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Computer Science Educators' Use of Twitter for Conference Engagements: A Grounded Theory Analysis

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Abstract

This study explored how the computer science education community used Twitter as a conference backchannel. Using the Constructivist Grounded Theory methodology, four themes and ten categories were developed from participants use of Twitter during five computer science education conferences. These themes are: Promote Scholarship; Connect, Promote and Extend the Research Community; Engage in Professional Learning; Humanise the Conference Space. Participants using the conference backchannel contributed to the scholarly discourse and extended the reach of the conferences they attended. They benefitted from various discourses, gained publicity, engaged in networking opportunities, enhanced their own professional learning while extending care for other participants. The findings of this study have practical implications for the computer science education research community. It provides insights for conference organisers on how to extend and enhance the conference experience for both registered and non-registered participants. For researchers, attendees and users of research output, the study highlights some tangible benefits of connecting, networking and professional learning. For those responsible for assessing researchers' contribution to scholarship, this study highlights different ways researchers engage in public scholarship to promote computer science education research.

Keywords

Twitter, Conference Backchannel, Scholarship, Computer Science Education

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Introduction

Conferences are an important element of academic life as they serve as a forum for knowledge exchange, discussions, conversations and networking (Henderson & Burford, 2020). Yet many academics are increasingly unable to attend conferences due to time and work commitment, cost (Cassar, Whitfield & Chapman, 2020), safety (Cro & Martins, 2018), and health issues, among others (Mair, Lockstone-Binney, & Whitelaw, 2018). To extend the reach of academic conferences, organisers have been exploring the Internet both as a means to deliver conferences and to support their delivery (Anderson & Anderson, 2010). Social media in particular have become a popular forum for academics (Jordan, 2020) with Twitter in particular used a backchannel for conference activities (Greenhow, Lai & Mai, 2019). This opening up of conferences in social media spaces like the Twitter backchannel has made it possible for those who cannot attend to participate in some ways (Fekete & Haffner, 2019).

In addition to the issues raised above, the covid19 pandemic has further disrupted the work of higher education in several ways (Watermeyer, Crick, Knight & Goodall, 2020) including the disruption and cancellation of many face-to-face conferences (Saliba, 2020; Viglione, 2020). To address this disruption, conferences are being moved to exclusively online delivery (Achakulvisut et al., 2020).

The computer science education research community (the object of this study) was forced to move several conferences online as a result of the COVID-19 pandemic. This study explores how Twitter was used by computer science education community for conference activities. It is exploratory in nature and seeks to provide insights from five originally scheduled face-to-face conferences – SIGCSE 2020, ITICSE 2020, ICER 2020, CCERS20 and WIPSCE2020 - which were moved online. Though Twitter was not the designated medium of delivery for these conferences, it was used by many conference participants for conference related activities. However, the extent of this engagement with Twitter is not fully understood.

Given the challenges of attendance, participation, engagement between researchers and practitioners, and the increasing use of online tools for facilitating conferences, especially in COVID-19 times, research that helps us understand how online tools support scholarly activities is imperative.

This study aims to offer insights into the ways Twitter as a conference backchannel can serve as an alternative scholarly space by the computer science education community. To address this aim, the following research question are addressed:

> RQ1. What is the demographics of the participants and the extent of their engagement in the five conferences under study?
>
> RQ2. How did computer science education researchers/educators use Twitter to engage in these conference conferences?
>
> RQ3: What implications can be drawn from computer science educators use of Twitter as a conference space to support future development in this field?

The answers to these questions will extend our understanding of the ways the computer science education community use online spaces to engage, promote their work, and extend the computer science education research discourse.

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Literature Review

Computer Science Education

Computer science education has been touted as an important area of interest globally (Yadav, Grettner, Hambrush & Sands, 2016) as it is often linked with economic development (Passey, 2017). Many educators, policy makers, and researchers are involved in the promotion and development of computer science education (Brown, Sentence, Crick & Humphreys, 2014). In particular, computer science education research community is working to improve our understanding of the domain and to advance the pedagogical foundations critical for teaching and learning (Joy, Sinclair, Sun, Sitthiworachart & López-González, 2009; Randolph, Julnes, Sutinen, & Lehman, 2008). However, challenges remain when it comes to the awareness and promotion of computing education research (Cooper et al., 2016).

The transfer of research from university environments to practitioners and teachers operating elsewhere presents a challenge for researchers interested in the utilisation of their work. Computer science education conferences with an online presence may provide opportunities for researchers, practitioners and teachers to engage. Online conferences may extend the reach of computer science education research to often excluded communities.

