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OPEN LETTER

REVISED From principles to practice: A code of conduct for the human-centered and ethical development of immersive technologies

[version 2; peer review: 2 approved, 3 approved with reservations]

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Abstract

The XR4Human Code of Conduct was developed over a 12-month period using a participatory co-design approach that combined multi-disciplinary expert workshops with members of the consortium followed by stakeholder and public consultations. The process was intentionally iterative. Drafting, review, and revision were guided by reflective equilibrium to reconcile empirical inputs from the project deliverables, normative principles, and practical constraints. The final Code is organised into nine domains that consolidate core principles relevant to the responsible design, development, and deployment of XR systems. These principles are made more concrete through seven articles that specify actionable obligations. To support real-world adoption, the Code is operationalised via an Ethical Impact Assessment and a companion Compliance Checklist aligned to the core principles and articles.

Keywords

eXtended reality, Immersive technologies, Ethics, Virtual reality, Virtual worlds, Code of Conduct, Augmented reality, Mixed reality

HE This article is included in the Horizon Europe gateway.

Open Peer Review

Approval Status ✓ ✓ ? ? ?

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REVISED **Amendments from Version 1**

This new version reflects the constructive combined feedback from the three reviewers. Initially, the open letter served as a overview and introduction to the main output i.e., the XR4Human Code of Conduct for the Human-Centered and Ethical Development of Immersive Technologies. However, the feedback from reviewers signalled a desire to understand the process of normative reflection and stakeholder engagement that led to the actual priniciples and articles. This we agreed is very important for reproducibility or to guide others in terms of how to approach the development of a code of conduct/ethics. We saw value in this and as such we have now detailed the process so that the reader can have greater insight into how the XR4Human consortium acheived its goal.

Any further responses from the reviewers can be found at the end of the article

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Introduction

Immersive technologies aka eXtended reality (XR) is fast becoming a highly relevant technology with a wide range of applications spanning different industries. XR includes Augmented Reality (AR), Mixed Reality (MR), and Virtual reality (VR) where AR is a digital overlay in physical spaces and is the least immersive experience, MR enables interactions with digital elements in physical spaces, and VR is completely immersive experience (Milgram & Kishno, 1994). XR technologies span various industries and use cases such as entertainment including gaming, research, education and training in military and healthcare industries, digital commerce, socialising and tourism (Voinov *et al.*, 2024). Concurrent with the development and the applications are various ethical and legal challenges. The Equitable, Inclusive, and Human-Centered XR project (XR4Human) had a goal to map various legal, ethical and interoperability challenges of XR technologies and propose guidance for developers and users of XR embedded in human centred and ethics by design principles. To achieve this, researchers in the project employed within seven work packages (WP) over a period of three years deep dived into XR literature and conducted stakeholder surveys and interviews to clearly elucidate and articulate ethical, legal and technological issues. These were published on the XR4human website and in peer reviewed journals. Reports include mapping of a) ethical issues in XR (WP 2), b) regulatory and governance issues (WP 3), c) existing and emerging interoperability and seamless integration of XR (WP4), and d) challenges and presentation of ethical, legal regulatory and technical interoperability solutions (XR4HUMAN, n.d.). Ethical and legal issues of XR were mapped across several work packages. Of significance are the issues associated with constant data capture, invasion of privacy, and risk of manipulation due to the inherent features of XR output devices (Cox *et al.*, 2025). Human rights issues, such as inclusivity and accessibility, may also arise with XR if a subset of the population is not culturally represented or is unable to access or use the devices because of age or varying types of physical and mental disabilities (Cox *et al.*, 2025). There are also societal, environmental and economic concerns such as increased risk of crime and anti-social behaviours such as stalking or virtual assaults, cybercrimes or real-world implications arising from virtual social interactions (Cox *et al.*, 2025). Economic disparity exists also where some groups in society will advance with the use of XR technology while others would be disadvantaged due to financial challenges (Cox *et al.*, 2025). WP2 also mapped and reported risks and harms associated with XR technology of ethical relevance using a risk typology under five themes: Health and Well-Being, Autonomy, Epistemic, Normative, Structural, and Technical Safety and Security. Health and well-being risks include cognitive, physical, psycho-emotional, and socio-relational harms. Some XR users may experience cybersickness, injuries secondary to falls, experience challenges with entering and exiting virtual and real spaces. False memories may be created where users are unable to distinguish between what they experience in the virtual space from what actually occurred in the physical world. Autonomy risks include issues of privacy, self-sovereignty, surveillance, and authenticity. Some XR experiences have the ability to capture eye movements, lip smacking, and other micro emotions unknown to the user. Epistemic risks of XR include issues of uncertainty and risk of manipulation. Normative risks include norm and rights violations while structural and technical safety/security risks include legal, socio-political, economic/financial and risks of hacking or dual use of technology (Voinov *et al.*, 2024). Legislation and interoperability standards for XR technologies are also lagging. What obtains are Codes of Conduct or guidance tools proposed mainly by academics or industry stakeholders (Cox *et al.*, 2025). The combined recommendations of these reports needed to be translated into a normative framework that could be used by XR industry stakeholders from idea to development and deployment. To this end, the normative output of the project is a Code of Conduct (CoC) for human-centered and ethical development of immersive technologies (Bernabe *et al.*, 2025).

