Collaborative Structures in WikiProjects: Wikipedia Users' Activity Case Study

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Abstract: The research presented in the article concerns the development of organizational and cooperation structures from interpersonal interactions in virtual communities sharing knowledge. It is assumed that the activity of communities functioning on the Internet reflects the organization of human communities in the offline space. The main aim of the research was to characterize the structures of cooperation groups that are formed around WikiProjects. The research question was: what is the structure of activity of Wikipedians in WikiProjects in chosen language versions of Wikipedia? The method used in the research is the content analysis method. The author calculated data thanks to the Wikipedia xTools. The numbers of participants involved in WikiProjects were analysed by referring to the Dunbar number concept and the cultural determinants of cooperation, thus referring to the masculinity index (MAS) according to Hofstede. Research has shown that WikiProject members show similarities to the layered community formation proposed by Dunbar. The sizes of groups of active editors are closer to these values. As the WikiProjects group grows, the ratio of declared participants to active participants decreases. The production of value in virtual communities, the ability to work together as a team in physical isolation, is becoming increasingly important. The results of the research may be significant to the knowledge management specialists and virtual communities practitioners.

Keywords: Dunbar's number, Collaboration in WikiProjects, Cultural dimensions, Knowledge management, Virtual communities

1. Introduction

Participation in the creation of a global knowledge exchange system by presenting one's intellectual skills is an attractive alternative activity for many people. Pro-social motives may create a sense of moral obligation to share knowledge for community development. By sharing knowledge with others, people fulfil their own altruistic needs while experiencing pleasure (Yu et al., 2010) and with the IT infrastructure in place, people are willing to share knowledge with others (Ruppel and Harrington, 2001). This is evidenced by the uninterrupted development of the global encyclopaedic project, namely, Wikipedia, for over 20 years. The spontaneous behaviour of individuals in editing activities leads to the formation of collaborative structures. Their form is difficult to predict. The foundations of the Wikimedia Movement, which unites Wikipedians, are freedom of expression, freedom to learn, social activities, and activities related to Wikimedia projects (‘Ruch Wikimedia’, 2021). In the view of the author, the phenomenon of Wikipedia is an interesting subject of research due to the spontaneously emerging structure of cooperation in the spirit of volunteering. Despite the lack of governance structures, the system works. On the one hand, the structure of the project is becoming increasingly hierarchical, but hierarchy is intertwined with horizontal structures (Arazy et al., 2018). It is indicated that its effectiveness in terms of durability and productivity is due to the fact of a kind of independence of the project's activists. The freedom to join and leave, with the effect of a high turnover of members, as has been written about by, among others (Chen et al., 2010) has not shaken the permanence of this structure.

WikiProjects are groups of Wikipedians working in teams to improve Wikipedia. WikiProjects may be dedicated by topic and coordinate a specific type of task (‘WikiProject’). The subject of the research undertaken by the author remains the collaborative structures of WikiProjects, with relation to the number of participants and their correspondence to Dunbar's number, as well as the cultural dimension of collaboration with relation to the Masculinity Index (MAS) according to Hofstede. The conclusions presented in this article are the result of an in-depth research process on WikiProjects that was commenced in 2022. The first stage of the research showed that according to the acquired data, WikiProjects show similarities to the layered community formation proposed by Dunbar (Kukowska, 2022). The second stage of the research involved updating the data and including a new indicator: the number of WikiProject members active in the last three months was extracted. Determining the number of active members with relation to the declared participation more accurately reflects the true picture of community structures and the level of cooperation in general terms.

2. Literature Review

The structural complexity of social systems determines the efficiency of the functioning of groups and individuals in social life. The structuring of groups, their stability and the dynamics of change within them have

certain social consequences. Regardless of the context of the groups' activities, micro-level processes merge into macro-level structures. The forces of attraction and disintegration, the cohesion of groups that consolidate cooperation, while also the formation of boundaries all remain the subject of research by representatives of various sciences (Dunbar and Sosis, 2018; Stadtfeld et al., 2020).