Twitter

Twitter is a microblogging social network that facilitates engagement using short text messages of 280 characters (Emke, 2019). These short messages or original content created by a user are called Tweets. These Tweets can be directed to other users (Mentions) using the @ sign and a username (e.g. @lenandlar). Twitter also allows 'Retweet' (RT) which is a method of forwarding or broadcasting the Tweets of others (Carpenter, Tani, Morrison & Keane, 2020); Replies to Tweets; and private/direct messaging (Emke, 2019; Powers, 2013).

The hashtag (#) is an important feature of Twitter. It facilitates the aggregation of tweets, connections, interactions, and the formation of communities (Carpenter, Tani, Morrison & Keane, 2020). Specifically, the hashtag enables activities such Twitter chats (Eaton & Pasquini, 2020) and conference participation (Singh, 2020).

Twitter in the Academy

Twitter provides a space where connections can be made to other users from across the globe, from different cultural and academic contexts if users are desirous of exploring connections and networking. (Lupton, 2014; Veletsianos, 2016; Veletsianos, 2017; Veletsianos & Shaw, 2018). Twitter is increasingly adopted by higher education academics for professional development (Carpenter & Harvey, 2019; Carpenter, Tani, Morrison & Keane, 2020; Malik, Heyman-Schrum & Johri, 2019; Veletsianos & Shaw, 2018). Professional development activities take different forms. In a systematic literature review of higher education academics' use of Twitter for professional development, Singh (2020) identified five themes: 1) academic backchannel, 2) networking, 3) information and resource sharing, 4) keeping updated, and 5) public engagement and social commentary.

Twitter is also a useful channel for scholarly communication among scientists and researchers (Holmberg & Thelwall, 2014; Lee et al., 2017; Zhu & Procter, 2012). Researchers have additionally used Twitter as a data source by citing Tweets and other content shared on Twitter (Priem & Costello, 2010). Identity development and impression management have been identified as a reason why scholars used Twitter (Veletsianos, 2012).

Twitter as a Conference Backchannel

Live Tweeting about conferences using a designated hashtag, referred to as the conference backchannel, is increasingly common among conference attendees and followers (Kimmons & Veletsianos, 2016; Ross, Terras, Warwick & Welsh, 2011). Several studies have pointed to the experiences, benefits and challenges of using Twitter as a conference backchannel. Greenhow, Lai and Mai (2019) reported that participants used the Twitter backchannel to promote scholarship, expand conference participation, create their own impressions and commentary of presentations, curate personal assessments, and share information. Retweeting was also a common practice, and information and resource sharing were common findings of several researchers (Albertson, 2019; Li & Greenhow, 2015; Reinhardt, Ebner, Beham & Costa, 2009; Ross, Terras, Warwick & Welsh, 2011; Wen, Lin, Trattner & Parra, 2014).

Networking is a common activity among participants as several researchers have observed (Fekete & Haffner, 2019; Li & Greenhow; Wen, Lin, Trattner & Parra, 2014). The Twitter backchannel has also served as a means for community integration and emotional support among participants (Risser & Waddell, 2018), for conversations, discussions and talking with each other (Li & Greenhow, 2015; Ross, Terras, Warwick & Welsh, 2011; Wen, Lin, Trattner & Parra, 2014). Note taking is also a common activity among users of the conference backchannel (Fekete & Haffner, 2019; Reinhardt, Ebner, Beham & Costa, 2009; Ross, Terras, Warwick & Welsh, 2011).

While the Twitter backchannel has been used in ways beneficial to participants, it has not always been perceived in positive terms. Kimmons and Veletsianos (2016) noted some participants have the tendency to express discontent with the platform. Greenhow, Lai and Mai (2019) reported that veteran academics complained about Twitter being a distraction to live presentations, while Li and Greenhow (2015) reported Twitter being described as ‘meaningless’.

Twitter as an online conference medium is a promising means for bridging the gap between researchers and practitioners as it provides an avenue for the dissemination of new research to a wider audience by connecting researchers and practitioners in a common space (Greenhow, Lai & Mai, 2019). However, though our understanding of Twitter’s utility is improving, much is yet to be known about the extent and character of Twitter as a conference channel and so it is imperative that research continues to help us better understand these online spaces (Kimmons & Veletsianos, 2016). Further, much remains to be understood about Twitter as a medium for conference engagements related to specific disciplines (Greenhow, Lai & Mai, 2019). This present study adds to the current literature by providing a discipline specific (computer science education) account of the use of Twitter as a conference backchannel. To the best of the researcher’s knowledge, no previous research has addressed this group’s use of Twitter as a conference backchannel.

