

This is a repository copy of *Social Aspects of the Game Development Process in the Global Gam Jam*.

White Rose Research Online URL for this paper:
<http://eprints.whiterose.ac.uk/133978/>

Version: Accepted Version

Proceedings Paper:

Pirker, Johanna, Lesjak, Isabel, Punz, Andreas et al. (1 more author) (2018) Social Aspects of the Game Development Process in the Global Gam Jam. In: ICGJ 2018 Proceedings of the International Conference on Game Jams, Hackathons, and Game Creation Events. New York, NY: ACM Press , New York , pp. 9-16.

<https://doi.org/10.1145/3196697.3196700>

Reuse

Items deposited in White Rose Research Online are protected by copyright, with all rights reserved unless indicated otherwise. They may be downloaded and/or printed for private study, or other acts as permitted by national copyright laws. The publisher or other rights holders may allow further reproduction and re-use of the full text version. This is indicated by the licence information on the White Rose Research Online record for the item.

Takedown

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.

Social Aspects of the Game Development Process in the Global Gam Jam

Johanna Pirker
Graz University of Technology
Graz, Austria
jpirker@iicm.edu

Isabel Lesjak
Graz University of Technology
Graz, Austria
isabel.lesjak@student.tugraz.at

Andreas Punz
Graz University of Technology
Graz, Austria
andreas.punz@student.tugraz.at

Anders Drachen
Digital Creativity Labs, University of York
York, United Kingdom
anders.drachen@york.ac.uk

ABSTRACT

Game jamming is a valuable tool and process to connect game developers from a range of disciplines such as art, programming, audio engineering, or story-telling. The *Global Game Jam*[®] (GGJ) thus fundamentally supports the process of connecting people, and forms a basis for studying teamwork formation and -mechanics. It is an annual event, where participants (jammers) meet on physical locations to develop games together within a short time-span of 48 hours. People with similar interest but different skill-sets have the chance to meet and collaborate to create prototypes of games together, whether digital or analog. In this explorative study, data from the GGJ website across four years of game jams and their participants are analyzed, towards investigating group interaction and group forming behavior. The focus is on using social network analysis and social metrics to evaluate the influence of a) jammer skillset and b) jam locations, on social and communicative structures among game jammers in the GGJ environment. The findings suggest that different skill-sets support different forms of social structures and also setups in countries refer to different group sizes and different social structures.

CCS CONCEPTS

• **Human-centered computing** → **Social networks**; *Social network analysis*; • **Social and professional topics** → **User characteristics**;

KEYWORDS

game jam, game development, social network analysis

ACM Reference Format:

Johanna Pirker, Andreas Punz, Isabel Lesjak, and Anders Drachen. 2018. Social Aspects of the Game Development Process in the Global Gam Jam. In *ICGJ 2018: International Conference on Game Jams, Hackathons, and Game Creation Events, March 18, 2018, San Francisco, CA, USA*. ACM, New York, NY, USA, 8 pages. <https://doi.org/10.1145/3196697.3196700>

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).

ICGJ 2018, March 18, 2018, San Francisco, CA, USA

© 2018 Copyright held by the owner/author(s).

ACM ISBN 978-1-4503-6484-3/18/03.

<https://doi.org/10.1145/3196697.3196700>

1 INTRODUCTION

Game development as a process has been shown as valuable tool for building social connections between people with similar (namely game development and playing games) but different skill-sets [4, 25, 28], supporting learning, collaboration and communication skills, and participants understanding of project management [4, 13, 15, 25]. The multidisciplinary nature of digital games typically requires a collaboration between people from disciplines such as art, programming, audio engineering, design, marketing, project management, and story telling [17]. With the current rise of *indie games* and game development tools (e.g. Unity or Game Maker), which make the development process easier and more open to people without technical skills, games and the game development process have become much more open and popular. Game jams have been shown as a valuable tool to connect people with these interests [32]. Game jams are events, which allow jammers to develop a game together in a relatively short time span (e.g. 48 hours). Often game jam organizers would give jammers a specific topic or technology as inspiration and jammers would form groups to develop games based on this topic or technology. In particular, this group forming process has been shown to be a complex and challenging task, and yet group formation is still a crucial factor for successful projects and development processes [30].

The Global Game Jam[®] is an annual event which invites people all over the world to develop games within the same time span about the same topic. At the end of the game jam, all games are uploaded to the Global Game Jam[®] website. Jammers who have worked on a game are credited to this game together with their team-mates. In this paper, we used the data collected on the GGJ website towards investigating the social networks and -behaviors of jammers, via social network analysis (SNA) [35]. SNA permits the analysis of whether jammers' skills have an impact on their social connections and whether social structures and group sizes varies across countries participating in the GGJ event.