Dunbar in his research demonstrates that the layers that define the closeness of relationships in traditional hunter-gatherer communities of primitive tribes is also reflected in contemporary structures of interaction (Dunbar, 2010; Dunbar, 2014). Moreover, it matters little whether they are set in real or virtual space. Their foundation remains the networks of interaction that bind the links together. Social populations are characterised by a high degree of sustainability, although the size of these populations is of course variable. Every day we spend about 2 hours on social interactions. In addition, we spend nearly 50 minutes on interacting with the 5 closest people. These are usually the people we live with. Another layer is the 15 people with whom we are in direct or mediated contact through digital media and telephony. Those who do not belong to layer 5, receive approx. 20% of our attention. A further 35 people in layer 50 receive an average of 0.4% of our time each day. Nowadays, this can be applied to colleagues who are not part of our support group. For layer 150, one person receives enough attention to fill one actual appointment per year (Gamble et al., 2014). Ties in the subsequent layers vary in terms of their strength and quality (Dunbar, 2012; Skolik and Kukowska, 2022). The growth, or loss of members of a layer over time can lead to its disintegration. The numbers defining layers 50, 150 and 500 are the optimum points around which the population sizes oscillate. The greater the deviation, the greater the risk of disintegration of the community in question. Natural dividing points differentiate organisations in terms of their size, while representing optimal values of cohesion and relative stability over time (Dunbar and Sosis, 2018).

The social nature of human beings triggers the desire to create networks of relationships with qualitatively diverse ties. It seems that the size of the communities in which we operate may condition the tendency to seek mutual similarities. Simply belonging to a social collective can be an important tool for creating bonds. Sharing common traits, e.g., cultural identity, may be enough to induce a sense of closeness with a stranger. In the persistence of the different layers of the collective, homophily plays an important function, which Launay and Dunbar present from the perspective of innate tendencies towards social behaviour and group categorisation. Evolutionarily speaking, we may show a drive towards intimacy with certain communities or groups with which we identify with common labels, such as interests. The exclusivity of the group in question plays an important role in this regard (Launay and Dunbar, 2015).

Dunbar numbers referred to in algebraic analyses of group sizes by Kurokawa (Kurokawa, 2022). Kurokawa and Ihara prove that the evolution of cooperation becomes more likely as the size of groups increases, as long as the goods they produce are public goods. When goods are common goods, the evolution of cooperation is less likely as group size increases (Kurokawa and Ihara, 2017; Kurokawa, 2021). The characteristics of Wikipedia's functioning are part of the afore-mentioned conditions. Furthermore, large-scale collaboration may be explained by the direct reciprocity, which is found in WikiProjects.

The research addressed in the WikiProjects collaboration was conducted, among others, by Forte et al. (2012) based on the English version of Wikipedia. The authors demonstrated the validity of WikiProjects as groups to coordinate work in different forms of support. In addition to their commitment to creating and improving the thematic content posted, WikiProject members also support each other by, for example, providing places to find contributors. Solomon and Wash conducted an analysis of WikiProjects in the context of their development by referring to the concept of critical mass. They proved, among other things, that the collective contribution of small actions in the early stages of establishing a WikiProject is more valuable to its sustainability than the participation of advanced editors. In addition, building a large membership early on has a greater impact on future community activity than accumulating many contributions (Solomon and Wash, 2014).

Qin et al. measured the effectiveness of WikiProjects by the amount of work done by its members. This used comments on WikiProject discussion pages to identify communication networks. Using the social network theory, the authors examined the structural properties of these networks and concluded that the moderate level of connectivity and internal consistency of the communication network could positively influence the efficiency of the project. The same is true for the longer membership period at WikiProjects on average (Qin et al., 2015).