Ethics Approval

Ethical approval for this study was granted by the Lancaster University Faculty of Arts and Social Sciences eResearch and Technology Enhanced Learning Programme ethics process. However, the use of publicly available social media data may raise specific ethical challenges that need contextual considerations (Ahmed, Bath & Demartini, 2017; Fiesler & Proferes, 2018). Therefore care should be taken when using social media data for research.

In this study, several measures were undertaken to address potential ethical issues. To ensure that authors of the tweets I quoted were in approval of the use of their tweets, I wrote each author asking for their permission to use the tweets. This was done via direct messages on Twitter where it was possible to do so. In cases where authors could not be messaged directly, a message was sent in reply to the actual tweet asking authors to talk to them about using the tweet. Further, emails were used to contact some authors.

In cases where communication was not established with authors, two approaches were adopted: 1) tweets originally identified for inclusion in the study were omitted entirely, or. 2) a small fragment of a tweet was used. Care was taken that the small fragments extracted were useful enough for the study, but which cannot be used as a means to search for and locate the original authors on Twitter.

Where authors responded with permission to use their tweets, they were asked if they would like to review how their tweets are used in the study. Those who indicated in the affirmative were sent a copy of the final draft paper.

Research Approach/Methodology

The purpose of this study is to explore how Twitter is used by computer science education community for conference engagements. This study follows a qualitative methodology and a grounded theory approach. Grounded theory allows for theory to be generated or evolved from empirical data rather than be developed a priori and then tested. Consequently, this approach aligns with the aim of the present exploratory study which seeks to derive a model from data. Specifically, the constructivist grounded theory approach by Charmaz (2008) is proposed as the method of analysis of the data used this study. The variant of grounded theory is used for data analysis since the researcher will engage in the subjective construction of codes, categories, and themes upon which the final theory is formed.

Data Collection

The study data are the datasets of Tweets created by participants of five academic conferences held in 2020 – SIGCSE 2020 (https://sigcse2020.sigcse.org/ ; March 11-14, 2020), ITICSE 2020 (https://iticse.acm.org/ITiCSE2020/ ; June 26-28, 2020), ICER 2020 (https://icer2020.acm.org/ ; August 8-13, 2020), CCERS20 (https://www.raspberrypi.org/cambridge-computing-education-research-symposium/ ; April 1, 2020) and WIPSCE2020 (https://www.wipsce.org/2020/ ; October 28, 2020). These conferences were selected because of their prominence in the computer science education research community. The Tweets from these five conferences were collected using the respective conference hashtags: #SIGCSE2020, #ITICSE2020, #ICER2020, #CCERS20 and #WIPSCE2020. The NodeXL software was used to harvest Tweets from Twitter with each dataset downloaded one day after each conference ended. Twitter allows for tweets to be collected up to seven days prior. This allowed for all conference-related data to be collected, as none of the conferences extended beyond seven days. All datasets collected by NodeXL were in the form of Microsoft (MS) Excel Spreadsheets.

Data Analysis

Two approaches were used to analyse the five datasets collected. Firstly, Social Network Analysis via NodeXL was used to generate summaries of the demographics and usage statistics. Secondly, a constructivist grounded theory approach proposed by Charmaz (2006) was used to analyse the tweets collected. This qualitative approach utilises three types of coding – initial coding, focused coding and theoretical coding. All of the tweets were analysed individually and manually using initial coding and by focusing on the verb elements of each tweet as proposed by Charmaz (2006). These codes were attached to each Tweet in separate columns parallel to the Tweets in the MS Excel software. Focused coding was then executed on the initial set of codes to arrive at categories. Since all five datasets were collected before the analysis commenced, constant comparison across the different conference datasets provided a means for comparisons to be made across datasets. Finally, theoretical/advanced coding was used to arrive at the final set of themes that forms the basis of the theoretical model. Memoing (accompanying notes to codes written in the MS Excel software) was used to document the researcher's thoughts about the codes created. Memos were used to guide the development of the final model. To increase the chance of achieving theoretical saturation (Charmaz, 2014) initial coding was done twice and comparisons were made across the five different datasets. This comparison of data from one dataset to another, collected at different points in time, aided with data saturation (Saunders et al., 2018). The researcher felt reasonably comfortable that cross comparisons of the five different datasets offered sufficient recurrences (repeated data points) across the datasets and that a new dataset may not have revealed new issues to consider.