The work presented here contributes to the understanding of team formation and social structures. [5, 23]. In this paper we present a construction of a social network of the Global Game Jam[®] network over a timespan of four years. We use the social network metrics combined with self-reported features to gain insights into how groups are formed and how different skill sets relate to different social aspects. We can summarize the main contributions as follows:

a) Construction and analysis of the GGJ jammer social network across four years of the global event, b) Mapping of jammers' skill sets to network metrics. We show that game jammers with skills, which allow them to contribute to several games in a smaller time span (e.g. audio and/or music, 3D art, writing and/or story telling) or game jammers who are more general-skilled (e.g. marketing, game design, project management, quality assurance) grow their social network faster and have in average more connections compared to jammers who are very focused and would work on one game per jam (e.g. programmers, animators, 2d artists, hardware, web design). c) Analysis of the relationship between jam locations and network metrics. We find that countries with experienced local GGJ sites are closer to the average degree centrality than countries who recently started local game jams.

2 RELATED WORK

Team formation and the social behavior of teams forms a core topic in organisational psychology (e.g. [5, 23, 31, 42]). While recognizing that social network analysis of game jams form a part of a larger domain of inquiry, this section will focus on literature associated with game jams and related social network analysis in the context of game development.

2.1 Game Jams

By definition, game jams are social events requiring collaboration among individuals and interaction with each other to create a game together [14]. Kultima [20] describes a game jam as "*an accelerated opportunistic game creation event where a game is created in a relatively short timeframe exploring given design constraint(s) and end results are shared publically*". Social aspects and collaboration have been shown as main motivators of jammers to participate [34]. It was also shown that a collaborative experience is preferred over a competitive setting [36].

Collaboration has not only been shown as a main motivator to participate in game jams, but also as a skill a jammer would gain [24]. Several authors have shown benefits of game jams as events to connect people with different skill-sets, as educational tools, and to boost innovation, entrepreneurship, business-relationships, and help students to build resumes [25]. Apart from application-relevant skills (programming, art, design, audio) also personal skills, such as social skills, communication skills, and self-efficacy can be improved. A study by [37] investigating the Global Game Jam 2016 in Orlando, Florida has shown that participating in a game jam can successfully improve social skills and personal self-efficacy. Additionally, jammers can engage in and improve their skills in creative thinking, disruptive innovations and rapid-prototyping techniques [14] due to the fact that game jams generally come with time constraints (e.g. 48 hours during a weekend to develop a game) and a given common theme.

Furthermore, earlier research [2] has examined the demographics, development processes and learning outcomes of participants at GGJ 2012 through a pre- and post-event survey.

In another large-scale study conducted by [32] with 150 survey responses from various universities, the characteristics and motivations of jammers as well the correlation between academic

performance and engagement in game jams have been extensively discussed.

To summarize, social aspects such as collaboration, communication, or social skill development have always been demonstrated as key elements and drivers of game jams. In [30] the authors also discuss the importance of the group finding process and good group constellations including size of groups (most of the time 3-5 jammers) and the distribution among different skills (e.g. at least one programmer, one artist, and one audio engineer).

Generally, previous research has revolved around the main characteristics and development of game jams including qualitative studies to demonstrate social aspects rather than specifically examining social networks within game jam networks. However, especially in the analysis of social structures, Social Network Analysis (SNA) has been a valuable tool. In the following section, we discuss relevant related work in the field of social network analysis.

2.2 Social Network Analysis (SNA)

Social network analysis (SNA) uses graph-based models to analyze and display social structures and is used in various fields including social sciences, economics, information science, or computer science [9, 35]. Already early work utilizes social networks as tool to analyze communication and structures within organizations [40] or business applications [8]. In recent years, many authors have used social network analysis as tool to represent and analyze social online platforms such as Facebook, Twitter, or LinkedIn [10, 18].

Recently, authors have found application in social network analysis of online multi-player games to identify and investigate social communities, to identify cheaters, or recommend match partners [6, 7, 22, 31, 38, 39] and to investigate the impact of social aspects on in-game behavior, game performance, engagement, and retention [33] in games and multi-user environments such as World of Warcraft, Second Life, or Destiny. Especially correlations between social network metrics and behavioral features or performance measures have been shown as valuable tools to utilize social network analysis [12, 29, 33]. In [33], for example, the authors show correlations between strong social connections and collaborations, and in-game performance and engagement.

