**Crowdsourcing in Health Professions Education: What Radiography Educators Can Learn From Other Disciplines.**

**Introduction**

Recent studies at colleges and universities have shown that applying crowdsourcing to education can be fruitful for both students and teachers 1. Furthermore crowdsourcing in higher education can potentially result in a more personalised education and learners can access the best learning material 2. The purpose of this paper to explore how healthcare educators are using the tool and if it can be applied in a radiography education context.

Coined by journalist Howe in 2006, the phrase ‘crowdsourcing’ originates from the combination of the words “crowd” and “outsourcing”. Crowdsourcing works through an institution outsourcing a function normally performed by an employee or group of individuals 3. Within the crowdsource, users known as the crowd form an online community who voluntarily undertake a task, online, which typically involves the pooling of knowledge resources, and in which mutual benefit is experienced 4. Hence the advantages of crowdsourcing is that it is easy to access a large pool of participants for a research problem, it offers time savings as a large number of contributors work in parallel and this can support lower labour costs. Furthermore, crowdsourcing is associated with innovative activities through collective solution finding which is due to the large network of potential users. There are also benefits for the participants. Through being part of a crowdsource, the user receives satisfaction of economic benefit, social recognition, self-esteem and/ or the development of individual skills 5.

The notion of crowdsourcing continues to evolve. In the digital age crowdsourcing involves an open-call through participatory online activity, providing a wider access to people internationally in less time and at a reduced cost than traditional methods 6. However traditional outsourcing has been used for centuries. Furthermore the practice of using the “wisdom of the crowd” can be traced back to Aristotle in the 4th century who explored the concept in his work titled “Politics” 7. Other significant pre-technology crowdsourcing events include the development of the [marine chronometer](https://en.wikipedia.org/wiki/Marine_chronometer), by John Harrison in 1774 an innovation which came to fruition through the government sponsored longitude prize 8.

Examples of applying this tool in the digital environment for UK health projects include the “Allied Health Professions into Action: Using Allied Health Professions to transform health, care and wellbeing” on-line resource 9 and the “Mind the Gap” project 10. Further ongoing activities include the “Health Education England Academy of Advanced Practice” programme 11 and the “Role of Allied Health Professions in Mental Health Service Provision 12” crowdsourcing initiatives. In these examples, crowdsourcing provides a data collection method in generating an accurate representation of statements whose contents are shared, broadly agreed and useful in achieving common goals within the setting under investigations 13. For “AHPs into Action” through using the “Clever Together” platform 14, 16,000 healthcare practitioners and members of the public across diverse geographic locations were involved in the resource design. Subsequently the publication highlighted a clear view of the transformative potential of AHPs, examples of innovative AHP practice and a framework to develop local delivery plans. In contrast, the “Mind the Gap” project looked at the experiences of millennials working for the UK National Health Service (NHS) in the West Midlands region. This campaign received 276 contributions. From these action points were delivered on how to support the careers of these health care professionals.

However crowdsourcing is not without challenges and historically the term crowd has conjured negative meanings e.g. riots, mob mentality, looting 15. Administrators of a crowdsource need to be aware of crowd-hijacking where a group respond to the initiative to pursue its own agenda 16. An example of a failed crowdsourcing activity in popular media is the Natural Environment Research Committee (NERC) requesting that the public be involved with the naming of their new research vessel, the most popular name being Boaty Mcboat face 17. Despite these challenges, carefully executed crowdsourcing campaigns can be valuable exercises that allow organisations to engage with stakeholders to elicit new ideas.

The objectives of this narrative review are:

* To provide a synopsis of current research in how crowdsourcing is applied in health professions education
* To review identified papers against an established crowdsourcing definition
* To explore how crowdsourcing could be applied to radiography education
* To suggest ways in which a crowdsource could be implemented in radiography education research.

**Methods**

The literature search alongside the initial groupings and analysis of identified papers was carried out by the lead article author. The lead author is a white, working-now-middle class, ethnic minority disabled female, who is a UK registered diagnostic radiographer with a decade of experience as a formal radiography educator in both the private sector and Higher Education where they have attained a teaching qualification and Fellowship of the Higher Education Academy. Her current role is as an academic director overseeing student journey for eight healthcare professions across fifteen programmes of study. She is also a doctorate candidate investigating inclusive curriculum design processes in pre-registration diagnostic radiography education using a participatory action research approach.

Using a framework to encapsulate the research question or problem aids the researcher in finding relevant evidence in the literature. Furthermore by using an objective tool it helps to address bias and ensure trustworthiness. For this search a SPIDER framework was adopted. SPIDER elements include: Sample; Phenomenon of Interest; Design; Evaluation; Research type. SPIDER is considered an alternative to PICO in health research as it more inclusive of qualitative and mixed methods research’ 18. Keywords adopted were: crowdsou\*; wisdom of the crowd; crowd capital, collaboration; education; radiography education. To increase the sensitivity of the search, Boolean logic was used linking words such as “OR”; “AND” and “NOT” 19. 2006 to present day was selected as the date for searching to reflect the identifiable date when crowdsourcing was first described as an on-line activity thus distinguishing the tool from traditional outsourcing.

The search was carried out using on-line electronic databases 20 subscribed to by the Swansea University Medical School library portal. These included Health, Medical and Education databases- Medline, the Applied Social Science Index and Abstracts (ASSIA), the Cumulative Index of Nursing and Allied Health (CINAHL), Science Direct and ProQuest Education. Zero articles were returned relating to crowdsourcing in radiography education. This was deemed significant as it indicated a gap in the literature. As it was considered that the findings from the education literature of other health professions could be generally applicable to radiographers the search was broadened to include other nursing, midwifery allied health professions and radiography. Again there were zero returns. Subsequently the search was widened further to include medical education. This returned 68 articles.

As electronic databases can have both geographical and language biases a hand search was also conducted in journals that would most likely yield relevant articles 20. A “snowballing” technique was also utilised to identify relevant articles included in the reference list of assessed articles thus helping to recognise any articles which may have been previously missed 21. This resulted in two further articles being located. Literature searching was not confined to published articles and included information arising from non-research papers, editorials, letters to the editor, discussion documents and previous thesis in this area. Given the nature of crowdsourcing as an open source tool- Google Scholar and ResearchGate were also utilised. This yielded one unpublished thesis.

The overall search resulted in 71 papers. Two review papers were removed 22, 23. The remaining 69 abstracts were screened. 49 were discarded as the content was not relevant to the review objectives. The Doctorate thesis was not included as the full thesis was embargoed 24. From here 19 articles were assessed for quality using the Medical Education Research Study Quality Instrument (MERSQI) 25. This tool has been validated as a reliable tool for appraising methodological quality of medical education research 26. Subsequently 17 articles remained 27-43.

Study background information (authors, year, journal, and methodology) was collected for each article. Data regarding crowdsource aims, sample numbers, crowdworkers, crowd motivation and study location were also documented. The papers were read and categorised by theme by the lead author with groupings representing educational context, lesson planning, instructional material design, assessment identified- table one (27- 43). Of these one paper examined lesson planning, three addressed instructional material design, eleven concentrated on the role of crowdsourcing in the assessment of basic non-complex surgical skills and a further two studies focused on the recruitment of learners onto a surgical training programme.

The lead author has experience of narrative literature reviews as part of assessed course work and previous publications. However she acknowledges a bias towards this method of inclusive co-creation given it is the tool that will be used for her Doctorate work and her personal values. Hence a summary of the papers together with the initial categories developed were presented to the local monthly *“Research in Health Professions Education (RiPHE)”* research group meeting for sense checking. This group includes professors, researchers, lecturers and doctorate candidates working in the field of health professions education. Three of the article authors are members of the group. The lead author is the only radiographer within the group. Other professions represented are biomedical science, midwifery and medicine and the level of research experience within the group ranges from novice to international discipline experts. Following discussion the research group confirmed the categories presented.

Crowdsourcing is a recent concept and as the tool evolves varying definitions have developed. It is deemed important to propose a definition of crowdsourcing so as not to confuse this with crowdlearning which is associated with platforms such as wikis, crowdtuition which can be used to fund individual tuition fees and crowdfunding to raise monies for educational infrastructures.

To determine how the term ‘crowdsourcing’ is used in health professions education, a crowdsourcing definition and typology was applied to the articles. As no definition is available in the literature specific to health professional’s education, a definition from another research field was adopted 4 –table 2. This definition, developed by Estelles-Arolas and Gonzalez-Ladron-de-Guevara 4, is the only one available relating to crowdsourcing and was developed following the systematic review of six scientific databases. From the 209 documents reviewed, 40 unique definitions of crowdsourcing were identified and used to develop a final 8-point classification tool, which defines ‘crowdsourcing’. However using this typology meant that three papers did not meet this established definition of crowdsourcing (shaded grey in table one) 27, 28, 29. All of these related to instructional material design- as they did not use the on-line environment to apply the crowdsource nor was the assigned task completed in the on-line environment.

Through carrying out this exercise it became apparent that the term *‘crowdsourcing’* in health professions education does not strictly meet a definition as established in the literature by Estellles-Arolas and Gonzalez-Ladron-de-Guevara 4. This is because the literature used to devise their definition has been drawn from business and human science literature and the health professions education articles yielded by this search were published after the definition was developed. As a result some of the nuances of crowdsourcing in health professions education as an emerging application may potentially be lost i.e. the space in which the crowdsource happens, the composition of the crowd and motivation of the crowd. Yet in the absence of another definition 4 it does provide an outline of how crowdsourcing differs from traditional group consensus techniques i.e. focus groups, nominal group techniques and the Delphi method hence the reason it was applied.

**Results**

The decision was made by the authors to include the initial seventeen articles identified so as to address the review question. The following offers a description and analysis of these.

The lesson planning paper, written by Penciner 30, describes how crowdsourcing had been used at an international emergency medicine conference to guide the delivery of a group conference session. Penciner29 acknowledged that in traditional conference proceedings it is assumed that a single presenter has knowledge to share with the group. Hence conference session titles and content are predetermined by a single expert or narrow group of individuals. In this instance the crowd attending the session were asked to submit three problems, controversies or questions to be discussed at the timetabled sessions. During the session the facilitator posed questions from the submitted lists. Rather than teach, the researcher facilitated the discussions. The study concluded a facilitated crowdsourced discussion can be used to harness collective wisdom and expertise from the crowd.

However the study does have limitations as the definition of expert is complex with participants self-reporting their level of expertise. Furthermore there are challenges with ensuring all voices are heard which is evident when comparison was made in this study 29  between the number of contributors to the crowdsource activity and the frequency of their contributions with some being more active than others. This “power law distribution” 44 or group dominance is important to note as one of the advantages cited for crowdsourcing as a group consensus technique is that it does not adopt a hierarchal management process. Therefore it is deemed more inclusive than face to face alternative techniques including focus groups 45 nominal group technique 46 andInteracting Groups 47. However the authors of this review acknowledge that it is not always desirable or possible to have equity of participation and just because someone isn’t verbal doesn’t mean they aren’t learning.

The largest yield of papers 31-43 addressed assessment of simulation surgical skills through crowdsourcing. Here learners preformed simple simulated surgical tasks including open square knot tying, surgical drills, laparoscopic peg transfer and robotic suturing. These were recorded and the videos were reviewed by crowd workers who worked for freelancing sites such as Amazon Mechanical Turk 48 and C-SATS 49 (Crowdsourced Assessment of Technical Skills). The outcomes of their assessment grading was compared to that of expert assessors. These papers acknowledged that although the employed crowd lacked demonstrable expertise within the relevant fields, the distribution of the wisdom of the group brought advantages of efficiency, scalability and flexibility to assessing learners. Moreover the crowdsourced “non-expert” feedback appeared to be comparable to expert feedback. It is however noted that on evaluating these papers research is still needed to increase consistency in expert evaluations, to explore sources of discrepant assessments between surgeons and crowds, and to identify optimal populations and novel applications for this technology.

The next group of papers related to educational instructional material design 27, 28, 29 with two of these studies developing a pool of resources through national networks. Of particular note is the development of the RADExam project in America which sought to develop a web based bank of 3,000 test questions drawing inspiration from the framework used by Radiopedia, an on-line wiki based collaborative radiology resource 50. In these papers mutual benefit was highlighted as a key driver of the crowdsource activity. Volunteers were encouraged to engage voluntarily and in return they were encouraged to use the exercise for their continuous professional development portfolios. Limitations of the papers was the need to edit the large amount of data generated 29. Furthermore data was often submitted in rough form and needed editing and reviewing for scientific accuracy 28.

The remaining papers 42, 43 addressed the recruitment of learners onto a surgical training programme through the use of simulated tasks similar to those described in the surgical assessment papers. These papers followed a similar method to the aforementioned assessment of simulation surgical skills literature and also used paid crowdworkers to complete the assessment. This type of assessment was not a replacement but rather an adjunct to traditional selection techniques of academic qualifications, personal statement writing and interviewing.

**Discussion**

In trying to define what crowdsourcing is in healthcare professions education it became apparent whilst undertaking this review that there is a piece of work required with formulating a definition. Undertaking the review proved difficult as articles would use the term crowdsourcing but on further analysis this was not the case with papers often describing crowd learning or crowdfunding. The authors sought to address these challenges of a typology by applying an objective definition to fully understand the nub of crowdsourcing in the field of health professions education. However as highlighted this did not capture the nuances of healthcare education requirements.

Despite this observation, the authors propose that the themes identified in this literature review, could potentially be applied to radiography education. The papers presented give a useful insight into how and where these could be implemented and areas for further research. For example, crowdsourcing may provide alternative ways of co-creation of instructional materials, providing timely and cost-effective assessment feedback, and methods of student selection onto pre and post registration radiography programmes. Furthermore, through the application of crowdsourcing the allocation of resources dedicated to a task can be reduced.

Possible applications in radiography for consideration include:

* Assessing student during simulation based sessions with practical task focused skills i.e. positioning of phantoms/ mannequins for a radiographic examination or cannulation technique. This could be used as a formative assessment tool.
* Development of a national bank of teaching materials for shared subjects including anatomy, physics, radiographic technique
* Development of a national bank of examination questions including image interpretation
* Design of continuous professional development (CPD) lesson plans

Information pertaining to the crowd workers was limited in the reviewed articles an observation also highlighted in a systematic literature review of crowdsourcing in health published earlier this year 51. Some points that remain controversial include the unethical aspect of payment and treatment of crowdworkers. For example Amazon Mturk 49 tasks are often completed by a small set of workers who spend long hours on the website, many with low income. Furthermore there is no way of ascertaining the work environment at the vendor location 52. The authors of this review note Amazon MTurk is not the only provider of these services with alternate availability companies such as C-SATs 50 as noted in one returned article 42. Using this option of crowdworkers may help address the concern of ethical and fair payment.

In the introduction the authors highlighted the role of crowdsourcing as a group consensus technique in co-production of framework developments and resources 8-11. Yet no papers were returned that had adopted the tool in this way. This is deemed significant as the lead author is currently undertaking research which explores the use of crowdsourcing to encourage a broader range of stakeholders to help co-produce a new, relevant curriculum which will then contribute to curriculum change. This is in place of methods currently adopted in radiography education research in the area of competency and curriculum development which have historically used tools such as focus groups, nominal group and the Delphi technique 53 for this work.

Given the relatively novel use of crowdsourcing in health professions education, and the lack of additional unique studies identified through speaking with subject matter experts the authors are confident this is the most comprehensive review on the topic to date. However it is acknowledged there are several limitations to this study. This report has been written to review the role of this established business tool in the realm of radiography education. In doing so a gap in the radiography education literature has been identified. Hence a limitation of the piece is that the discussions presented are theoretical in nature and seek to highlight how radiography educators could potentially use crowdsourcing.

Another limitation is that the selection, review and analysis of the papers presented has been performed by a single reviewer thus creating a potential bias. To address this, a robust search strategy and a validated appraisal tool were adopted and the proposed grouping of articles was presented to a local health professions education research group. Furthermore the lead author drew up a positionality statement to ensure they were conscious of how their values and experiences would affect their interpretation of the findings including power dynamics and inclusivity 54.Finally while the authors acknowledge it is reasonable to draw parallels from other healthcare profession education research, it is noted radiographer skill sets do differ due to time-limited episodes of care 55.

As per the challenges described of mapping health professions education literature against an established crowdsourcing definition it might be appropriate to reconsider this definition, or identify one which has a better fit with health professions education.

**Conclusion**

Crowdsourcing is associated with innovative activities through collective solution seeking via a large network of active on-line users. As crowdsourcing in health professions education remains a novel tool, the review has highlighted gaps in the current evidence base. The majority of the studies identified used crowdsourcing as a means of assessment. The remaining papers hint at the potential of crowdsourcing to benefit other areas of health professions training and there is clearly a need to develop this potential further, e.g. in design of instructional materials and the development of education policy or procedures. No papers addressed the co-design capabilities of the tool. This application is of interest as the tool has been used in Health campaigns such as *“AHPS into Action”* and *“Mind the Gap”*. Therefore the authors conclude that by reviewing crowdsourcing in the context of wider health professions education opportunities exist for radiography educators to explore the role of the tool within their own field.

**References**

1. Turner, M. E, Pratkanis, A. R. Twenty-five years of groupthink theory and research: Lessons from the evaluation of a theory. *Organizational Behaviour and Human Decision Processes*. 1998, **73** (2): 105—115.
2. Loreneto, R. & Morant, M. Crowdsourcing in Higher Education. In: Garrigos-Simon, Gill-Pechuan, I, Estelles-Migeul, S. (eds). *Advances in Crowdsourcing.* Springer International Publishing, London, 2015. p.87-95
3. Howe J. The Rise of Crowdsourcing. *Wired Magazine.* 2006; 14(6): 1-4. Available from: <http://sistemas-humano-computacionais.wdfiles.com/local--files/capitulo%3Aredes-sociais/Howe_The_Rise_of_Crowdsourcing.pdf> [Accessed 01st Feburary.2018]
4. Estellés-Arolas E, Navarro-Giner R, González-Ladrón-de-Guevara F. Crowdsourcing Fundamentals: Definition and Typology. In: Advances in Crowdsourcing Springer, Cham; 2015, pp.33–48
5. Borras S, Edquist C. Education, Training and Skills in Innovation Policy. *Science and Public Policy*. 2014; **42**: 215–27
6. Schenk, Eric; Guittard, Claude (2009). Une typologie des pratiques de Crowdsourcing: L'externalisation vers la foule, au-delà du processus d'innovation. *Management International.* 2012 **16**; 1-28
7. Lord, C (ed). *Aristotle’s Politics.* 2nd. ed. Chicago: University of Chicago Press. 2013.
8. Hern, C, G.(2002). *Tracks in the Sea*, p. 123 & 246. McGraw Hill: United States of America, 2002.
9. NHS England. *Allied Health Professions into Action*. Available from: <https://www.england.nhs.uk/ourwork/qual-clin-lead/ahp/> [Accessed 09th May 2018]
10. Health Education England. *Mind the Gap: Exploring the needs of early career nurses and midwives in the workplace*. 2017 Available from: <https://www.hee.nhs.uk/sites/default/files/documents/Mind%20the%20Gap%20Report.pdf> [Accessed 14th April 2018]
11. Health Education England. Academy of Advanced Practice. 2018 Available at: <https://advancedpractice.clevertogether.com/welcome> [Accessed 02nd November 2018]
12. Health Education England. Role of Allied Health Professions in Mental Health Service Provision. 2018. Available at: <https://www.ahpnw.nhs.uk/cpd/8-news> [Accessed: 02nd November 2018]
13. Aitamurto, T. Crowdsourcing as a Knowledge-Search Method in Digital Journalism: Ruptured Ideals and blended responsibility. *Digital Journalism,* 2016; **4** (2): 280-297
14. Clever Together. Clever together crowdsourcing platform. (2018) Available at: <https://www.clevertogether.com/web/> [Accessed 03rd April 2018]
15. Prpić, J, Taeihagh, A, Melton, J. The Fundamentals of Policy Crowdsourcing. *Policy & Internet,* 2014; **7** (3): 340–361
16. William E, Carter M, Carter S. Wayback Machine. *American Scientist.* 2012. Available from: <https://web.archive.org/web/20120220051000/http://americanscientist.advertserve.com/servlet/view/banner/javascript/html/zone?zid=6&pid=0&random=94556592&millis=1507200083073> [Accessed 15th April 2018].
17. Wilson, M, Robson, K, Botha, E. Crowdsourcing in a time of empowered stakeholders: Lessons from crowdsourcing campaigns. *Business Horizons.* [2017; **60** (2](http://www.sciencedirect.com/science/journal/00076813/60/2)): 247-253
18. Cooke, A, Smith, D. Booth, A. [Beyond PICO: The SPIDER tool for qualitative evidence synthesis *Qualitative Health Res*, 2012, **22** (10) 1435-1443](http://qhr.sagepub.com/content/22/10/1435.long#cited-by)
19. Marshall, G. Critiquing a Research Article. *Radiography*. 2005, **11**; 55-59.
20. Torgersen, C. *Systematic Reviews.* Continuum International Publishing Group: New York, 2003
21. Hart, C**.** *Doing Your Masters Dissertation*. London: Sage Publication; 2005.
22. Katz, A. J. The Role of Crowdsourcing in Assessing Surgical Skills: Review Article. *Surgical Laparoscopy, Endoscopy and Percutaneous Techniques.* 2016. **26** (4); 271:277
23. Dai, J., Lendavy, T., Sorenson, M.D. 2017, Crowdsourcing in Surgical Skills Acquisition: A developing Technology in Surgical Education. *Journal of Graduate Medical Education.* 9 (6): 697-705
24. Grichanick, M. Many hands make light work: Crowdsourced ratings of Medical student OSCE Performance. (2017). Available from: <http://scholarcommons.usf.edu/etd/6706/> Accessed: 03rd February 2018]
25. Reed DA, Cook DA, Beckman TJ, et al. Association between funding and quality of published medical education research. *JAMA.* 2007; **298**(9):1002
26. Cook, D. A. Reed, D.A. Appraising the quality of medical education research methods: the Medical Education Research Study Quality Instrument and the Newcastle-Ottawa Scale-Education. *Academic Medicine*, 2015; **90** (8), pp 1067-1076
27. Bow, H.C, Dattilo, J.R, Jonas, A.M, Lehmann, CU. A crowdsourcing model for creating preclinical medical education study tools. *Academic Medicine : Journal of the Association of American Medical Colleges*. 2013, **88** (6):766–70
28. Blackwell, K, Travis, M.J, Arbuckle, M. R, Ross, D. A. Crowdsourcing Medical Education. *Medical Education.* 2016, **50** (5): 57
29. Lewis PJ, Nyberg E, Cayere J, Valle A, Davis LP. Educational Crowdsourcing: Developing RadExam. *Journal of the American College of Radiology.* 2017, **14** (6): 800–803
30. Penciner R. Crowdsourcing: An instructional method at an emergency medicine continuing education course. *Canadian Journal of Emergency Medicine.* 2015, **17**(4):433-436
31. Chen C, White L, Kowalewski T, Aggarwal R, Lintott C, Comstock B, et al. Crowd-Sourced Assessment of Technical Skills: a novel method to evaluate surgical performance. *Journal of Surgical Research,* **187** (1):65–71.
32. Holst D, Kowalewski TM, White LW, Brand TC, Harper JD, Sorensen MD, et al. Crowd-Sourced Assessment of Technical Skills: Differentiating Animate Surgical Skill through the Wisdom of Crowds. *Journal of Endourology.* 2015, **29** (10):1183–8
33. Aghdasi N, Bly R, White LW, Hannaford B, Moe K, Lendvay TS. Crowd-sourced assessment of surgical skills in cricothyrotomy procedure. *Journal of Surgical Research.* 2015, **196** (2):302–306
34. Malpani A, Vedula SS, Chen CCG, Hager GD. A study of crowdsourced segment-level surgical skill assessment using pairwise rankings. *International J CARS.* 2015, **10** (9):1435–47
35. White LW, Kowalewski TM, Dockter RL, Comstock B, Hannaford B, Lendvay TS. Crowd-Sourced Assessment of Technical Skill: A Valid Method for Discriminating Basic Robotic Surgery Skills. *Journal of Endourology*. 2015, 29 (11):1295–301
36. Polin, MR., Sidiqui, NY, Comstock, BA, Hesham, H., Brown, C, Lendavy, TS, Martino, MA. Crowdsourcing: A Vaild Alternatve to Expert Evaluation of Robotic Surgery Skills. *American Journal Obstetrics and Gynaecological.* 2016; **215**(5): 644. E1-644.e7.
37. Deal SB, Lendvay TS, Haque MI, Brand T, Comstock B, Warren J, et al. Crowd-sourced assessment of technical skills: an opportunity for improvement in the assessment of laparoscopic surgical skills. *The American Journal of Surgery*. 2016, **211** (2): 398–404
38. Powers, Mk., Boonjindasup, A., Pinsky, M., [Dorsey P](https://www.ncbi.nlm.nih.gov/pubmed/?term=Dorsey%20P%5BAuthor%5D&cauthor=true&cauthor_uid=26597352), [Maddox M](https://www.ncbi.nlm.nih.gov/pubmed/?term=Maddox%20M%5BAuthor%5D&cauthor=true&cauthor_uid=26597352), [Su LM](https://www.ncbi.nlm.nih.gov/pubmed/?term=Su%20LM%5BAuthor%5D&cauthor=true&cauthor_uid=26597352), [Gettman M](https://www.ncbi.nlm.nih.gov/pubmed/?term=Gettman%20M%5BAuthor%5D&cauthor=true&cauthor_uid=26597352), [Sundaram CP](https://www.ncbi.nlm.nih.gov/pubmed/?term=Sundaram%20CP%5BAuthor%5D&cauthor=true&cauthor_uid=26597352), [Castle EP](https://www.ncbi.nlm.nih.gov/pubmed/?term=Castle%20EP%5BAuthor%5D&cauthor=true&cauthor_uid=26597352), [Lee JY](https://www.ncbi.nlm.nih.gov/pubmed/?term=Lee%20JY%5BAuthor%5D&cauthor=true&cauthor_uid=26597352), [Lee BR](https://www.ncbi.nlm.nih.gov/pubmed/?term=Lee%20BR%5BAuthor%5D&cauthor=true&cauthor_uid=26597352). Crowdsourcing Assessment of Surgeon Dissection of Renal Artery and Vein during Robotic Partial Nephrectomy: A Novel Approach for Quantitative Assessment of Surgical Performance. *Journal of Endourology*. 2016; **30** (4): 447-452.
39. Ghani KR, Miller DC, Linsell S, et al. Measuring to improve: peer and crowd-sourced assessments of technical skill with robot-assisted radical prostatectomy. European Urology. 2016; **69** (4):547–550
40. [Kowalewski TM](https://www.ncbi.nlm.nih.gov/pubmed/?term=Kowalewski%20TM%5BAuthor%5D&cauthor=true&cauthor_uid=26778711), [Comstock B](https://www.ncbi.nlm.nih.gov/pubmed/?term=Comstock%20B%5BAuthor%5D&cauthor=true&cauthor_uid=26778711), [Sweet R](https://www.ncbi.nlm.nih.gov/pubmed/?term=Sweet%20R%5BAuthor%5D&cauthor=true&cauthor_uid=26778711), [Schaffhausen C](https://www.ncbi.nlm.nih.gov/pubmed/?term=Schaffhausen%20C%5BAuthor%5D&cauthor=true&cauthor_uid=26778711), [Menhadji A](https://www.ncbi.nlm.nih.gov/pubmed/?term=Menhadji%20A%5BAuthor%5D&cauthor=true&cauthor_uid=26778711), [Averch T](https://www.ncbi.nlm.nih.gov/pubmed/?term=Averch%20T%5BAuthor%5D&cauthor=true&cauthor_uid=26778711), [Box G](https://www.ncbi.nlm.nih.gov/pubmed/?term=Box%20G%5BAuthor%5D&cauthor=true&cauthor_uid=26778711), [Brand T](https://www.ncbi.nlm.nih.gov/pubmed/?term=Brand%20T%5BAuthor%5D&cauthor=true&cauthor_uid=26778711), [Ferrandino M](https://www.ncbi.nlm.nih.gov/pubmed/?term=Ferrandino%20M%5BAuthor%5D&cauthor=true&cauthor_uid=26778711), [Kaouk J](https://www.ncbi.nlm.nih.gov/pubmed/?term=Kaouk%20J%5BAuthor%5D&cauthor=true&cauthor_uid=26778711), [Knudsen B](https://www.ncbi.nlm.nih.gov/pubmed/?term=Knudsen%20B%5BAuthor%5D&cauthor=true&cauthor_uid=26778711), [Landman J](https://www.ncbi.nlm.nih.gov/pubmed/?term=Landman%20J%5BAuthor%5D&cauthor=true&cauthor_uid=26778711), [Lee B](https://www.ncbi.nlm.nih.gov/pubmed/?term=Lee%20B%5BAuthor%5D&cauthor=true&cauthor_uid=26778711), [Schwartz BF](https://www.ncbi.nlm.nih.gov/pubmed/?term=Schwartz%20BF%5BAuthor%5D&cauthor=true&cauthor_uid=26778711), [McDougall E](https://www.ncbi.nlm.nih.gov/pubmed/?term=McDougall%20E%5BAuthor%5D&cauthor=true&cauthor_uid=26778711), [Lendvay TS](https://www.ncbi.nlm.nih.gov/pubmed/?term=Lendvay%20TS%5BAuthor%5D&cauthor=true&cauthor_uid=26778711). Crowd-Sourced Assessment of Technical Skills for Validation of Basic Laparoscopic Urological. *Journal of Urology*. 2016. **195** (6):1859-65
41. Yeung, C, Carillo, B., Pope, V, Hosseinpour, S, Gersstle, JT., Azzie, G. Video Assessment of Laparoscopic Skills by Novices and Experts: Implications for Surgical Education. *Surgical Endoscopy*.2016, **31**: 3883-3889
42. Vernaz, S. L., Huynh, V., Osann, K., Okhynov, Z, Landman, J and Calyman, R. CATs: Assessing surgical skills among Urology Residency Applications. Journal of Endourology. 2017; **31** (1)
43. Lee, JY, Andonoan, S., Pace, KT, Grober, E. Basic Laparoscopic Skills Assessment Study- Validation and Standard Setting Among Canadian Urology Trainees. *Journal of Urology.* 2017; **197**(6): 1539-1544
44. Shirky, C. Here comes everybody: the power of organising without organisations. New York: Penguin Press; 2008
45. Merton, R. K. & Kendall, L, P. The focused interview. *American Journal of Sociology,* 1946; **51** (6), 541-557
46. Delbecq, A. L., VandeVen, A. H. A Group Process Model for Problem Identification and Program Planning. *Journal of Applied Behavioural Science,* 1971, **7**; 466–91
47. Clayton, M.J. Delphi: a technique to harness expert opinion for critical decision-making tasks in education. *Educational Psychology,* 1997, **17** (4)
48. Amazon Mechanical Turk. MTurk: Amazon Mechanical Turk. (2018) Available at : <https://www.mturk.com/> [Accessed: 02nd May 2018]
49. C-SATS. C-SATS: How it works (2018) Available at: <http://www.csats.com/how-it-works/> [Accessed: 02nd May 2018]
50. Radiopedia. Available at: <https://radiopaedia.org/> [Accessed: 02nd November 2018]
51. Crequit, P., Monsouri, M., Benchouti, M., Viviot, A., Ravaud, P. Mapping of Crowdsourcing in health: systematic review*. Journal of medical Internet research,* 2018, **20** (5): e187
52. Ndubsai, N.O. & Nygard A. [The ethics of outsourcing: when companies fail at responsibility](http://scholar.google.co.uk/scholar_url?url=https%3A%2F%2Fwww.emeraldinsight.com%2Fdoi%2Fabs%2F10.1108%2FJBS-03-2018-0037&hl=en&sa=T&ct=res&cd=0&d=3222468284272437945&ei=eK7cW-2oAY6wmwGfsJ_oBA&scisig=AAGBfm0CVx4hNAZo8uVLEVqNOWVNnV9Qpg&nossl=1&ws=1051x518). Journal of Business Strategy. 2018 Available at: <https://www.emeraldinsight.com/doi/pdfplus/10.1108/JBS-03-2018-0037> [Accessed: 01st November 2018]
53. St. John-Matthews, J., Wallace, M. & Robinson, L. The Delphi technique in Radiography education research, *Radiography,* 2017, **23** (1), S53-S57.
54. Clarke, K.R. & Veale, B.L. Strategies to Enhance Data Collection and Analysis in Qualitative Research. *Radiologic Technology* 2018. **89** (5): 482-485
55. Reeves, P. *Models of Care for Diagnostic Radiography and Their Use in the Education of Undergraduate and Postgraduate Students*. PhD, University of Wales, Bangor. 1999. Available at: <http://e.bangor.ac.uk/4068/1/DX214131.pdf> [Accessed 02 November 2018]