Findings

This section is a presentation of the findings of the study. A discussion of these findings is offered in the next section.

Three tables provide summary statistics of participants and the types and levels of engagement for the five conferences.

Table 1 shows the number of participants (vertices) and the connections among participants (edges) for the five conferences. Unique edges are number of connections between two vertices/participants where multiple connections are counted only once. Edges with duplicates represents the total count of multiple connections between vertices/participants. Total edges is a sum of unique and duplicate edges (Hansen, Shneiderman, Smith & Himelboin, 2020). The data shows similar numbers of participants are noted for all conferences except WIPSCE2020 which had approximately 50% less than others. In terms of connections and engagements, CCERS was the most active while WIPSCE2020 was the least active.

Table 1: Participants and Connections

Metrics/Conference	**SIGCSE2020**	**ITICSE2020**	**ICER2020**	**CCERS20**	**WIPSCE2020**
Vertices (participants)	145	142	159	138	64
Unique Edges (connections)	222	360	269	292	119
Edges with Duplicates	80	152	63	411	79
Total Edges	**302**	**512**	**332**	**703**	**198**

The method of engagement (Table 2) shows the highest level of engagement as Retweeting (broadcasting the Tweets of others) (28%) and Mentions in Retweets (broadcasting the Tweets of others directed to specific users via their @username) (25%)). Tweeting (creating original messages) (23%) and Mentions (Tweets directed to others via their @username) (20%) accounted for the second and third highest levels of engagement. Repliesto (direct responses to original Tweets) (5%) was the least common form of engagement, indicating very low levels of direct dialog with others.

Table 2: Method of Engagement

Metrics	**SIGCSE2020**	**ITICSE2020**	**ICER2020**	**CCERS20**	**WIPSCE2020**	**Total**	**%**
Retweets	40	139	171	142	76	568	28%
Mentions	86	88	32	157	40	403	20%
Tweets	64	112	49	216	22	463	23%
Mentions in Retweet	73	151	65	169	58	516	25%
Repliesto	39	22	15	19	2	97	5%
Total						**2047**	**100 %**

Table 3 shows the top 10 participants by location for each conference. Four participants (labelled P1,P2,P3,P4, P5, respectively) appeared more than once as a top 10 contributor over multiple conferences.

Table 3: Top 10 Participants for each Conference

Top 10 Vertices /Conference	**SIGCSE2020**	**ITICSE2020**	**ICER2020**	**CCERS20**	**WIPSCE2020**
1	USA	Australia	UK	UK	Switzerland
2	**(P1) USA**	**P5 (USA)**	USA	**P2 (UK)**	**P4 (UK)**
3	USA	USA	**P5 (USA)**	USA	UK
4	USA	**P3 (USA)**	**P1 (USA)**	UK	USA
5	USA	UK	**P3 (USA)**	**P4 (UK)**	USA
6	USA	Ireland	USA	UK	UK
7	USA	Belgium	USA	UK	**P2 (UK)**
8	**P2 (UK)**	France	USA	UK	Germany
9	USA	UK	UK	UK	Germany
10	USA	P2 (UK)	USA	UK	bot

Table 3 above shows that majority of participants (42/50, 84%) of top 10 participants are from the USA or the UK - 23 / 50 (46%) from the USA; 19/50 (38%) from the UK. The remaining 8 top 10 participants are from 6 different countries (Australia(1), Belgium(1), France(1), Germany (2), Ireland (1), Switzerland (1). There was one bot account.

Themes/Categories of Descriptions

Ten categories of descriptions representing keys aspects of Twitter as a conference backchannel emerged from the analysis of the Twitter datasets of the five conferences examined in this study. These categories are:

1. Promote/Highlight Own Work
2. Promote/Highlight Work of Others
3. Share Information/Resources
4. Promote Online Conference as an Inclusive, Connected Space
5. Seek out Opportunities to Connect with Others
6. Identify Future Learning Opportunities
7. Share Personal Impression, Summaries and Commentaries
8. Highlight Researchers
9. Commend Others
10. Express Personal Feelings and Interest
11.

Together, these ten categories, further organised as four overarching themes (Table 4), represent a model that offers reasons why computer science education researchers and educators engage Twitter for conferences.

Table 4: Themes and Corresponding Categories

Themes (1-4)	**Categories (1-10)**
Promote Scholarship	1. Promote/Highlight Own Work 2. Promote/Highlight Work of Others 3. Share Information/Resources
Connect, Promote and Extend the Research Community	4. Promote Online Conference as an Inclusive, Connected Space 5. Seek out Opportunities to Connect with Others
Engage in Professional Learning	6. Identify Future Learning Opportunities 7. Share Personal Impression, Summaries and Commentaries
Humanise the Conference Space	8. Highlight Researchers 9. Commend Others 10. Express Personal Feelings and Interest

This section presents the themes and categories using data points the Twitter datasets analysed.

Theme 1 – Promote Scholarship

Promoting the scholarly work of the research community is the most common activity among computer science educators and scholars using the Twitter as a conference backchannel. This promotion relates to personal work but also that of other scholars. Promoting the work of others appear to be more common than promoting personal work but this requires a closer examination. Information sharing is also a major aspect of scholarship promotion.

Category 1: Promote/Highlight Own Work

The use of Twitter to promote personal and collaborative scholarly work is an activity of computer science education researchers during conferences.
The Tweet below from the CCERS20 conference highlights one participant promoting their work by outlining the topic, a brief summary, and an accompanying link to more information:

> Great being able to present my poster on [topic] at the … #ccers20

From ICER2020, one participant commended a co-author about the quality of a presentation and the value of their research:

> OMG, the talk that Yim created for our work on learning machine learning for self-advocacy was overwhelmingly cute, stunningly clear. Yim's discoveries are exciting too: personalize data for better learning! Video: https://t.co/G0q5bgqlVc Paper: https://t.co/ASKHMTMlF9 #ICER2020

In ITICSE2020, one participant highlighted the commencement of a new piece of group work, indicated future directions, and encouraged others to share information of value to the project:

> Our #iticse2020 working group on meaningful assessment at scale is starting serious work today! Wonderful to take some time to focus on such an interesting topic. We'll be gathering case studies - please send our way! #assessment #cseducation @nickfalkner @RebeccaVivian

Another participant from ITICSE2020 promoted their work by offering a brief summary with accompanying links to video and other resources:

> Check out our #ITiCSE2020 paper on student code & their understanding: https://t.co/VD5wMf6pzD, slides: https://t.co/wgJTuOIFYU, & video presentation: https://t.co/5yA6P5up5n https://t.co/4O3K0c8AVr

Participants at conferences are generally open to sharing their own work and to convey their sense of excitement and satisfaction to the wider research community. They promoted their work with a brief summary and also expressed excitement and satisfaction about their presentation

Category 2: Promote/Highlight Work of Others

Similar to the promotion of personal work, the promotion of the work of others was evident among conference participants.
Keynote speakers and their presentation was shared by a participant of ICER2020:

> A wonderful keynote from Tim Bell. Build #csed teachers' self-efficacy. Tons of inspiring takeaways. https://t.co/o89RvUE1eq #ICER2020

In addition to sharing from keynotes, participants shared information about papers and presentations along with the names of presenters, as is noticeable from CCERS20:

> survey presentation regarding female A Level student perceptions by [author] #CCERS20

Participants are keen to highlight their personal affiliation to others when sharing as highlight in the following Tweet:

> If you want learn more about how students transition between PLs, check out my awesome friend @EthelTshukudu's #ITiCSE2020 paper. :) https://t.co/Xrqifcua3Z

In one instance, a participant of ICER2020 created and shared links to an extensive report of the entire conference using the conference hashtag:

> My #ICER2020 virtual conference trip report! You know what? I think it worked: unlike all past virtual conferences I've attended, this time I felt a real sense community, serendipity, and connection. On to #ICER2021! https://t.co/sGFv7LeQxc

Participants shared a range of information related to the work of others. These included summaries, links and related resources about paper, and actual names of presenters.

Category 3: Share Information/Resources

To compliment information shared when promoting personal work and that of others, participants also shared additional information related to the conferences.

These resources included links to websites:

> #wipsce2020 #wispsce20 Some great resources being shared https://t.co/XVTBztVspR https://t.co/UBwjnPkwmm https://t.co/AKf0QCJqnz @StefanSeegerer @cs4fn @TeachingLDNComp https://t.co/nbXBcNgeEL

And link to free conference proceedings:

> Proceedings of the 2020 ACM Conference … #ITiCSE2020 [URL]

Theme 2 – Connect, Promote and Extend the Research Community

Category 4: Promote Online Conference as an Inclusive, Connected Space

The online conference space has provided a means to include others in the research community. Two participants highlighted how this space facilitated their participation for those who could not attend in person:

> would not have made it to #icer2020… happy it is online and I get to see/hear people I normally only read about.

> #ICER2020 lots of people here that wouldn't have come in-person otherwise. A cool benefit of being online - inclusivity! Though the time zone issues...

Another participant expressed how connectivity is facilitated by the many different platforms available including Twitter:

> Even though there's no face to face communication, I'm impressed by how people have used different platforms to maintain social connections during #ITiCSE2020: in the past few hours I've used Moodle, Slack, Twitter, Zoom, iMessage and Jitsi to discuss proceedings and make plans!

Overall, the Twitter online conference space extended the reach of conferences by allowing otherwise absent but interested participants a means to connect with the community and to engage with conferences.

Category 5: Seek out Opportunities to Connect with Others

Several participants used the Twitter conference space to document their interest in connecting with others for personal and professional reasons. One participant indicated the possibility of connecting virtually with potential collaborators:

> Same. Most of my reason for attending #SIGCSE2020 is to meet with prospective authors, which can be done virtually. Haven't cancelled flights yet but leaning that way. :/

Another participant used the space to extend an invitation to others to get in touch if they had questions about their presentation:

> Has been a lovely morning listening to many great talks. Thanks for all the useful comments and positive feedback! Do get in touch if you have more questions about CTC. #ccers20

Yet other participants were interested in meeting up with others for social reasons:

> @suesentance @NALooker @cs4fn Paul Curzon @TilmanMichaeli @StefanSeegerer see you at the #WiPSCE2020 bar in GatherTown- such fun! What time are you arriving on Wed the 28th??? Who else is coming? (@quintincutts - is there dancing ;) ? https://t.co/N9dNSrAfd9

Participants used the Twitter space to express their desire to connect with others for social reasons and to discuss the potential for collaboration.

Theme 3 – Engage in Professional Learning

Deliberate engagement in professional learning opportunities was observed among participants in each of the five conferences. Three elements of engagement related to professional learning were identified. These relate to the identification of learning opportunities and through sharing personal impressions, summaries and commentaries.

Category 6: Identify Future Learning Opportunities

Participants identified opportunities for future personal learning engagement and for their teaching. In one instance, a participant in CCERS20 noted missing an important personal activity to attend the conference. They indicated that they would compensate for this by discussing all the presentations:

> I've written off the home schooling today. Will make up for it by discussion all the interesting presentations from today's conference #ccers20 https://t.co/EGItw2vp5Y

Another participant in the ITICSE2020 conference made a personal commitment to use a video of a keynote to teach:

> if this closing keynote is posted to YouTube, use it in a CS Ed course … #ITiCSE2020

In the same conference, a participant indicated interest in learning more about a particular topic after a panel discussion:

> Panel discussion looking at how computing is integrated into disciplines across K-16 education at #iticse2020. Interested to hear perspectives from elementary right up to university education.

Another participant indicated downloading conference papers for future reading:

> Happily downloading #ICER2020 papers for later reading https://t.co/e7duJdIG3I Hey CS teachers - some great stuff here.

Several opportunities for learning along with the possibilities for using conference resources as part of professional work activities were identified by participants.

Category 7: Share Personal Impressions, Summaries and Commentaries

Participants created and shared personal impressions, summaries and commentaries from presentations they attended.

The following Tweet from CCERS20 highlights a summary of a presentation on the value of code clubs:

> Extracurricular code clubs are an important route into the subject for many children. When code club leaders were asked "Who has more...", it highlights the need consider that different students will have different needs, for example shown by @feniaiv as a gender divide #ccers20 https://t.co/vVXrNZVdcr

One participant from ITICSE2020 shared a commentary about understanding a concept as the Tweets following highlights:

> Paul Dickson helped me understand notional machine. It's an abstract way of representing the inputs and outputs of a machine with the right amount of detail for what matters to your Ss. paper: https://t.co/SUvEJd9gnE #ITiCSE2020

Commentaries may also be directed to participants and with suggestions for action:

> #ccers20 @ProfTomCrick Tom Prickett - I wondered if research on locus of control might be interesting for your super research on CS undergrad 1st-year success and grit and persistence - crazy findings here ... https://t.co/QhVAD6ED02

Theme 4 – Humanise the Conference Space

Participants used the Twitter backchannel to add a very personal and human touch to conferences. By highlighting researchers, adding commendations, and by expressing their own feelings and interests, participants extended the conference space beyond its academic nature.

Category 8: Highlighting Researchers

In highlighting the creative work of a presenter, one participant shared the feeling of being in a cultural:

> @user presented a great poster on how [topic] #ccers20 … feel like I'm at a cultural event!

Another participant identified a team of multidisciplinary researcher and expressed how enriching cross disciplinary work can be:

> A research conducted by a multidisciplinary team... Great job! @ManuelNinaus @k_tsarava #ITiCSE2020 Crossing disciplines brings a real enrichment 😉 #Educ0Num https://t.co/QWiQthXF67

Highlighting the work and affiliation of early career researchers can be viewed as a signal of recognition and care from the research community:

> Ethel Tshukudu from the University of Glasgow is studying transfer from one programming language to the other as part of her PhD - interesting talk at #ccers20

The use of the words ‘beautiful’ and ‘heart’ in the following Tweet is an explication that is a representation of the conference space being used to recognise personal qualities not separate and independent of their academic work:

> Tim Bell's #ICER2020 keynote was beautiful! Always so much heart in his talks! At home version of #CSUnplugged activities -- https://t.co/PHrnGoeJiw

While highlighting researchers, conference participants described the whole selves of those academics while pointing to the value and unique contributions of their intellectual work.

Category 9: Commending Others

The Twitter backchannel was used by participants to express thanks, gratitude and commendations for their work. A sample of Tweets show the personalised nature of this appreciation as named presenters are commended for their contributions:

> #ccers20 ... Can I commend this excellent work by @user

> Thanks [author] for a great explanation on the need for [topic] … #ccers20

Participants also expressed in several instances how their gratitude was related to their own learning and the benefits gained.

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Category 10: Expressing Personal Feelings and Interests

Participants expressed their own feelings and interests towards the conferences they attended and the presentations they delivered themselves or attended. The following Tweet highlight a participants' eagerness and anticipation of an upcoming conferences:

> So delighted to get to attend #icer2020 from the comfort of my own home (it's hosted in new Zealand this year). Really interesting talks, looking forward to a great week ! https://t.co/JlKqq4Sm88

In some instances, participants expressed appreciation to those who supported their presentations:

> First #icer2020 … Thank you to everyone who came by, chatted, asked questions, and followed up afterward.

However, not all experiences were entirely without effort and challenges as one participant indicated feeling tired after attending late night presentations:

> Tired… after a late one last night at virtual #ITiCSE2020 … every moment was worth it.

Self-expressions and reflections were commonly shared by conference participants as the above Tweets suggested, indicating the opportunity the backchannel affords for expressing personal feelings and views.

Discussion

Using a grounded theory methodology, this study examined how computer science education researchers and educators used Twitter as a conference backchannel in five conferences. Four themes and ten categories emerged from the analysis and together they describe a model showing how computer science education researchers used Twitter as a conference backchannel. These themes are: Promote Scholarship; Connect, Promote and Extend the Research Community; Engage in Professional Learning; Humanise the Conference Space. A discussion of teach theme is presented below.

Promote Scholarship

Participants of the conference backchannel engaged extensively in the promotion of scholarly work presented at the various conferences. Participants presented their own work, those of others and also shared various resources. Previous studies of the Twitter conference backchannel but outside the computer science education research domain have reported similar findings (Greenhow, Lai & Mai, 2019; Kimmons & Veletsianos, 2016). Stewart (2015) found similar scholarly promotional activities of users of Twitter in general. This evidence shows that scholars are willing to engage in public scholarship and to build public identities (Stewart, 2016). In particular, for early career researchers, scholarly reputation is an important element in their development and digital spaces and online scholarly communities like the Twitter conference backchannel may provide opportunities for improved visibility and maximisation of research impact (Nicholas et al., 2018).

Connect, Promote and Extend the Research Community

The Twitter conference backchannel facilitated a connectedness among participants. This is visible both in the patterns of Tweeting and by the content of communication among participants. The Mentions and MentionsinRetweet are both types of Tweets that include the reference (or mention) of other users and are indicative of the number of direct connections participants created to others. Participants themselves have indicated interest in meeting others they are already familiar with and new connections with whom they can explore collaborative opportunities. Connecting with other scholars is an important element to digital scholarly practices, as it can influence social capital and online networks according to Costa (2014). Networking engagements themselves are found to broaden scholarship by fostering extensive cross-disciplinary connections and collaborations among individuals (Stewart, 2015).