Table 1: Overview of the dataset

Year	2017	2016	2015	2014
Countries	84	81	72	64
Sites	607	559	461	421
Jammers	25.704	24.622	19.863	16.052
Games	7.193	6.856	5.430	4.203

While authors have shed light on social structures within online games through social network analysis, the use of this method to analyze the game development process is barely covered yet. The first attempt to involve quantitative data analysis based on the Global Game Jam® (GGJ) data was presented by Pirker et al. [26]. The authors introduced the representation of game jammers as social graphs and discussed the potential of social network analysis (SNA) in the specific use case of game jams. In the work presented here, SNA is applied in more depth. A network is constructed for

jammers of the Global Game Jam over the time span of four years, and this is utilized to investigate the relationship between social network metrics and self-reported measures such as jammer skill, as well as the social graphs of different jam locations (countries).

3 DATASET AND PRE-PROCESSING

This paper builds upon data retrieved from the Global Game Jam[®] (GGJ) website and uses social network analysis to understand social interactions and connections between jammers. In the following sections, we shortly describe the background about the (1) Global Game Jam and (2) the retrieved dataset.

3.1 Global Game Jam[®] (GGJ)

The Global Game Jam[®] (GGJ) is a game jam, which is taking place over a time-span of 48 hours all around the world and is organized locally at various physical locations [1]. Starting on Friday afternoon (time-zone independent) jammers would be informed first about the common theme of the annual jam. This theme is the same for all participating locations. The jamming locations are also referred to as "*jam sites*". After the announcement of the theme, jammers would form teams. Different jam sites would organize and promote different types of group forming processes [30]. Often these groups form around game ideas or technologies and take into account different skills of the participants. Usually - depending on the scope and topic of the game idea - every game development team should consist of at least one programmer, one artist (2D or 3D), and one audio engineer.

All jammers register on the GGJ website (globalgamejam.org) and add themselves to a location. In their profile they would list their skills based on a given form. Skills to list include: "2D Art", "3D Art", "Animation", "Audio", "Game Design", "Game Development", "Hardware", "Marketing", "Music", "Programming", "Project Management", "Quality Assurance", "Story and Narrative", "Web Design", or "Writing". Every team would create an own sub-page for their game and jammers assign themselves to the game. Jammers can work on more than one game and assign themselves also to other games.

The GGJ is growing every year. By 2017 more than 700 location sites in 84 countries were organized. Almost 7200 games were developed.

3.2 Dataset

Based on the information provided on the official GGJ website we constructed a dataset over the time span of four years (2014-2017) by crawling the official GGJ web page.

- **Jam Site:** location name, jammers registered, games developed, jam year, country
- **Jammer:** jammer name, skills, games developed
- **Jam Game:** jam game name, tools and technologies (e.g. game engine), jam year, team members

Table 1 summarizes the data entries of the used jammer dataset. This dataset is used as basis for the global game jammer network, which we describe in the following section.

Table 2: Overview of the network (2014-2017)

Nodes	65,320
Avg. Degree	5.184
Avg. Weighted Degree	5.519
Edges	169,313
Diameter	73
Avg. Clustering Coefficient	0.892

4 GLOBAL GAME JAMMER NETWORK

Social network analysis (SNA) is a graph-based method to describe and measure social relations and social structures. It became extremely popular through the popularized idea of Stanley Milgram's *Six Degrees of Separation*, describing the connectivity between the world's population [19, 41]. In SNA, social structures are described through nodes (v) and connections between nodes are described as edges (e) [35].

4.1 Building the Global Game Jammer Network

Since the GGJ website does not provide jammer "friendship" information, and jammers cannot be connected directly through explicit connections, the Global Game Jammer network was built through implicit connections. As introduced in our previous work [27], three networks can be built based on implicit connection information within the GGJ dataset: (1) the jammer networks, which describe connections between jammers through games developed together; (2) location networks, which describe connections between locations through jammers who have changed locations over the years; (3) game networks, which represent a network of games developed through jammers.

Following, we refer to the *Global Game Jammer Network* as social network built between jammers over the time span of four years, which are connected as soon as two jammers have developed a game together. Jammers represent nodes (v) and edges (e) represent the connection through a game developed together as a team. Since it is a weighted graph, edges are weighted with the number of games developed together. A weight of four would refer to four games developed together within the time span of four years.

The tool used to analyze and visualize the network is Gephi, an open network analysis and visualization tool¹ [3].

4.2 Social Network Metrics

Table 2 summarizes the typical social metrics identified through network analysis. The Global Game Jammer network over the time-span over four years is represented as undirected, weighted graph with 65,320 nodes (jammers) and 169,313 edges (connections through games developed as a team).

Average Degree. With the average degree, we can describe the average of all jammers' degrees within the network. The average degree in the four-year network is 5.184. This means, that jammers are connected in average to more than 5 jammers. The degree will be the main social metric when analyzing differences between different jammer skills.

¹<https://gephi.org/>

Average Weighted Degree. As we formed the graph as weighted graph, with the weights representing the number of games developed together, we can build the average degree also with weighted degrees. As jammers work together on a project again, the weight of the edge is raised. The average weighted degree is 5.519. As already noted in [27], the small difference between the average degree and the average weighted degree refers to the likelihood that jammers would rather work again with jammers they have already worked with on previous games.

Diameter (D). The diameter is defined as "the length of the shortest path between the most distanced nodes" [11], and is used to describe the entire size of the network. The diameter of this network is 73, which can be described as relatively large. However, it is also noted that not all nodes can be reached from all other nodes.

Average Clustering Coefficient. The average cluster coefficient describes the average cluster coefficient over all jammers. The cluster coefficient is used to describe the connectivity to the neighbors. The average clustering coefficient in the Global Game Jammer network is 0.892.

5 ANALYSES

In this paper, on the one hand, we focus on understanding social metrics of specific developer groups based on their skill sets, and on the other hand we focus on gaining insights into differences in social aspects at different jam sites in different countries. Three main questions are in the focus of the following analyses:

- Do jammers' skills have an impact on their social connections?
- Do social structures and group sizes differ in different countries?
- Is a country's average degree related to the number of jam sites in this country?

We investigate these research topics with two separate analyses by combining the social metrics as identified in the described Global Game Jammer network with self-reported metrics based on the GGJ website.

5.1 Do jammers' skills have an impact on their social connections?

The game development process is known as interdisciplinary process requiring the collaboration between people with different skills. Through the GGJ site jammers can identify themselves based on the following skills: "2D Art", "3D Art", "Animation", "Audio", "Game Design", "Game Development", "Hardware", "Marketing", "Music", "Programming", "Project Management", "Quality Assurance", "Story and Narrative", "Web Design", or "Writing".

Table 3 connects the average degree of players as retrieved from the social network analysis of the global network with self-reported skills. The average degree of jammers with any skill is 5,1841. Over the span of four years the average degree grows from 4,2526 to 12,2992. We can observe that especially jammers with self-reported skills including 2D art, hardware, programming, and web design grow their social network relatively slowly and below this average. Compared to that, jammers with self-reported skills such as 3D art, audio, marketing, music, or project management grow their social

network faster. An explanation could be that jammers with skills, which allow to contribute to several games in a short time span (e.g. audio assets, 3D models, writing and/or story telling) or jammers who are more generally skilled (e.g. marketing, game design, project management, quality assurance) grow their social network faster. Additionally, they also have more connections compared to the average. Jammers who are growing their network relatively slowly are programmers, animators, 2d artists, hardware experts, and web designers. These disciplines often allow participants to only contribute in one game per jam.

5.2 Do social structures and group sizes differ in different countries?

One key driver of the GGJ is the international factor. At the same time thousands of jammers would develop games about the same topic in different countries. While the digital setting is the same for every jam site, experience with the game development process, on-site setting, and collaboration processes can differ between sites and countries [32]. Table 6 lists all investigated countries, their average degree in the four year time span, and the number of sites organized in this country. It should be noted that not all countries or sites were organized in all four years. The average degree varies between 1.6552 (Morocco) and 11.2152 (Uruguay). Countries which are more experienced in organizing game jams are closer to the average degree between 5 and 6, as compared to countries with fewer jam sites or less experience.

5.3 Is a country's average degree related to the number of jam sites in this country?

For this subsection, network analysis was performed using k-means in order to find clusters and relationships among the data. Remote outliers (two jammers and three countries with the highest degrees) have been removed from the original dataset and the elbow algorithm [16] as implemented in Python here[21] was used to determine the optimal number k of clusters.

In Figure 2, it is shown that countries that have between 1 and 20 jam sites also have an average degree with the widest span, ranging from 0 to 11. Most countries have up to 20 jam sites, therefore the biggest cluster lies in this area. As the number of sites in a country increases, the range of the average degree as well as the size of the cluster both decrease. In total, four clusters were identified by the k-means algorithm.

6 DISCUSSION AND CONCLUSION

Collaboration, social aspects, and meeting new development peers have been shown as important motivators for jammers to participate in game jams [34] and are well-known topics in organisational psychology [23], but also valuable skills to learn within game jams [24]. To this point the focus of research in game development and game jam research has been on qualitative studies and self-reported measures. However, as events such as the Global Game Jam[®] are becoming complex, large-scale, developing gatherings, large-scale quantitative methodologies such as behavioral analytics and social network analytics, can be implemented and provide a way to handle increasingly large datasets from the GGJ. Importantly, the GGJ website connects game jammers and thus provides a unique

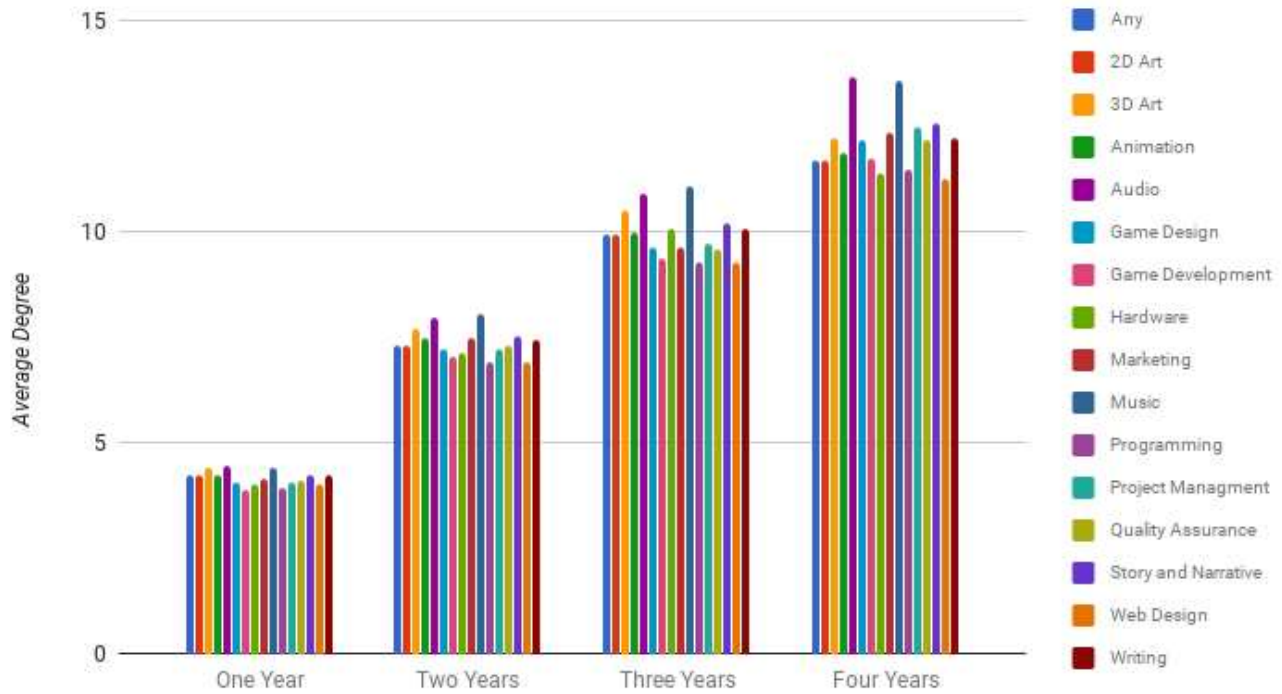


Figure 1: Overview of degrees of different skills.

Table 3: Average degree of jammers with specific skills over time

Skill	One Year	Two Years	Three Years	Four Years	Overall
2D Art	4.2289	7.3236	9.9264	11.6890	5.2964
3D Art	4.4176	7.7223	10.5348	12.2420	5.6222
Animation	4.2485	7.4762	9.9733	11.8671	5.4253
Audio	4.4642	7.9614	10.9322	13.6606	5.7863
Game Design	4.0498	7.2263	9.6236	12.1998	5.2936
Game Development	3.9025	7.0303	9.3748	11.7618	5.1406
Hardware	4.0232	7.1183	10.0954	11.3784	5.1032
Marketing	4.1680	7.4891	9.6225	12.3571	5.2226
Music	4.4268	8.0479	11.0696	13.6087	5.7052
Programming	3.9210	6.9112	9.3086	11.4774	5.0011
Project Management	4.0824	7.2036	9.7323	12.4847	5.3376
Quality Assurance	4.1174	7.3192	9.5974	12.1963	5.3554
Story and Narrative	4.2531	7.5403	10.2193	12.5905	5.4063
Web Design	3.9997	6.9199	9.2995	11.2446	5.0308
Writing	4.2354	7.4475	10.0834	12.2245	5.3157
Any (all skills)	4.2526	7.3713	9.9433	12.2992	5.1841

opportunity for analysing social structures, team formation and social behavior in a global-scale event.