Additionally, it is important that the CoC is not a document that provides superficial guidance but one which is practical for seamless adoption by developers and users. This approach aligns with translational ethics which bridges theoretical, empirical and practical aspects of ethics i.e. ensuring the actual application of ethical principles to real world situations

(Bærøe, 2014). One way to bridge the gap between theory and practice is the use of impact assessments. Impact assessments have become commonplace for effecting standards in various industries including artificial intelligence, risk management and privacy (Trilateral Research, 2020; Wernick, 2024). The approach is to consider relevant principles, values or issues of an area of impact drawing from various sources, then create questions that would cause one to reflect on the impact of the idea/work in progress (Wright, 2011). In the context of ethical impact assessment of technology, David Wright notes:

> "an ethical impact assessment is needed of new and emerging technologies because technologies are not neutral, nor value free. Technologies, how they are configured and used, reflect the interests and values of their developers and owners. Over time, other stakeholders, including users, may become developers too by creating new applications for the technology or by adapting the technology for uses unforeseen when the technology was originally developed. An ethical impact assessment is also needed because ethical considerations are often context-dependent. What may be ethically acceptable in one context may not be acceptable in another context" (Wright, 2011).

This open letter describes how the Code of Conduct was developed, together with the complementary Ethical Impact Assessment (EIA) and Compliance Checklist. These tools operationalise the Code.

Aim

The XR4Human project aims to co-create living guidance documents on ethical and related policy, regulatory, governance and interoperability issues of XR technologies in Europe.

Approach

The XR4Human Code of Conduct was developed using a participatory co-design methodology facilitated through expert-led workshops as well as stakeholder and public consultations (Brouwers *et al.*, 2010). A multidisciplinary working group of WP leaders and researchers (n = 18) drafted, refined and finalised the Code of Conduct through a series of in person/virtual workshops held over a 12 month period (Figure 1). The initial brainstorming and drafting by experts took place in August 2024 and continued until January 2025. The working group included XR technology experts, vision scientists, ethicists, philosophers, lawyers, and researchers. Stakeholder consultations were conducted from February to May 2025, followed by editing from June until publication in August 2025. The process entailed reflecting on the recommendations of the individual WP deliverables, then identifying and drafting of guiding principles and corresponding articles. The draft was then circulated for consultation with stakeholders (policy makers, developers, users) via email, targeted expert Zoom meetings, the XR4Human forum, and on Linkedin. In addition, stakeholder engagement were facilitated by XR4Europe and the Communication and Dissemination WP lead with support from researchers from the

