarative Agent Languages and Technologies II*, volume 3476 of *Lecture Notes in Computer Science*, pages 183–197. 2005.

[97] D. Robertson. A lightweight coordination calculus for agent systems: Retrospective and prospective. In C. Sakama, S. Sardina, W. Vasconcelos, and M. Winikoff, editors, *Declarative Agent Languages and Technologies IX*, volume 7169 of *Lecture Notes in Computer Science*, pages 84–89. 2012.

[98] C. Rosental. Certifying knowledge: The sociology of a logical theorem in artificial intelligence. *American Sociological Review*, 68(4):623–644, 2003.

This paper argues that logic itself is also a proper object of sociological inquiry and ethnographic observation, and a privileged source of data for exploring the material and social forms of intellectual work, such as the building of credibility. It studies a theorem in logic, Elkan's theorem, that was first presented in a context of strong competition between proponents of various approaches to artificial intelligence. Representations of Elkan's theorem were primarily constituted during interactions between readers and texts. The readings it did receive were often rapid and partial, when they existed at all. According to the author, simple agreement on the question of the correctness of Elkan's proof was particularly difficult to obtain because his texts were not read in the same way, despite the use of shared symbolic language. The fact that some of the debates took place in an electronic forum certainly contributed to this interplay. The author bases his assertions on ethnographic observations, interviews, and textual analysis.

[99] C. Rosental. *Weaving Self-Evidence: A Sociology of Logic*. Princeton University Press, 2008.

[100] C. Rosental. Toward a sociology of public demonstrations. *Sociological Theory*, 31(4):343–365, 2013.

[101] S. Schwartzman. Legitimacy, controversies and translation in public statistics: The experience of the brazilian institute of geography and statistics. *Science, Technology & Society*, 4(1):1–34, 1999.

This paper focuses on "public," or "official statistics:" statistics produced by government statistical agencies which are both research centres, and public institutions. In the author's opinion this dual nature of public statistics breaks down the dividing lines between producers and users of scientific knowledge. On one hand, producers of knowledge are being evaluated more closely by the worthiness of the products they provide, and travel through the whole chain of translations, from data production to product dissemination. On the other hand, the informed user is much more able to revise and reorganise the information he receives for his personal use than in the past. The author agues, in addition, that the statistical offices must also be able to travel in the opposite direction in the translation process, from products to production, making more open and explicit the technical and methodological choices that are part of the daily life of any research institution. The role of the translator, that arises as a result, is not to make sure that everybody uses the term in the same way the statistician does, but to build bridges and help each to understand the way the word is used by others.

[102] A. Soifer. Ramsey theory before Ramsey, prehistory and early history: An essay in 13 parts. In A. Soifer, editor, *Ramsey Theory: Yesterday, Today, and Tomorrow*, Progress in Mathematics, pages 1–26. Birkhuser Boston, 2011.

[103] J. V. Spickard. A guide to Mary Douglas's three versions of grid/group theory. *Sociological Analysis*, 50(2):151–170, 1989.

[104] S. L. Star. Simplification in scientific work: An example from neuroscience research. *Social Studies of Science*, 13(2):205–228, 1983.

[105] S. L. Star. Scientific work and uncertainty. *Social Studies Of Science*, 15(3):391–427, 1985.

[106] S. L. Star. The ethnography of infrastructure. *American Behavioral Scientist*, 43(3):377–391, 1999.

[107] S. L. Star. This is not a boundary object: Reflections on the origin of a concept. *Science, Technology, & Human Values*, 35(5):601–617, 2010.

[108] S. L. Star and J. R. Griesemer. Institutional ecology, 'translations' and boundary objects: Amateurs and professionals in Berkeley's museum of vertebrate zoology. *Social Studies of Science*, 19(3):387–420, 1989.

[109] A. Steingart. A group theory of group theory: Collaborative mathematics and the 'uninvention' of a 1000-page proof. *Social Studies of Science*, 42(2):185–213, 2012.

This paper focuses on the proof of the theorem on the classification of the finite simple groups. The history of the classification proof spans more than three decades, it involved more than a hundred mathematicians, and when the theorem was officially declared proved there had been already published around 200 to 500 research articles. The author promotes the idea that making sense in a community of practitioners is embedded in that particular community and cannot be separated from a wider body of literature this community has produced. She suggests that a mathematical proof is a collective effort during which every participant has an individual, and local, view of the proof but no participant has has an all-encompassing, and global, perspective of the whole project. Moreover she traces the history of the classification theorem in the social and political context of 20th century US history.

[110] S. B. Steinhardt and J. J. Jackson. Reconciling rhythms: Plans and temporal alignment in collaborative scientific work. In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing*, 2014.

This paper connects *rhytms*, i.e. the temporal patterns and regularities that stem from and in turn help to frame and support ongoing forms of action in the worldi, with *plans* as important sites for unearthing practices of temporal alignment and identifying discordant rhythms. The authors focus, in particular, on intersections between plans and rythms at two crucial moments: formation, as *plans-in-the-making*, and enactment, as *plans-in-action*. This is an ethnographic study of Ocean Observatories Initiative, a US-based, large-scale, and long-term collaborative research program.

[111] Y.R. Tauschik and J. W. Pennebaker. Predicting the perceived quality of online mathematics contributions from users' reputations. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1885–1888. Association for Computing Machinery, 2011.

This paper examines to what extent reputation in MathOverflow is related to the perceived quality of contributions. Perceive quality of contributions by a user was measured by the rated quality of his or her answers and questions by other users. Four measures of reputation were used: *offline reputation* measured by the number of publications each contributor had; *MathOverflow points*, that is, the rating a contributor received based on the past votes by other contributors; *authoritativenes*, based on the confidence a contributor answered a question; *social connectedness*, found by network analysis of past questions and answers. In general, a low to moderate correlation was found among these measures of reputations, and the authors conclude that these most probably are different types of reputation. The strongest predictors of perceived quality were offline reputation and MathOverflow points. The final aim of this paper was how to optimize the emphasis on reputation.

[112] Y. R. Tausczik, A. Kittur, and R. E. Kraut. Collaborative problem solving: a study of MathOverflow. In *Proceedings of the 17th ACM Conference on Computer Supported Cooperative Work and Social Computing*, pages 355–367. Association for Computing Machinery, 2014.

[113] Y. R. Tausczik and J. W. Pennebaker. Participation in an online mathematics community: Differentiating motivations to add. In *Proceedings of the ACM 2012 conference on Computer Supported Cooperative Work*, pages 207–216. Association for Computing Machinery, 2012.

This paper deals with MathOverflow, a questions and answers site, designed for research level mathematics. The authors used an inventory of six motivators: getting information; giving information; reputation building; relationship development; recreation; self-discovery. This inventory was taken from previous studies. Using statistical analysis the authors found that getting information, reputation building, and relationship development were strongly correlated, while self discovery was found to be irrelevant to the MathOverflow community. They explain this high correlation by observing that the first three motivators are necessary components in a professional mathematician's career. Moreover, reputation building, in particular, was found to encourage contributions to the MathOverflow community.

[114] S. Tippman. Programming tools: Adventures with R. *Nature*, 517(7532):109–110, 2014.

[115] M. Tomassini and L. Luthi. Empirical analysis of the evolution of a scientific collaboration network. *Physica A: Statistical Mechanics and its Applications*, 385(2):750–764, 2007.

[116] M. Vähämaa. Groups as epistemic communities: Social forces and affect as antecedents to knowledge. *Social Epistemology*, 27(1):3–20, 2013.

[117] A. Vance. Data analysts captivated by R's power. *The New York Times*, 6 January 2009.

[118] T. Velden. Explaining field differences in openness and sharing in scientific communities. In *Proceedings of the 2013 conference on Computer supported cooperative work*, pages 445–458, 2013.

This paper explores the tension between cooperation and openness and competition for prority and secrecy with respect to scientific knowledge as played out in two scientific specialties: experimental physics and synthetic chemistry. The author employs ethnographic methods, and, in particular, semi-structured interviews. The main finding, most probably, is that the synthetic chemists rely on a competition strategy that maintains secrecy around practical and conceptual details of syntheses, whereas the experimental physicists pursue a cooperative competition strategy that invests into the advancement and strength of the community as a whole.

[119] T. Velden, E. I. Bietz, M. J. Diamant, J. D. Herbslep, J. Howison, and S. B. Steinhardt. Sharing, re-use and circulation of resources in cooperative scientific work. In *Proceedings of the companion publication of the 17th ACM conference on Computer supported cooperative work & social computing*, pages 347–350, 2014.

This is a summary of a workshop on sharing and reuse of scientific resources in cooperative scientific work. The organisers discuss a variety of resources in the workshop, such as data, software, materials and specimens, workflows, technical know-how, clinical and laboratory protocols, and algorithms.

[120] A. Vucinich. *Empire of Knowledge: The Academy of Sciences of the USSR (1917–1970).* University of California Press, 1984.

[121] S. Weinberg. *The Quantum Theory of Fields, Vol. I: Foundations.* Cambridge University Press, 1995.

[122] E. Welsh, M. Jirotka, and D. Gavaghan. Post-genomic science: cross-disciplinary and large-scale collaborative research and its organizational and technological challenges for the scientific research process. *Philosophical Transactions of the Royal Society A*, 364(1843):1533–1549, 2006.

This paper deals with "Big Science", a term which has been used to describe large-scale research which is often cross-disciplinary and multinational. According to the authors, biology is becoming "Big Biology:" its original disciplinary goal is turning from description and classification to determination of biological function. The paper draws on a large collaborative e-Science project, the Integrative Biology (IB) project, an international consortium of seven universities and one research institution with a mix of both theoretical and experimental groups who are collaborating at different levels, and who are drawn from a very wide range of disciplines (including computer science, mathematics, medical and software engineering, biophysics, biochemistry, physiology, genetics, molecular biology and several areas of clinical medicine). The primary aim of the IB project is the development of the IT or Grid infrastructure to support the entire research process, and to develop a virtual research environment, based on state-of-the-art Grid technologies. This paper seems to be more theoretical, rather, than empirical, and proposes, as part of a future research agenda, the conduct of more ethnographic research on "Big Science.".

[123] M. Willis, S. Sharma, J. Snyder, M. Brown, C. Østerlund, and S. Sawyer. Documents and distributed scientific collaboration. In *Proceedings of the companion publication of the 17th ACM conference on Computer supported cooperative work & social computing*, pages 257–260, 2014.

This paper focuses on the document infrastructures that scientists, from the social, behavioural, and economic disciplines, build in order to support their virtual organising and documenting practices. They used ethnographic research to answer their research questions, and, in particular, interviews.i one important dimension of document infrastructure that the authors present is the tool materiality: physical tools, such as fields notes, face-to-face meetings, whiteboard, paper notebook/journal; as well as digital tools, such as the R programming language, the Atlas.ti software package, Microsoft Word, Dropbox, Mendeley, Google Calendar, and Skype.

[124] P. Zhou and H. Tian. Funded collaboration research in mathematics in China. *Scientometrics*, 99(3):695–715, 2014.

[125] J. Ziman. *Real science: What it is, and what it means.* Cambridge University Press, 2000.