In the work presented here, it was shown that jammers with specific skill-sets such as programmers, hardware experts, or 2D

artists are growing their social network slower compared to audio engineers or jammers with project management or story-writing skills. Additional investigation is needed to evaluate the cause, for example if this pattern occurs because of a bias in the types of

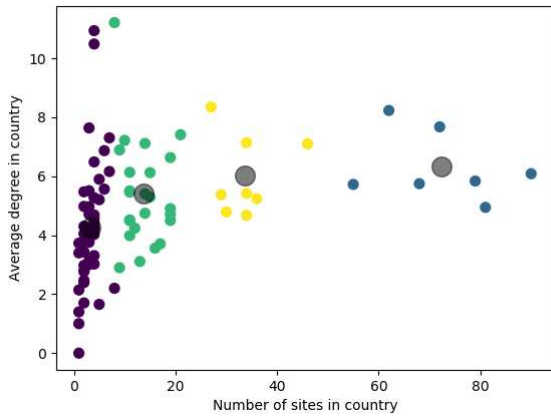


Figure 2: K-means clustering for average degree and number of jam sites in a country.

personalities that seek specific job types in game development. We also tried to gain first insights into typical social metrics found in different countries and found that countries which are already more experienced in the organization of local GGJ sites are closer to the average degree between 5 and 6, while countries with fewer sites and those which have just started organizing jams often have a smaller average degree. This might suggest that with experience and repeated game jams, local sites will tend to gravitate towards degrees between 5 and 6. Summarizing, social network analysis as tool to analyze structures in collaborative processes appears to be a promising tool and social metrics such as the degree or average degree can help to shed light on various open questions about social behavior in development processes, for example on how to build strongly cohesive groups [5, 23, 42]. Moving forward, we will advance this research by adding additional features such as development tools used or retention rate to the analysis, as well as potentially detailed behavioral information, with the ultimate aim of building recommender systems for group formation at GGJ events. This perspective can also include using recommender systems to help extend the social networks of jammers, which could for example be measured via the change in the number of people who the jammer can approach with a question.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to the Global Game Jam®, for access to social network data and the reviewers for the valuable feedback. Part of this work was conducted in the Digital Creativity Labs, jointly funded by EPSRC/AHRC/InnovateUK under grant no EP/M023265/1.

APPENDIX

Country	Average Degree	No. of Sites
Algeria	1.7027	2

Country	Average Degree	No. of Sites
Angola	1.0000	1
Argentina	7.1055	46
Australia	5.4190	34
Austria	7.3048	7
Belarus	4.9781	2
Belgium	5.4050	14
Bolivia	5.2051	5
Brazil	6.9989	164
Bulgaria	5.4625	11
Canada	4.9461	81
Chile	6.1340	11
China	4.5024	19
Colombia	7.1164	14
Costa Rica	4.5656	4
Croatia	2.7778	2
Cuba	4.0922	3
Czech Republic	3.3091	4
Denmark	4.0263	4
Ecuador	4.9692	3
Egypt	6.1633	7
Estonia	3.8036	2
Faroe Islands	5.4737	2
Finland	5.7498	68
France	6.0870	90
Georgia	4.3043	2
Germany	5.8390	79
Ghana	10.9412	4
Greece	3.9856	11
Guatemala	5.5100	3
Hungary	4.6897	4
India	3.1098	13
Indonesia	5.2406	36
Iran	4.7169	19
Ireland	4.9019	19
Israel	6.6363	19
Italy	8.3527	27
Jamaica	1.4000	1
Japan	7.6774	72
Jordan	2.2000	8
Kuwait	2.7838	2
Latvia	3.8611	3
Lebanon	2.3947	2
Lithuania	4.5207	11
Luxembourg	4.7155	3
Macedonia	5.5644	6
Malaysia	6.8705	6
Malta	6.4882	4
Mexico	8.2335	62
Moldova	2.1429	1
Morocco	1.6552	6

Country	Average Degree	No. of Sites
Netherlands	7.1383	34
New Zealand	4.7456	14
Nigeria	7.6400	3
Norway	7.4120	21
Pakistan	3.1379	3
Palestinian Territory	2.9762	2
Panama	10.4889	4
Paraguay	4.0492	2
Peru	6.8934	9
Philippines	5.2959	15
Poland	4.6751	34
Portugal	4.2400	12
Puerto Rico	3.4333	2
Romania	3.0077	3
Russia	3.5620	16
Saudi Arabia	3.4000	1
Serbia	4.4157	4
Singapore	5.8992	5
Slovenia	3.7619	3
South Africa	4.4957	11
South Korea	3.7084	17
Spain	5.7248	55
Sweden	4.7895	30
Switzerland	5.5060	11
Taiwan	6.1246	15
Thailand	5.2742	4
Trinidad and Tobago	0.0000	1
Tunisia	2.8978	9
Turkey	5.3769	29
Ukraine	3.7300	1
United Arab Emirates	4.2308	4
United Kingdom	5.1523	136
United States	6.4602	490
Uruguay	11.2152	8
Venezuela	7.2178	10
Vietnam	2.4722	2
Zambia	3.0233	4