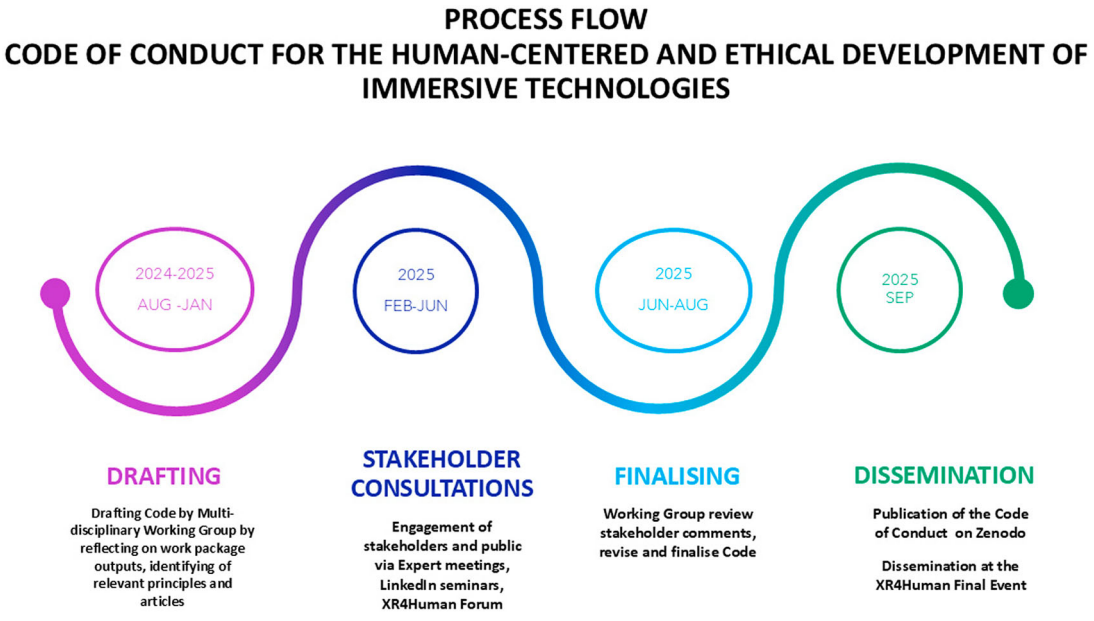


Figure 1. Process timeline for development of the XR4Human Code of Conduct.

University of South-East Norway (USN), OpenAR Cloud, Europe, and the University of Oslo, Norway (UiO). Three online workshops were held on 4, 6 and 13 May 2025. Stakeholders were invited via a Google Forms survey. The workshop attendees included representatives from the training and education sector; software development (software as a service/SaS); industry associations (France Immersive Learning, for example); researchers in computer science, engineering, design and psychology. Nationalities represented were French, Norwegian, German, Italian, Spanish, British, Irish, Dutch, Belgian, and Greek. The online seminars discussing the CoC were hosted by XR4Europe. During these seminars, researchers were asked for feedback, and suggestions were collected on how to improve the CoC.

Code of Conduct Promotion and Stakeholder Consultation via LinkedIn:

- *Guidance or Governance?* – Apr 29, 2025–168 Unique Views – 256 Minutes Viewed - https://www.linkedin.com/events/7313524939150491648/
- *The Language of Ethics* – Apr 22, 2025–237 Unique Views – 617 Minutes Viewed - https://www.linkedin.com/events/7313521359827947520/
- *What Guides Ethical XR?* – Apr 15, 2025–279 Unique Views – 870 Minutes Viewed - https://www.linkedin.com/events/7313517658300166144/

Sample prompts were used in the XR4Human forum and LinkedIn to stimulate engagement on clarity, practicality, and comprehensiveness of the Code (Table 1). Stakeholders had the opportunity to comment directly on the CoC draft using the document's commenting feature. One researcher compiled the comments into a single report. All feedback, including those from members of the consortium, was logged and reviewed weekly. Proposed changes were tracked, discussed, and informed iterative revisions of the draft. Additional meetings were held to consider the cumulative comments-first to finalise the principles, then the articles. The working group was divided into smaller subgroups; each assigned a specific area to assess potential revisions. Each subgroup considered the inputs received from stakeholders then presented its recommendations to the full working group where consensus was reached on the final content. Comments that were not incorporated were either already addressed in some form in the Code or were outside its scope (for example, issues of data protection covered under General Data Protection Regulations, GDPR).

Table 1. Sample prompts used in the XR4Human forum and LinkedIn to stimulate engagement on clarity, practicality, and comprehensiveness of the Code.

1. Are there any sections of the Code of Conduct that are unclear or need further explanation?
2. Is the language used in the Code of Conduct clear, concise, and easily understandable for a broad audience, including developers, policymakers, and end-users?
3. Are there any terms or concepts in the Code of Conduct that require additional definitions or clarification?
4. Are any sections overly technical or complex for the intended audience?
5. How practical do you find the guidelines in the Code of Conduct for real-world application?
6. What potential challenges do you foresee in implementing this Code of Conduct in real-world scenarios? How can these challenges be addressed?
7. