A technical democracy design experiment: Making the UK exam algorithm controversy game

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Algorithmic system controversies are increasingly issues of concern for diverse publics plus a growing design challenge. For example, the 2020 UK exam controversy sparked wide-spread public debate about the role of algorithms in regard to not only student grading systems, but also the design of automated systems in the public sector. In light of this particular controversy, our study introduces a technical democracy design experiment *to examine algorithmic system controversies. We propose an iterative, collaborative design process specific to the study of algorithmic systems which informs our collaborative making of the UK exam algorithm game: a prototype to explore controversies, generate design things, deliberate ethical tensions, and spark thought collectives. This* socio-technical acts of contestation model *offers a novel and adaptable tool to interrupt public sector design possibilities in two key ways: first, to expand collective learning and experimentation about the political design of algorithmic system controversies; and, second, to support* agonistic design thinging *about emerging technologies associated with high stakes decision-making across society.*
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Keywords: democratic design experiments, agonistic design thinging, algorithmic system controversies, technical democracy, education

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1 *Introduction: Re-imagining algorithms, design, and participation*

Algorithms and automation are increasingly central to not only public sector design and decision-making, but also existing and emerging inequalities (Eubanks, 2018). However, incidences of algorithmic controversies spanning education, urban planning, and predictive policing and automated content moderation are becoming more prevalent (Goodman & Powles, 2019; Katzenbach & Ulbricht, 2019; Selwyn, O'Neill, Smith, Andrejevic, & Gu, 2021). Awareness about the potential role of participatory design to explore the accountability, transparency, and governance of such big data and algorithm-based systems is expanding (Whitman, Hsiang, & Roark, 2018). Yet recognising the uncertainty of public concerns and issues draws attention to the complex dynamics of technologies, participation, and society (Latour, 1999; Chilvers & Kearnes, 2019). Conflicting values associated with rapidly evolving algorithms, data, and artificial intelligence are therefore a central challenge for all sectors of society (Whittlestone, Nyrup, Alexandrova, Dihal, & Cave, 2019). Surfacing the critical design possibilities associated with emerging technologies requires re-imagining algorithms, design, and public participation.

This paper builds upon a 'democratic design experiments' (Binder, Brandt, Ehn, & Halse, 2015) approach which integrates participatory design (PD) and Actor-Network Theory (ANT) to explore how collaborative issues, publics, and designs emerge across society. This approach shifts the focus of design from finite objects to emergent 'design Things', 'things-in-the-making', or '*design thinging*' (Andersen, Danholt, Halskov, Brodersen Hansen, & Lauritsen, 2015; Binder et al., 2015; Bjögvinsson et al., 2012). Key characteristics of this process span infrastructuring, experiments and prototypes which circulate beyond the confines of a particular group, location, or project (Andersen, Danholt, Halskov, Brodersen Hansen, & Lauritsen, 2015; Binder et al., 2015; Bjögvinsson et al., 2012). Learning is collective, contingent, and continual: an ongoing experiment with emergent designs, objects, and concerns aligned with the following task: "to draw people together in a collaborative process of issue identification and possible action: *what is at issue here? What to do about it?*" (Lanng, Laursen, & Borg, 2022, p. 88). Democratic design experiments therefore seek to spark learning, experimentation, and dissensus beyond a particular project timeframe, product, audience, or 'solution'.

Aligned with this democratic design experiment ethos, the concept of *agonistic* design thinging is a synthesis of political design, science and technology studies, plus critical data studies which emphasises both social and technical contestations of emerging technologies. Agonistic studies of design, data, and algorithms seek to open up spaces for contestation (DiSalvo, 2012;

Björgvinsson, Ehn, & Hillgren, 2012; Crawford, 2016; Crooks & Currie, 2021). Drawing upon the notion of 'agonistic pluralism' (Mouffe, 2013), contestations and struggles associated with emerging technologies are key to understanding the political, social, and ethical impacts of algorithms. In turn, a democratic, adversarial design approach aims to surface bias and divisive positions, create opportunities to participate in disputes (over values, beliefs, and desires), plus model alternate socio-material configurations and future possibilities (DiSalvo, 2012). A key feature of such political design is to "create spaces for the confrontation of power relations and influence by the identification of new terms and themes for contestation and new trajectories for action." (DiSalvo, 2010). These modes of democracy and design are therefore not rigid and prescriptive, they are relational and constitutive of 'emergent publics' (Chilvers & Kearnes, 2019). Furthermore, a model of agonism applied to algorithms, Crawford (2016) argues, can surface the ongoing struggles and negotiations between people, algorithms, and institutions.

Since research conducted about sociotechnical change and diffusion can often be constrained by the limits of particular disciplines and scholarly communities, conceptual and methodological innovation is necessary to test the boundaries of how technology change and society are studied (Sovacool & Hess, 2017, p. 742). We therefore invite the reader to travel with us on a journey to explore the following lines of inquiry about democratic design experiments; in particular, their twofold potential as conceptual and methodological innovations to: *expand collective learning and experimentation about the political design of algorithmic system controversies*; as well as support *agonistic design thinging about emerging technologies associated with high stakes decision-making in the public sector*. The structure of our paper is as follows. Next, we introduce a technical democracy design experiment, which introduces an approach and process to both open up, and slow down, scrutiny of algorithmic system controversies. Study findings are then presented in the form of a *socio-technical contestation model* which proposes acts to explore controversies, generate design things, deliberate fairness, and spark thought collectives. We conclude with a proposal that technical democracy design experiments can potentially open up collective learning and experimentation through the generation of agonistic design things about high-stakes algorithmic decision-making in the public sector.

2 Method: A technical democracy design experiment

Next, this technical democracy design experiment is outlined according to the following 'opening up approaches' and 'slowing down processes'. The former articulates the technical democracy ethos and its openness to exploring new modes of cooperation; whereas the latter draws attention to the slowing down processes, or interruptions, offered by competency group dynamics.

Findings which follow introduce a *socio-technical acts of contestation model* which integrates transdisciplinary and study insights.

2.1 Opening up approaches

A technical democracy approach has the potential to expand collective learning and experimentation about socio-technical controversies (Callon, Lascoumes, & Barthe, 2009). Grounded in Science and Technology Studies (STS), technical democracy (Callon et al., 2009) draws attention to the controversies surrounding scientific and technological issues, and the need for collective forms of learning and experimentation. Callon and colleagues argue that 'hybrid forums' can foster dialogue between diverse actors and expertise, so as to better face uncertainties and surface possibilities. Such forums seek to explore the shared uncertainty and material politics of particular socio-technical controversies (Thompson, Gulson, Swist, & Witzenberger, 2023). Uncertainty is integral to the creative and transformative aspects of the design process which inherently unsettles disciplinary, interdisciplinary, and transdisciplinary work (Dyer, Power, Steen, Wallis, & Davison, 2021).

The purpose of this experiment is to explore the potential of applying technical democracy to the design field, in particular how "modalities of cooperation between secluded research and research in the wild are clearly very varied and to a large extent remain to be invented" (Callon et al., 2009, p. 105). This transdisciplinary approach transcends disciplinary boundaries, is context specific, involves multiple stakeholders, and orients team members to "work collectively and develop new language, logic, and concepts for their projects to produce knowledge that is shared and leads to new theoretical frameworks and areas of research" (Nimkulrat, Groth, Tomico, & Valle-Noronha, 2020, p. 271). We propose that a technical democracy approach offers a unique way to extend knowledge and research about democratic design experiments by foregrounding the role of socio-technical controversies and material objects in opening up avenues for collective learning and experimentation, especially in the context of education (Thompson, Gulson, Swist, & Witzenberger, 2023).

2.2 Slowing down processes

In tandem with this 'opening-up' technical democracy approach, we deployed a 'slowing down' process that brings together diverse stakeholders as a group to explore algorithmic system controversies in education. Competency groups are "forums for collaborative thinking" (Whatmore & Landström, 2011, p. 586): a generative, emergent event where reasoning about particular controversies can be 'slowed down' and scrutinised carefully in new and pluralistic ways with participants who have a range of expertise. Such groups have four key features: they are formed in relation to a particular controversy; highlight the connections between scientific/technical work and other activities; develop new collective competences to handle uncertainty of knowledge claims

and practices; and, in this process re-distribute expertise between professionals and the public (Whatmore, 2009). This aligns with a science and technology studies (STS) approach to experiments in participation, where a certain 'public' can be mobilised in various ways: as research participants, evaluators of knowledge propositions and evidence, as well as agents for new forms of social and political knowledge (Lezaun, Marres, & Tironi, 2017).

Our competency group involved a team of Australian interdisciplinary researchers and students based at a Sydney higher education institution over the course of a year (Figure 1).

Participant researchers were invited from an existing researcher network, and student participants were recruited from a student organisation committed to the development of human-centred technology. In the process of making the UK exam algorithm game, we developed 'collective competencies' (Whatmore, 2009) about algorithmic system controversies in education. The range of expertise in the group spanned the following areas: education, philosophy, sociology, data science, machine learning, engineering (biomedical and mechatronics), statistics and law. Over the course of two generative workshops, researchers and students shared this diverse expertise to co-create the UK exam algorithm game (Table 1). The aim of this process was to: i) co-create an online learning tool using a participatory design approach; ii) involve interdisciplinary researchers and students in a mutual learning and co-construction process; and iii) translate the process and outputs in a variety of ways for diverse audiences (e.g., students, educators, policymakers, technology companies). This study was approved by the Human Research Ethics Committee Protocol #:

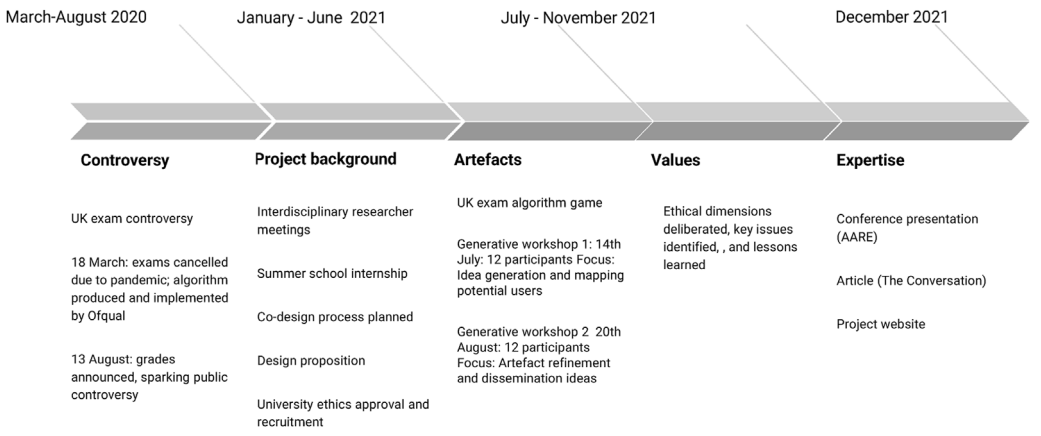

Figure 1 Project timeline and model alignment.

A technical democracy design experiment

Table 1 Workshop overview.

	Workshop 1	*Workshop 2*
Date	14th July 2021	20th August 2021
Duration, mode, and participants	3 h workshop via Zoom 4 students, 8 researchers	2 h workshop via Zoom 4 students, 8 researchers
Methodology	Technical democracy, participatory design, competency group	
Purpose	Generating ideas for artefact development and mapping potential users	Refining the updated artefact and ideas for knowledge sharing
Artefacts	Draft storyboard; stakeholder personas	Updated storyboard; stakeholder map
Activities and outputs	Activity 1: Sharing expertise Output: identifying expertise of competency group Activity 2: Algorithm game review and brainstorm Output: insights and ideas for specific sections Activity 3: Develop personas and stories about potential users Output: Stakeholder needs, motivations, and mapping	Activity 1: Share impressions and ideas about the updated storyboard Output: Insights to refine the algorithm game narrative, visuals, and fairness/ethical tensions Activity 2: Share connections to potential users that could help to refine and promote the game Output: Brainstorming promotion and feedback ideas

3 *Findings: Socio-technical acts of contestation*

Our findings demonstrate the potential to expand the concepts and methods of democratic design experiments utilising a technical democracy approach. Conceptual design frameworks are valuable for interdisciplinary teams as they can support common understandings about design activities and directions (Macmillan, Steele, Austin, Kirby, & Spence, 2001). In this section we propose a *socio-technical acts of contestation model* to frame our process of making the UK exam algorithm game (Figure 2). Our proposed model spans four acts of contestation: explore algorithmic system controversy, generate agonistic design thing, deliberate ethical dimensions, and spark thought collectives. Each contestation act is briefly described next, based on a synthesis of political design, science and technology studies, plus critical data and algorithmic fairness studies.

3.1 *Contestation #1: Explore algorithmic system controversy*

The first contestation act, *explore algorithmic system controversy,* directs investigative focus upon the selection of a specific type of controversy to inform collective learning and experimentation. Central to controversy studies is the focus upon catalysing events where "social actors express difference and seek to advance their goals by challenging each other's knowledge claims" (Jasanoff, 2019, p. 2). Controversies broadly span two key areas which shed light on knowledge-making processes and contexts: firstly, contestation within scientific and technical communities surrounding a dispute; secondly,

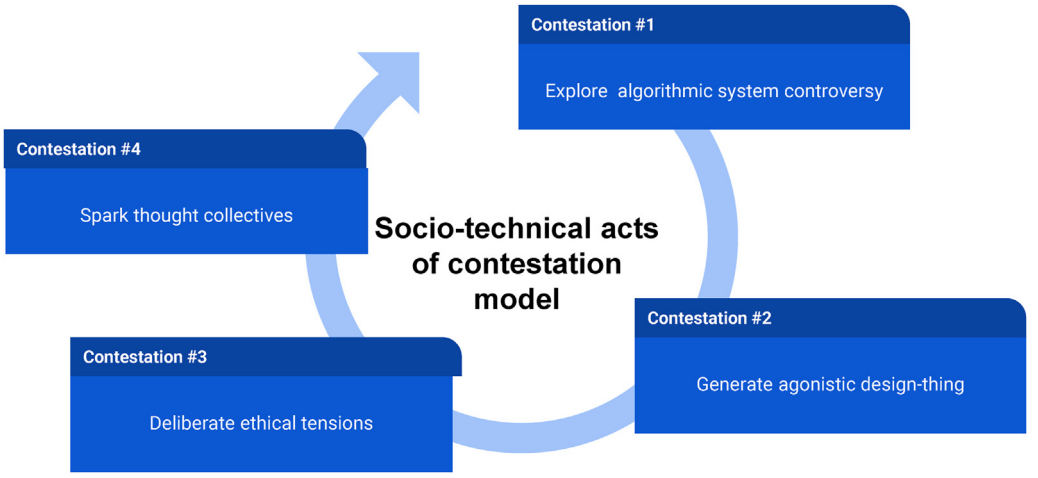

Figure 2 Socio-technical acts of contestation model.

contestation over broader social and political issues that are entangled with scientific and technical claims (ibid).

The focus of this study is the UK exam controversy. In 2020, during the height of the COVID-19 pandemic, students in the UK could not sit their final matriculation exams, the grades from which are necessary for meeting the conditional offers of entry to University. As in other years, at this stage teachers had already provided *predictions* of student grades, and these were used by universities to make conditional offers of entry that had been accepted by students; that is, a student achieving a grade profile AAA in the exams, having accepted a conditional offer, would gain entry to the institution. In the absence of exams, the UK exam regulator instead applied a simple sorting algorithm to teacher provided predictions for their students, using this algorithm to assign students' A-Level grades (Kippin & Cairney, 2021). The A-level algorithm can be considered as a simple form of automated decision making. While it was designed to ensure fairness through standardisation of teacher judgements based on historic data, this tool ultimately penalised students who were higher performing than the historic data for the school context might predict. The algorithmically moderated grades were withdrawn after widespread appeal, protest, and legal action (Kelly, 2021).

This technical democracy design experiment draws attention to a controversy which hurtled the topic of an automated grading system into the mainstream media spotlight and sparked much public controversy (Porter, 2020). Suddenly, a range of intricate technical and ethical concepts (such as algorithms, fairness, bias, standardisation, prediction) became objects of collective attention and concern. However, there is currently a lack of practical mechanisms to embed ethical principles throughout algorithmic system lifecycles, which is

A technical democracy design experiment

a complex process due to the range of stakeholders and issues involved (BCS, 2020).

3.2 Contestation #2: Generate agonistic design thing

This contestation act specifies the value of generating artefacts that seek to mobilise conflicting passions and beliefs towards 'democratic designs' (Mouffe, 2013). Instead of focusing on an end product or service, agonistic participatory design focuses on engaging with controversial issues to create *publics* through the creation of 'design-things' (Björgvinsson, Ehn, & Hillgren, 2012). Foregrounding 'publics' in participatory design aligns with John Dewey's pragmatist philosophy focused on community interest groups and action beyond finite objects, or solutions (Dixon, 2020). Significantly, this socio-technical act of contestation produces an artefact to advance dialogue with controversial issues that generates publics, not simply end-products or services (Björgvinsson, Ehn, & Hillgren, 2012).

Our project's *agonistic design thing* is an algorithm game (Figure 3), a form of 'emergent serious games' that invites players to: learn about algorithms and automation; play with thresholds, data, scenario; reflect upon human and non-human decision making processes; consider issues associated with fairness, inequality, and morals; plus re-appropriate data for collective learning and experimentation (Education Futures Studio, 2023). Aligned with this ethos, this game does not guide the participant to a specific conclusion. Instead, the participant is guided through the complexity of ethical problems and solutions based on the 2020 UK exam controversy.

This technical democracy design experiment invited people to learn and think about how algorithms work, such as how different inputs lead to different outputs. In doing so, our game provokes insights into the complexity of fairness issues in using algorithms. A model of agonism applied to algorithms, Crawford (2016) argues, focuses on dissensus to highlight the "ongoing struggle between different groups and structures — recognizing that complex, shifting negotiations are occurring between people, algorithms and institutions, always acting in relation to each other." (p. 4). Creating publics, or 'spaces of democracy', is therefore not simply about practices, but also the *devices* which organise participation: an "experimental assembly of specific technologies, settings, and objects" (Marres, 2012, p. 149). With this in mind, we propose that *agonistic design thinging* resonates with a key aim of technical democracy: to advance democratic dialogue about the uncertainties and complexities of socio-technical controversies. In accord with an 'adversarial design' (DiSalvo, 2012) approach, the 'design-thing' must be one that promotes further dialogue and disagreement; that educates and elucidates but doesn't propose or demand one viewpoint or approach to the issue it engages with.

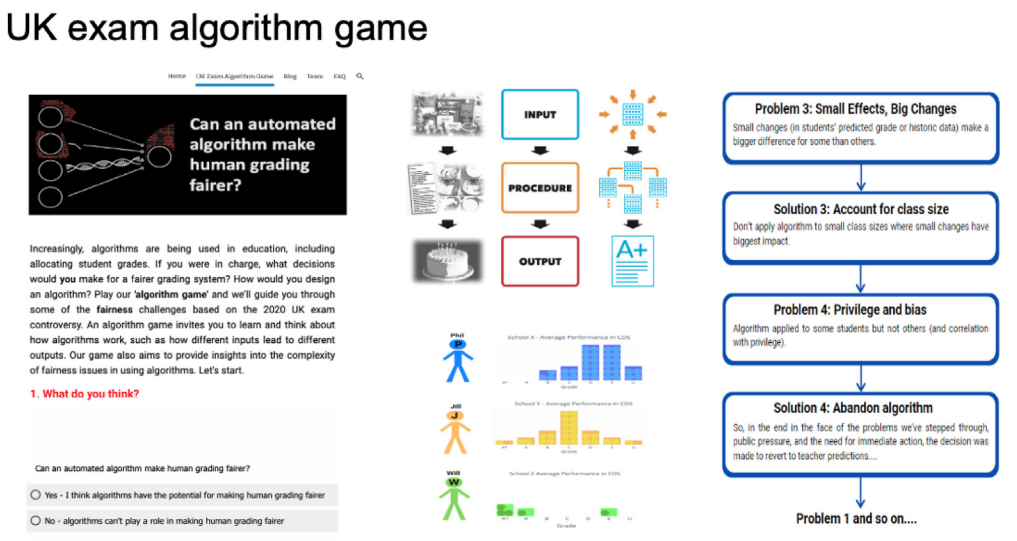

Figure 3 UK exam algorithm game snapshot.

3.3 Contestation #3: Deliberate ethical tensions

This contestation act draws attention to the benefits and harms of algorithmic design and development. Generating knowledge about algorithmic consequences and implications as a political issue can enable individuals and publics to deliberate competently towards the purpose of democratising algorithmic fairness (Wong, 2020). Fairness-enhancing mechanisms include: pre-process mechanisms (before adding to the algorithm); in-process mechanisms (modifying the algorithm); and post-process mechanisms (post-processing of output scores) (Pessach & Shmueli, 2020). However, Green (2021) argues that caution must be exercised so that the frame of algorithmic fairness design and development is not restricted to the *formal* functioning of an algorithm; in contrast, a *substantive* approach proposes the need to identify social hierarchies and decision-making in particular contexts that may exacerbate conditions of inequality, as well as exploring change and reforms which do not presuppose that algorithms are the only solution. This substantive approach is central in our phase of exploring and deliberating algorithmic fairness.

As part of this contestation act, the competency group considered a range of ethical problems, principles and applications which often drew on fairness notions but avoided overly technical definitions and measures. This resonates with a broader, *substantive* approach to algorithmic fairness that explores the social context, decision-making conditions, and interrelationships which shape inequalities and the extent to which algorithms contribute to proposed

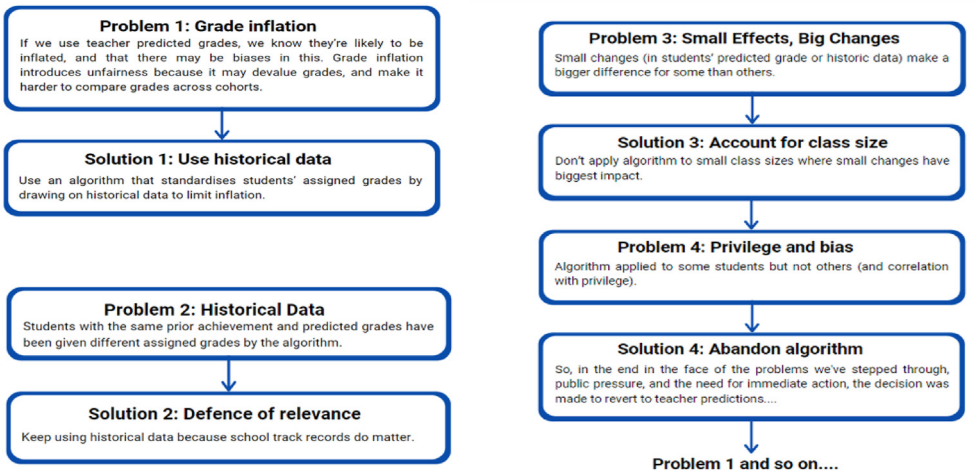

Figure 4 Ethical tensions walk-through.

reforms (Green, 2021). In doing so, the group sought to communicate the range of ethical tensions which the controversy raised (Figure 4).

In the game, these problems (grade inflation, historical data, small changes with big effects, privilege and bias) were woven throughout the narrative. This narrative motif aimed to teach the player that each of the proposed solutions (use historical data, defence of relevance, accounting for class size, and abandoning the algorithm) never guaranteed a neat solution. Specifically, this was achieved by holding some game elements constant. For example, student characters shared key attributes, which then demonstrated how changes in other variables (school/centre size) produced different results. In doing so, the game draws attention to not only the limits of techno/data-centric solutions, but also the broader societal conditions, which shape the 'algorithmic injustice' of disproportionately impacted communities (Birhane, 2021).

This technical democracy design experiment focused on problematising the design and deployment of the algorithm. This meant that future users and audiences can see the many problems with finding a 'fair outcome' and discover that when things get fairer for some, it may be at a cost for others. In doing so, this tool offers a way to re-distribute algorithmic expertise in education through demonstrating the fairness tensions that emerged specific to the UK exam case (which are always broadly 'baked in' to any algorithmic application, cannot be eliminated, and would vary in other use-cases). In an examination of algorithmic fairness in education and other domains, Kizilcec & Lee, H. (2020), propose that understanding the impact of innovation upon the educational outcomes of advantaged and disadvantaged groups can be gleaned as to whether the introduced technology reduces, expands, or bypasses gaps in outcomes. To implement practical approaches to ethics in education, a collaborative

'middle space' is needed to ensure that artificial intelligence and data analytics are "neither underused, overused, or misused" (Kitto & Knight, 2019).

3.4 Contestation #4: Spark thought collectives

The final contestation act of this model surfaces how collective expertise from the co-design process evolve and travel within, and beyond, the transdisciplinary research project phase. The concept of 'thought collective' was introduced by philosopher of science Ludwik Fleck (1979) to denote how a group of individuals exchange ideas and nurture a particular 'thought style' which directs the object of inquiry, mode of investigation, and 'proto-ideas' both within a thought collective *(intracollective communication*) and between collectives (*intercollective communication*). In contrast to Thomas Kuhn's concept of paradigm shift which focuses on revolutionary breaks with past developments specific to the scientific domain, Fleck's philosophy situates knowledge production as a processual and continuous practice of communicative interaction between different thought collectives (Mößner, 2011). Another key difference between these philosophers is their interpretation of incommensurability: for Kuhn, incommensurability is a barrier to knowledge production, whereas Fleck frames incommensurability as a "productive source of innovation" which can spark minor to major changes in thought styles (Peine, 2011, p. 495).

In the process of making the UK exam algorithm game as an agonistic design-thing, our group became a 'thought collective' (Fleck, 1979) that connected varying forms of expertise, so as to explore an emerge fnt idea and mode of inquiry. We chose to focus on a particular style of game-play, known as 'emergent serious games' (Education Futures Studio, 2023), that invites players to learn about algorithms and reflect upon decision-making processes associated with values, ethics, fairness, and inequality. To this end, a series of questions were devised to provoke player knowledge and decision-making throughout the course of the game (Figure 5).

This structure aimed to provoke players' values and reflexivity about algorithms: (*What do you think?*); decision-making junctures (*What would you do?*); evaluation of data inputs (*What do you think is most important?*); testing decision-making boundaries (*So, what would you do?*); and, whether their thinking had changed by the end of the game, or not (*What do you think now?*). In doing so, the aim of the UK exam algorithm game is to support collective experimentation and learning for both intracollective and intercollective thought collectives: interdisciplinary researchers and students within the project time-frame in the process of developing the UK exam algorithm game; and, the broader players and publics (of researchers, students, and professionals) who might utilise the game for collective learning in future contexts. To date, we have presented the game at Australian Association of Research in

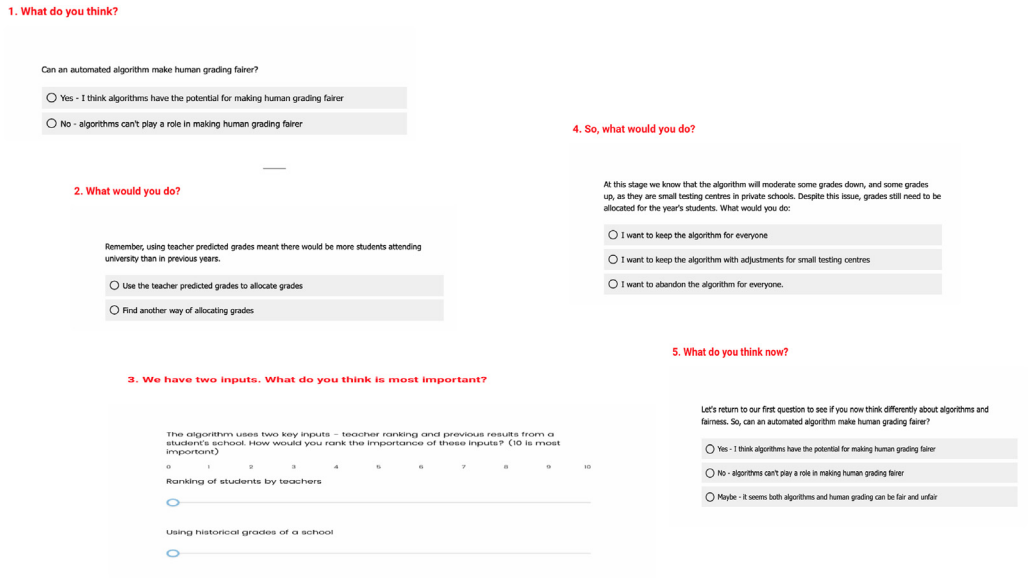

Figure 5 Algorithmic system game-play.

Education conferences, published an online media article, and embedded it as a project resource (Education Futures Studio, 2023).

This technical democracy design experiment highlights the significant potential in developing models of varied abstractions and frameworks for explaining algorithms and trade-offs for members across technical and non-technical backgrounds. In doing so, this object of integrative knowledge and action aims to inspire 'thought collectives' (Fleck, 1979) with a range of researchers, policymakers, professionals, and publics. Applying a Fleckian perspective to sociotechnical change and innovation draws attention to how artefacts travel across various contexts and use and "facilitate heterogeneous problem solving and crystallise the knowledge inputs from diverse specialisms" (Peine, 2011, p. 502). Information and communication technologies, Callon (2004) argues, mediate how individuals and groups across different collectives think and act, so participatory design inquiry should reflect how knowledge and agency is distributed across human and nonhuman systems. Emergent data technologies and networked forms of power and information, raise a host of conceptual and technical challenges: this requires a multidimensional focus upon institutions, algorithmic technology, and the role of formats (how data is produced, processed, and applied) (Koopman, 2022). Yet expertise to deal with such escalated complexity does not reside with one institution, discipline, or sector, so a focus upon thought collectives offers a productive way to open up inquiry beyond finite project timelines plus traditional modes of participation and expertise.

4 Discussion: democratic design possibilities

In this section we return to the lines of inquiry flagged at the start of this paper about the twofold potential of democratic design experiments; that is to: *expand collective learning and experimentation about the political design of algorithmic system controversies*; and, support *agonistic design thinging about emerging technologies associated with high stakes decision-making*. Next we explore these possibilities in relation to the technical democracy design experiment and model identified through this study.

4.1 Expanding collective learning and experimentation about the political design of socio-technical controversies

Our project's 'competency group' (Whatmore, 2009) was instituted in response to the UK exam controversy which sparked broad public interest about scientific and technical knowledge claims connected to the education sector. This technical democracy design experiment deployed this controversy to explore tradeoffs in fairness and decision making procedures, and, within a narrative, 'algorithm game' style interface, surfaced that accuracy and fairness are both technical and political designs. In doing so, this *agonistic design thinging* process critically exposed how algorithms are embedded, operate, and shape both immediate and longer-term impacts. Ultimately, the collision of actors, expertise, and claims of socio-technical controversies makes such unpredictable events "powerful apparatuses for exploring and learning about possible worlds" (Callon et al., 2009, p. 28).

Moreover, the *socio-technical acts of contestation* model findings seek to orient research applied to controversies specific to algorithmic systems both within education and more broadly. For instance, there are many areas in which our model can be applied. These include: the allocation of welfare, decisions about visas, law and justice (e.g., jury selection), workplace and workforce decisions (shortlisting, hiring, tracking employee engagement and productivity), personalisation, as well as other educational controversies such as college admission in the US (e.g., evaluation of applications). All these examples have several key features in common. They all involve high stakes decisions for individuals or groups, in spheres with historic injustice, where it is hard to say what the 'correct' decision should be. Yet such decisions must be made one way or another. Together, these features identify decision-making where the turn to automation seems understandable, but which is ripe for ethical problems.

By problematising these decisions and showing the understandable motivation of those deploying these systems alongside the understandable concerns and objections of those impacted, we can create something that opens up conversation and dissensus ("why are we implementing this?") rather than demanding a consensus ("what's the best way for us to implement this?"). This problematisation could be readily applied to co-design practices engaging

diverse stakeholders to enhance algorithmic design and governance in a range of contexts, such as child welfare systems and on-demand food donation transportation services (Saxena & Guha, 2020; Kyung Lee et al., 2019). Furthermore, approaches to co-designing emerging technologies with civil society have been identified as vital, so as to mitigate risks and maximise collective good (World Economic Forum, 2021). Such expanded public engagement is particularly important, as the co-design and iteration of algorithmic decision-making tools are recognised as a key way to more effectively meet user needs and contexts, as well as build trust and agency with relevant practitioners (Snow, 2019). To potentially embed political design in such endeavours, opening up approaches with technical democracy, and slowing down processes with competency groups, offer rich avenues for re-imagining algorithms, design, and public participation.

4.2 *Supporting agonistic design thinging about emerging technologies associated with high stakes decision-making across society*

In this study, the aim was not to come to a best solution, or to focus on teaching about algorithms, but rather to foreground the complexity and uncertainty of algorithmic system controversies, plus to support shared learning between stakeholders with diverse expertise. Instituting a 'competency group' (Whatmore, 2009) contributed to planning and enacting transdisciplinary research: that transcended disciplinary boundaries by exposing new, contextual understandings of technology and society. The UK exam algorithm design thing co-created by our competency group is therefore a non-traditional research output that aims to inspire ongoing collective collaboration and inquiry beyond academia. As an example of an *agonistic design thinging* the game artefact sought to unsettle knowledge claims associated with algorithmic systems in education.

Furthermore, our *socio-technical acts of contestation model* offers a flexible process for other competency groups to investigate the complexity and uncertainties surrounding algorithmic system controversies. For instance, competency group participants with no previous in-depth knowledge of algorithms found it interesting to see how algorithms trigger decisions that ultimately impact society. Participants also communicated that the process offered a good understanding of how much work goes into designing such a tool and how it can incorporate so many different perspectives and users/audiences. Further iterations and development of such models focused on other algorithmic system controversies would offer additional examples and resources that may be shared. These other agonistic design things could materialise adaptable artefacts for communicating technical democracy design experiments in relation to other controversies. Yet, to combat 'participation-washing' plus exploitative and extractive forms of community involvement

in forms of artificial intelligence, more attention to situated and context-dependent design approaches is recommended (Sloane, Moss, Awomolo, & Forlano, 2020).

Reflections from our competency group flagged that bringing people together around a controversy can be challenging; people come with preconceived ideas, and there are tensions between both on the one hand getting tangled up in the weeds of technical detail, and on the other high-level principles that may not connect to the practical situations faced by the decision makers. There is potential for competency groups to foreground a range of voices and perspectives, and both issues and potentials in algorithmic systems. Despite these opportunities, common challenges of interaction, dialogue and representation remain. One such issue is in establishing a common ground of shared language, and in synthesising viewpoints that may reflect differences in both language and expertise. Another issue relates to the power relations of participation, and that groups may be dominated by particular voices, and that even where representation of marginalised voices occurs, contributions to discussions may still privilege a particular type of expertise. In addition, competency group participants identified the challenges of getting our message out to different groups of people. For instance, participatory approaches can support 'dialectic exchange' between the various stakeholders which will design, implement, and interact with algorithmic systems (Baumer, 2017, p. 9). Further research is required to establish the mechanisms of these *agonistic design thinging* models, so as to open up - and slow down - how algorithms, design, and public participation are both imagined and implemented.

5 *Conclusion: public sector design, interrupted*

Our *technical democracy design experiment* sought to provide a conceptual heuristic and practical tool for diverse stakeholders to enact democratic design possibilities in the public sector. In doing so, we invited readers to travel with us on a journey of "conceptual stretching and traveling[sic]" (Sovacool & Hess, 2017) to test a technical democracy approach for unsettling knowledge and design claims associated with algorithmic system controversies in education. By building upon the political design processes of *agonistic design thinging*, we hope this method sparks collective learning and experimentation to help re-imagine algorithms, design, and participation. In the context of public sector design, we propose interrupting techno-solutionist approaches by unsettling the 'roots and growth' of algorithms embedded in foundational data infrastructures, such as data collection, service delivery, and population management (Levy, Chasalow, & Riley, 2021).

In sum, we presented a transdisciplinary design model applied to the process of designing a serious game based on a significant socio-technical controversy: the 2020 UK exam algorithm and the government regulators charged with

moderating marks after the cancellation of exams due to the COVID-19 pandemic. Findings from this technical democracy design experiment identified four socio-technical acts of contestation: explore an algorithmic system controversy, generate an agonistic design thing, deliberate ethical tensions, and spark thought collectives. Our introduced model and its exemplification through these contestation acts offer an exploratory, yet pragmatic, tool for enacting technical democracy design experiments in relation to other public sector algorithmic system controversies. In doing so, we aim to inspire collective learning and experimentation towards *political and democratic designs* (DiSalvo, 2012; Mouffe, 2013) which interrupt public sector design: by making spaces which move from consensus to dissensus in an age of automated decision-making.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors are unable or have chosen not to specify which data has been used.

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