REFERENCES

- [1] 2016. Global Game Jam About. (Nov 2016). <http://globalgamejam.org/about>
- [2] Ali Arya, Jeff Chastine, Jon Preston, and Allan Fowler. 2013. An international study on learning and process choices in the global game jam. *International Journal of Game-Based Learning (IJGBL)* 3, 4 (2013), 27–46.
- [3] Mathieu Bastian, Sebastien Heymann, Mathieu Jacomy, et al. 2009. Gephi: an open source software for exploring and manipulating networks. *ICWSM* 8 (2009), 361–362.
- [4] Jessica D Bayliss and Sean Strout. 2006. *Games as a flavor of CS1*. Vol. 38. ACM.
- [5] S. T. Bell. 2007. Deep-level composition variables as predictors of team performance: a meta-analysis. *Journal of applied psychology* 92, 3 (2007), 595.
- [6] Jeremy Blackburn, Nicolas Kourtellis, John Skvoretz, Matei Ripeanu, and Adriana Iamnitchi. 2014. Cheating in online games: A social network perspective. *ACM Transactions on Internet Technology (TOIT)* 13, 3 (2014), 9.
- [7] Blizzard Entertainment. 2010. StarCraft II. Game [PC]. (27 July 2010). Blizzard Entertainment, Irvine, CA, USA.
- [8] Francesco Bonchi, Carlos Castillo, Aristides Gionis, and Alejandro Jaimes. 2011. Social network analysis and mining for business applications. *ACM Transactions on Intelligent Systems and Technology (TIST)* 2, 3 (2011), 22.
- [9] Stephen P Borgatti, Ajay Mehra, Daniel J Brass, and Giuseppe Labianca. 2009. Network analysis in the social sciences. *science* 323, 5916 (2009), 892–895.
- [10] Salvatore A Catanese, Pasquale De Meo, Emilio Ferrara, Giacomo Fiumara, and Alessandro Provetti. 2011. Crawling facebook for social network analysis purposes. In *Proc. of the international conference on web intelligence, mining and semantics*. ACM, 52.
- [11] New York USA Dr. Jean-Paul Rodrigue, Hofstra University. 2018. Diameter of a Graph. (2018). <https://people.hofstra.edu/geotrans/eng/methods/diameter1.html>
- [12] Nicolas Ducheneaut, Nicholas Yee, Eric Nickell, and Robert J Moore. 2006. Alone together?: exploring the social dynamics of massively multiplayer online games. In *Proc. of the SIGCHI conference on Human Factors in computing systems*. ACM, 407–416.
- [13] Magy Seif El-Nasr and Brian K Smith. 2006. Learning through game modding. *Computers in Entertainment (CIE)* 4, 1 (2006), 7.
- [14] Allan Fowler, Foaad Khosmood, Ali Arya, and Gorm Lai. 2013. The global game jam for teaching and learning. In *Proceedings of the 4th Annual Conference on Computing and Information Technology Research and Education New Zealand*. 28–34.
- [15] Allan Fowler, Johanna Pirker, Ian Pollock, Bruno Campagnola de Paula, Maria Emilia Echeveste, and Marcos J Gómez. 2016. Understanding the benefits of game jams: Exploring the potential for engaging young learners in STEM. In *Proc. of the 2016 ITICSE Working Group Reports*. ACM, 119–135.
- [16] C. Fraley and A. E. Raftery. 1998. How Many Clusters? Which Clustering Method? Answers Via Model-Based Cluster Analysis. *Comput. J.* 41, 8 (1998), 578 – 588.
- [17] Tracy Fullerton, Chris Swain, and Steven Hoffman. 2004. *Game design workshop: Designing, prototyping, & playtesting games*. CRC Press.
- [18] Martin Grandjean. 2016. A social network analysis of Twitter: Mapping the digital humanities community. *Cogent Arts and Humanities* 3, 1 (2016), 1171458.
- [19] David Knoke and Song Yang. 2008. *Social network analysis*. Vol. 154. Sage.
- [20] Annakaisa Kultima. 2015. Defining Game Jam.. In *Proc. of the 10th International Conference on the Foundations of Digital Games*.
- [21] Python Programming Language. [n. d.]. kmeans elbow method, year = 2018, url = <https://pythonprogramminglanguage.com/kmeans-elbow-method/>, urldate = 2018-02-08. ([n. d.]).
- [22] Alexandru Losup, Ruud Van De Bovenkamp, Siqi Shen, Adele Lu Jia, and Fernando Kuipers. 2014. Analyzing implicit social networks in multiplayer online games. *IEEE Internet Computing* 18, 3 (2014), 36–44.
- [23] J. E. Mathieu, J. R. Hollenbeck, D. van Knippenberg, and D. R. Ilgen. 2017. A century of work teams in the Journal of Applied Psychology. *Journal of applied psychology* 102, 3 (2017), 452.
- [24] Juergen Musil, Angelika Schweda, Dietmar Winkler, and Stefan Biffl. 2010. Synthesized essence: what game jams teach about prototyping of new software products. In *2010 ACM/IEEE 32nd International Conference on Software Engineering*, Vol. 2. IEEE, 183–186.
- [25] Johanna Pirker, Daphne Economou, and Christian Gütl. 2016. Interdisciplinary and International Game Projects for Creative Learning. In *Proc. of the 2016 ACM Conference on Innovation and Technology in Computer Science Education*. ACM, 29–34.
- [26] Johanna Pirker, Foaad Khosmood, and Christian Guetl. 2017. Social Network Analysis of the Global Game Jam Network. In *Proc. of International Conference on Game Jams, Hackathons, and Game Creation Events (ICGJ)*.
- [27] Johanna Pirker, Foaad Khosmood, and Christian Gütl. 2017. Social network analysis of the global game jam network. In *Proc. of the Second International Conference on Game Jams, Hackathons, and Game Creation Events*. ACM, 10–14.
- [28] Johanna Pirker, Annakaisa Kultima, and Christian Gütl. 2016. The Value of Game Prototyping Projects for Students and Industry. In *Proc. of the International Conference on Game Jams, Hackathons, and Game Creation Events*. ACM, 54–57.
- [29] Johanna Pirker, André Rattinger, Anders Drachen, and Rafet Sifa. 2018. Analyzing player networks in Destiny. *Entertainment Computing* 25 (2018), 71–83.
- [30] Johanna Pirker and Kimberly Voll. 2015. Group forming processes-experiences and best practice from different game jams. In *Workshop Proc. of the 10th International Conference on the Foundations of Digital Games (Pacific Grove, California, Asilomar Conference Grounds)*.
- [31] N. Pobiedina, J. Neidhardt, M. Moreno, L. Grad-Gyenge, and H. Werthner. 2013. On successful team formation: Statistical analysis of a multiplayer online game. In *Business Informatics (CBI), 2013 IEEE 15th Conference on*. IEEE, 55–62.
- [32] Jon A Preston, Jeff Chastine, Casey O’Donnell, Tony Tseng, and Blair MacIntyre. 2012. Game jams: Community, motivations, and learning among jammers. *International Journal of Game-Based Learning (IJGBL)* 2, 3 (2012), 51–70.
- [33] André Rattinger, Günter Wallner, Anders Drachen, Johanna Pirker, and Rafet Sifa. 2016. Integrating and Inspecting Combined Behavioral Profiling and Social Network Models in Destiny. In *Proc. Entertainment Computing - ICEC 2016: 15th IFIP TC 14 International Conference*, Günter Wallner, Simone Kriglstein, Helmut Hlavacs, Rainer Malaka, Artur Lugmayr, and Hyun-Seung Yang (Eds.). Springer, 77–89. https://doi.org/10.1007/978-3-319-46100-7_7
- [34] L. Reng, H. Schoenau-Fog, and L. B. Kofoed. 2013. The motivational power of game communities-engaged through game jamming. In *Proc. of the 8th International Conference on the Foundations of Digital Games*. Foundations of Digital Games.
- [35] John Scott. 2012. *Social network analysis*. Sage.
- [36] Kiyoshi Shin, Kosuke Kaneko, Yu Matsui, Koji Mikami, Masaru Nagaku, Toshifumi Nakabayashi, Kenji Ono, and Shinji R Yamane. 2012. Localizing global game jam: Designing game development for collaborative learning in the social context. In