However, this study also noted the relatively low level of dialogic and conversational engagements indicated by the very low levels of direct replies to the Tweets of others. Engagements were more oriented towards dissemination or reporting (Williamson & Ruming, 2018) as reflected by the number of Tweets and Retweets. This low level of dialogic engagement is a kind of participatory gap as Jenkins (2007) suggested, with participants perhaps not possessing the literacies to engage in this element of open scholarship (Veletsianos & Kimmons, 2012).

Engage in Professional Learning

The engagement in activities related to learning gains were visible among participants in this study. Participants provided summaries, offered commentaries and their personal impressions of the presentations they were following. This finding is consistent with those of previous studies addressing the Twitter conference backchannel specifically (Greenhow, Lai & Mai, 2019) and from using Twitter in general (Singh, 2020; Veletsianos, 2012). The study also showed that participants identified opportunities for future learning, signalling that their conference experience extends beyond the conference schedule. One possible reason for scholars openly sharing their learning is to provide others with access to their ‘expertise and knowledge’ (Gilbert & Paulin, 2015; Li & Greenhow, 2015) and to formation and development of their digital and scholarly identity (Greenhow & Robelia, 2009; Kozinets, 2010; Li & Greenhow, 2015; Stewart, 2016).The development of identity by exposure to opportunities for learning is especially important as it has implications for academic career development (Zacher, Rudolph, Todorovic, & Ammann, 2019).

Professional development and learning networks are highlighted as key elements to the development of computer science education. Crick et al. (2021) highlighted some of the challenges early career academics encounter in computer science education and noted that access to communities of practice both at the national and international levels are important for their development. This study highlights the potential of the Twitter conference backchannel to connect members of the computer science education community. For early career academics in the computer science education, the Twitter backchannel may offer opportunities for networking with other early career and more senior academics and researchers, mentoring and support which may help address some of the challenges highlighted by Crick et al. (2021). For teachers alike, the Twitter conference backchannel is also potentially useful for engaging in professional learning related to the latest research in computer science education, and to connect with other practitioners and researchers (Cutts, Robertson, Donaldson & O’Donnell, 2017; Menekse, 2015).

Humanise the Conference Space

It is evident that many participants saw the backchannel as a more exclusively academic space reserved for scholarly discourse. To humanise this space – to add the human and personal touch - participants highlighted researchers, offered commendations and appreciation for the work of others and also expressed their own feelings and interests. In a previous study, this 'slippage between the personal and the professional' (p.75) accounted for participants' expressions of care as observed by Stewart (2016). Participants in this study reported receiving explicit attention of care as they engaged in their networks and that networks served as 'valuable sites of belonging and meaning' (p.75). Stewart (2016) also found that commendations or public recognition draws attention to the recognised individuals in very visible ways. This visibility may serve to highlight otherwise invisible or marginalised scholars and those from minority groups.

Conclusion, Limitation, Future Work, and Implications

This study highlighted four ways in which computer science education researchers and educators benefitted from and contributed to the conference arena. These findings underscore the utility of Twitter as a space for extending the research of conferences in computer science education and a demonstration of the commitment of participants to expand their own reach, highlight other scholars, and to provide support for presenters. These themes are a demonstration of the "various strategies of visibility and identity expression" (p. 24) that participants engage with in order to establish relationships and status (Kozinets (2010).

Though several studies have investigated the use of Twitter as a conference backchannel across several domains, this study is the first to examine computer science education. The findings in this study suggest that the computer science education conference backchannel is potentially a useful space for professional development for researchers and teachers alike.

While previous studies have engaged with theory in exploring the Twitter backchannel, this study is the first to employ a grounded theory approach to understand this phenomenon. Though it falls short due to its scope, it offers a model as a starting point towards theory development in this context. In particular this has shown one new finding – that the Twitter backchannel is a humanising space – one that can be leveraged to further promote computer science education research.

Several limitations are to be noted in this study when its results are interpreted. These results of this study are for conferences held entirely online, which may be different for traditional offline conferences. The data from the conference hashtags may not reflect the entirety of participation on Twitter as others may have engaged without using the designated hashtags. Future work may explore other means of engagement on Twitter by participants. Notwithstanding these limitations, the findings of this study may yet inform the computer science education research community about approaches to extend the reach of conferences and to disseminate research findings to a larger audience of researchers, practitioners and policy makers.

Future studies can explore participants' use of Twitter when following exclusively online and offline conferences. This may help us understand differences of engagement between the two formats. This may shed further light on the universality of the model derived from this study.

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