Online communities are subject to the same rules and norms as in the offline world. Thus, the analysis of these social structures provides valuable characterisations of the determinants of organisation in both spaces (Lu et

al., 2014; Vesa et al., 2017; Dunbar, 2021). Studies of virtual communities have shown that the increased turnover of participants may increase interest in these groups. Communities with a high turnover seem to be potentially more attractive and people are more likely to join them. Changes in the composition of members make interactions more dynamic, thus creating the impression of activity and commitment. This recovery catalyses the level of group participation (Dabbish et al., 2012). At the same time, it has been suggested that such communities may be more sustainable than communities with a relatively fixed membership (Farzan et al., 2011).

The issue of group cohesion in the dynamically changing membership of the Wikipedia community was addressed by Benkler. Horizontal structures are characteristic of Wikipedia's structure, but users are partly constrained by the rules adopted by the community. User contributions are controlled by those with greater authority. They are awarded to committed individuals who enjoy the trust of the community. The existence of procedures and inequalities of power allows for greater efficiency, thus maintaining quality and also maintaining consistency. This gives the site a better chance of survival (Benkler, 2006).

Knowledge sharing is influenced by psychological and organisational culture factors Yu et al. (2010). The motivation to work for the public good may therefore be fuelled or extinguished depending on the values embedded in a given culture. Research citing Hofstede's analysis of cultural dimensions in the context of cooperation and collaboration in Wikipedia was undertaken, among others, by Konieczny (2009). The author describes Wikipedia's decision-making processes by identifying the determinants of their control and relating them to the development of power in Wikipedia. Wikipedia's organisational culture is aligned with power distance, avoidance of uncertainty, while also individualism and collectivism. Hara et al. (2010) argued that the cultural dimensions according to Hofstede allow for the interpretation of differences between eastern and western Wikipedia. The polite behaviour of Eastern Wikipedians was explained by a greater respect for the hierarchical structure of society and a preference for teamwork. Western Wikipedia editors showed less power distance. Petrushyna et al. (2014) analysed European and Asian Wikipedias. User edits were compared to analyse differences in knowledge construction. Reference was made to the cultural dimensions according to Hofstede and Schwartz considering power distance, rootedness and egalitarianism of cultures. Samoilenko et al. (2016) used data on the co-occurrence of edits in different language versions of Wikipedia to explore cultural similarities. They concluded that the linguistic versions represent a common point of view when there are linguistic similarities. They explain the similarity of editorial interests by the number of bilingual people and the similarity of languages. It was discovered that cultural similarity as defined by dimensions according to Hofstede also applies to language. Usman and Yennita (2018) compared Italian and Indonesian Wikipedias with each other on the basis of a survey. Differences were shown regarding the relationship between members' interactions and community promotion and knowledge sharing. In the collectivist Indonesian culture, with greater interaction between members, there was more willingness to share knowledge and more promotion of one's own community. The interactions of members of the individualistic Italian culture did not promote community, and community participation did not ultimately lead to knowledge sharing.

Research on the diversity of Wikipedia's language version community due to IDV and MAS was also carried out by the author of this article together with her team. IDV has been shown to correlate with the activity (number of edits per page). In individualistic cultures, activities on Wikipedia are relatively less regulated, and user activity may indicate a greater boldness in editing others' content. In collectivist cultures, less assertiveness and a greater degree of regulation of actions can have an inhibiting effect on knowledge sharing (Kukowska and Skolik, 2021). With regard to the MAS research, a method of content analysis and analysis of the user activity log was adopted as follows: showing accolades, expressing thanks for contributions to Wikipedia content, manifesting one's gender as a Wikipedia user and participating in the Women in Red project. Cultures with a high MAS place high value on achievements and symbols of success, while nurturing relationships and appreciation, concern for individual needs and quality of life are closer to female cultures. According to the study, in cultures with lower MAS, there was more acknowledgement of contributions and cooperation, and gender marking was less important. In cultures with high MAS, decorations and symbols of success were important and more prominent (Karczewska and Kukowska, 2021).