- Advances in Computer Entertainment*. Springer, 117–132.
- [37] Peter A Smith Ph D and Clint Bowers Ph D. 2016. Improving social skills through game jam participation. In *Proc. of the International Conference on Game Jams, Hackathons, and Game Creation Events*. ACM, 8–14.
 - [38] Gregory Stafford, Hiep Luong, John Gauch, Susan Gauch, and Joshua Eno. 2012. Social network analysis of virtual worlds. In *International Conference on Active Media Technology*. Springer, 411–422.
 - [39] Christian Thureau and Christian Bauckhage. 2010. Analyzing the evolution of social groups in World of Warcraft®. In *Computational Intelligence and Games (CIG), 2010 IEEE Symposium on*. IEEE, 170–177.
 - [40] Noel M Tichy, Michael L Tushman, and Charles Fombrun. 1979. Social network analysis for organizations. *Academy of management review* 4, 4 (1979), 507–519.
 - [41] Jeffrey Travers and Stanley Milgram. 1967. The small world problem. *Psychology Today* 1 (1967), 61–67.
 - [42] J. M. Wilson, S. G. Straus, and B. McEvily. 2006. All in due time: The development of trust in computer-mediated and face-to-face teams. *rganizational behavior and human decision processes* 99, 1 (2006), 16–33.