3. Methodology

This study was based on a measurement of WikiProjects membership and user activity frequency. The original 2021/2022 study analysed the number of all enrolled participants in 55 randomised WikiProjects from a selection of 36 language versions of Wikipedia (Kukowska, 2022). The research was developed more

profoundly in late 2022 and early 2023. The criteria for selecting a particular language version in both parts of the study was to have a minimum of 300 active Wikipedians. As a result, the following language versions were selected: English, Arabic, Bengali, Bulgarian, Chinese, Croatian, Czech, Danish, Finnish, French, Greek, Hebrew, Spanish, Dutch, Indonesian, Japanese, Korean, Lithuanian, Malay, German, Norwegian, Persian, Polish, Portuguese, Russian, Romanian, Serbian, Slovak, Slovenian, Swedish, Thai, Turkish, Ukrainian, Hungarian, Vietnamese and Italian. WikiProjects were related to various scientific, cultural and technical issues.

The method used was to analyse the activity records of the number of WikiProjects participants. Participants were counted from WikiProjects pages or their subpages. A similar method of sampling the membership based on lists of enrolled participants on WikiProjects was used in the study of Chen et al. (2010), among others. The study looked at the impact of group diversity on the amount of work done and on drop-outs from WikiProjects. In this study, the tool (gadget) "Who is active?" was used to check the activity of Wikipedians in most language versions. This made it possible to measure the actual number of users involved in individual WikiProjects. The numbers of enrolled and recently active users (i.e., active in the last three months) differed significantly, especially in the large WikiProjects. The analysis of enrolled and active WikiProject users helped to reduce the number of WikiProjects surveyed compared to the first phase of the study. While 55 WikiProjects were studied in the first phase, there were 33 in the second phase.

The first hypothesis was adopted in order to contrast the result with the conclusions obtained from the first stage of the research, in which only declared participation in WikiProjects was considered. The variable of editing activity in the last 3 months was assumed to be a more precise indicator for measurement.

> *H1: WikiProjects as groups of Wikipedians show a similarity to the layering of communities according to Dunbar's 'rule of three' numbers (5, 15, 50, 150, 500). The sizes of groups of active users (editors in the last 3 months) are closer to these sizes than in the case of groups of declared users.*

The optimum number of a staff team, depending on the author, oscillates between three and 25 people, subject to slight modifications. Teams of 5 to 12 people are considered to be most effective (Robbins, 2002), or from 3 to 8 people (Gellert Manfred and Nowak Claus, 2008). Therefore, it is to be expected that small numbers of users will be the most active, regardless of the total number of users enrolled in WikiProjects. This justifies the second hypothesis.

> *H2: The ratio of active users to all WikiProject participants decreases as the number of WikiProjects participants increases.*

As MAS had previously been correlated with the activity of Wikipedians (Pfeil et al., 2006; Karczewska and Kukowska, 2021), it seems reasonable to also correlate it with the activity of WikiProjects participants. It is noteworthy that the focus of activity in Wikipedia is primarily on individual action, close to the cultural dimensions described as masculine.

> *H3: The ratio of active users per language version to the total number of users enrolled in projects correlates with a lower Masculinity Index (MAS).*

To verify the afore-mentioned hypotheses, statements of the following variables were prepared:

- The number of total participants enrolled in the individual WikiProjects in the language versions studied;
- The number of active WikiProjects participants in the last 3 months;
- The number of active WikiProject users as a proportion of the total number of enrolled users per language version;
- The number of WikiProject domains - the number of WikiProjects from the selected knowledge domains from a pool of 33 WikiProjects that occurred in the language version;
- MAS - masculinity versus femininity.

4. Research Results and Discussion

4.1 Size of the WikiProjects Editorial Community vs. Dunbar's Number

The study verified user activity through their participation in WikiProjects. For a better illustration and a certain level of smoothing of the high-variability data, the calculation used in the study involved the average measured for the k (equal to 5, 7, 9 and 11, respectively) of the consecutive user groups. The boundary value

for the test (for two mean values) is equal to 1.64. A very clear change in the number of participants is observed for WikiProjects with group sizes of 14-20 participants (depending on the length k from t∈{-1.80 : 5.88}, for each t p < 0.036), with their dynamics only decreasing around groups of 35. Another clear change starts for projects with 45 participants and slows down around 51 (for the 11-period series 69) participants with an incidental point of 59 participants. The last statistically significant decrease in active WikiProjects users in the studied range (up to 200 participants) includes counts for 112 participants. As k = 11, we still register significant drops in the number of participants at 120-129. However, we also observe statistically significant increases for 39 (t = 2.200; p = 0.014) participants, 52 (t = 2.157; p = 0.015) participants and 106 (t = 2.449; p = 0.007) participants. Each of these groups is significantly higher (in terms of numbers) relative to its neighbours (Fig. 1).

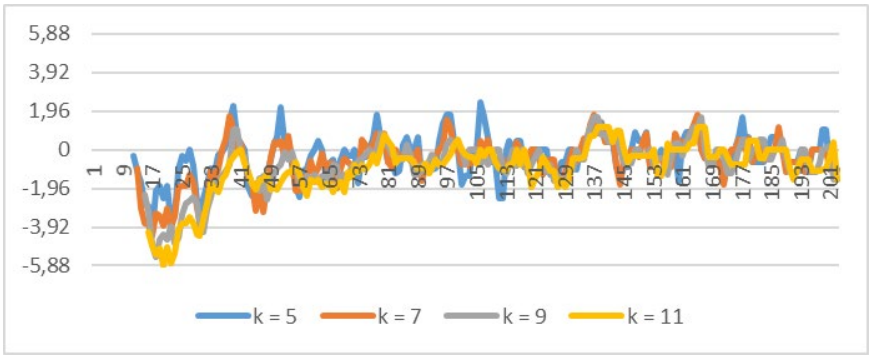

Figure 1: Average Test Values for the Number of WikiProjects with a Given Number of WikiProjects Participants Depending on Their Size

The results show significant changes in the number of WikiProject participants primarily in the layer referred to by Dunbar as the support group, whose numbers include approx. 15 people. These groups form strong bonds and in this group, the individual may receive support in daily activities. The next layer is the so-called good friends, whose numbers are approx. 50 people. In the case of WikiProject participants, the groups and the changes in them number counts between 35 and 45 are visible. The size of the groups of Wikipedians involved in WikiProjects show a similarity to the layering of communities according to Dunbar's number. It may therefore be assumed that H1 has been positively verified.

In H2, it was assumed that the ratio of active users with regard to all WikiProject participants decreases as the number of WikiProjects participants increases. There is a weak, yet statistically significant negative linear correlation (r = -0.097; p = 0.008) between the number of people subscribed to WikiProjects and the percentage of active users. As WikiProjects teams grow, the ratio of those enrolled with regard to active participants decreases.

4.2 Masculinity Index (MAS) of Individual Language Versions and the Activity of WikiProjects Participants

The study assumed that the ratio of active users in each language version with relation to the total number of users enrolled in the projects correlates with lower MAS according to Hofstede (H3). The results did not support (r_s = 0.115; t = 0.677; p = 0.503) this hypothesis (Fig. 2). This may be due to the fact that there is very little representation of women both in the different versions of Wikipedia and in most WikiProjects.

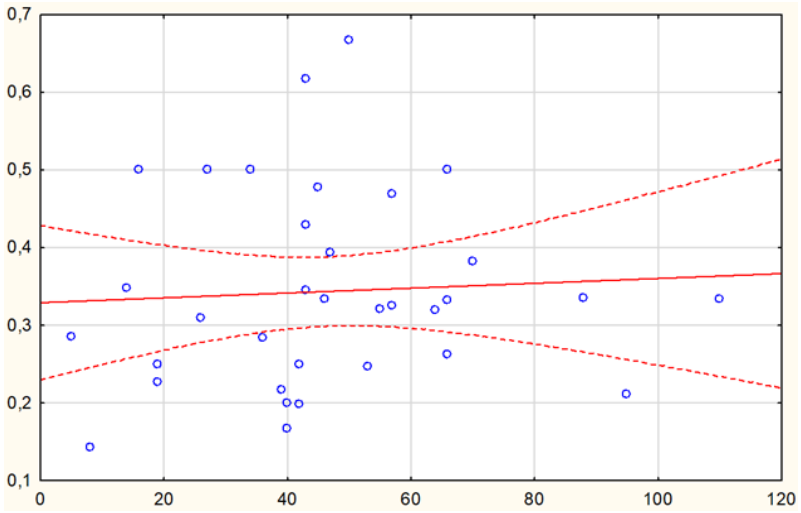

Figure 2: Relationship Between the size of MAS and the ratio of Active WikiProjects Members to Total WikiProjects Subscriptions

WikiProject structures develop in a spontaneous process, with the impetus for their creation coming from topics in various fields. The studied WikiProjects were characterised using Ward's clustering method. This gave control over the resulting number of groups, allowing the most natural clusters of survey elements to be presented (Szajt, 2014). For the 2021-2022 data, it seems clear that there are two main clusters, the first more numerous and the second far less numerous. In the former, a close proximity is observed between medical science, whereas sport in the latter – biographies, flying, films, football aside, as it were. Data from 2022-2023 with the same indicators (WikiProjects in selected language versions) and little change in the number of participants yielded a different result. For the 2022-2023 data it seems reasonable to divide it into three main clusters, the first and second more numerous and the third far less numerous comprising only biographies, flying, films, football (isolated earlier) and anime & manga, while also computer games. In the first focus, the previously observed close proximity between medical science and sport extended to music and musicology. WikiProjects are seemingly grouped together regardless of subject matter. However, in the right-hand side of both graphs (Fig. 3 and 4) are the very popular WikiProjects related to the sphere of mass culture. Biographical topics, on the other hand, cover a large part of Wikipedia and heated disputes often erupt around them. Aviation, on the other hand, gathers disproportionately more hobbyists than other technical and military issues.

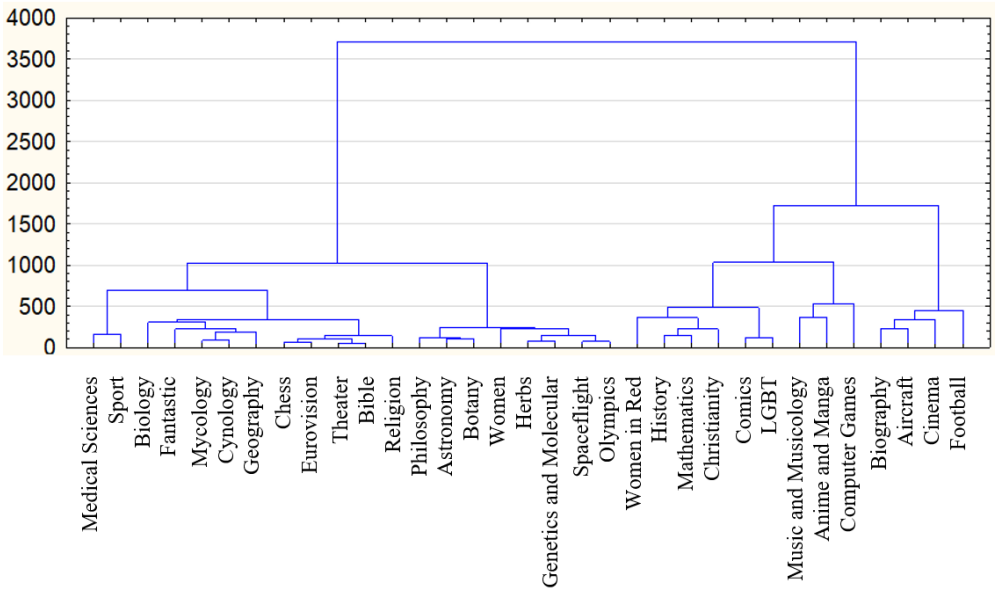

Figure 3: Ward Cluster Analysis Graph (Euclidean distance) for WikiProject in 2021/2022 by Popularity in 34 Language Groups

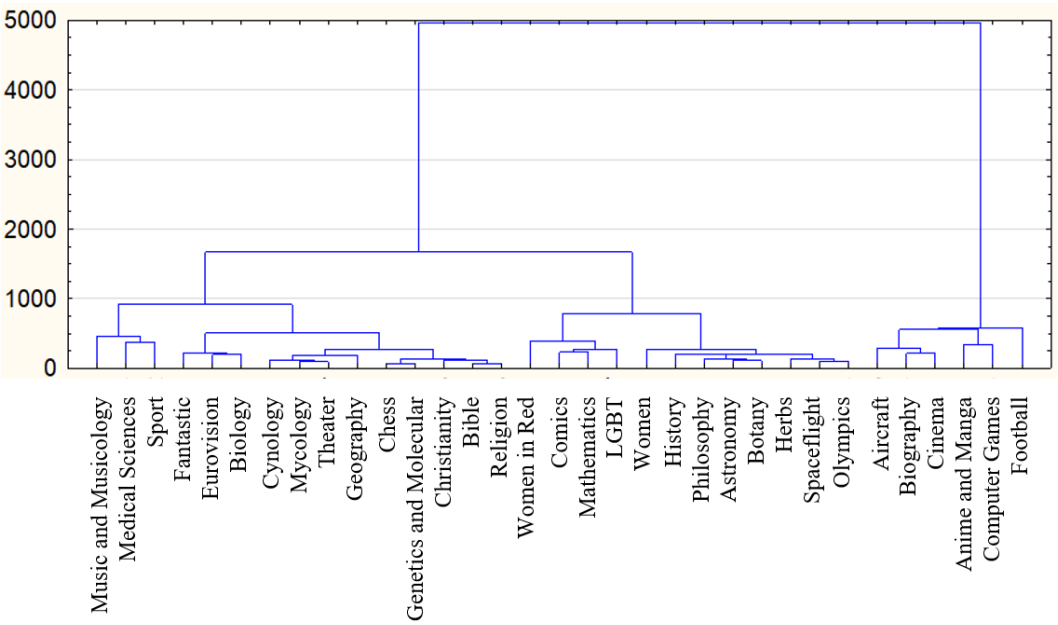

Figure 4: Ward Cluster Analysis Graph (Euclidean distance) for WikiProject in 2022/2023 by Popularity in 34 Language Groups

5. Conclusions

Measuring membership in WikiProjects and measuring the productivity of these communities has been cited as one of the significant difficulties associated with studying WikiProjects (Solomon and Wash, 2014). A practical contribution to the research so far is the presentation of the ratio of declared participation in WikiProjects to actual commitment to work for the improvement of Wikipedia. The "Who is active" tool used in the study simplified the data counts and made it possible to scan this work as a single source. Counting only the declared participation in a given WikiProject in advance was fraught with the falsification of participant activity. The fact that the majority of efforts to make content public are made by a vast minority of individuals was pointed out by Peddibhotla and Subramani (2007) and Raban and Rabin, (2009). The characterisation of online group structures based on the actual activity of their members facilitates a better description of the communities studied. In the future, expanding the research to include more WikiProjects and more language versions of Wikipedia would enable more accurate conclusions.

It seems that with the organisational changes brought about by the global pandemic, the theme of the emergence of spontaneous collaborative structures in online communities has become even more cognitively attractive. The safety and security crisis has changed perceptions of the determinants of online group activity and thus the specifics of their functioning and effectiveness. The production of value in social interactions in the online sphere, the ability to work together as a team in physical isolation, is becoming increasingly important. The conditions surrounding these processes are therefore worth exploring.

6. Limitations

The method used to measure participation in WikiProjects from lists of their participants was not possible in every case. This is because it is not a universal way of declaring participation in WikiProjects. In several cases, the count required searching for participants on directly inaccessible WikiProject subpages. Despite the care taken in mapping the data, the values of which are often small in terms of recently active members, there remains a margin of error that is difficult to estimate. A different issue also highlighted by Morgan et al. (2013) remains the contribution to the WikiProjects of individuals who do not explicitly declare their affiliation.

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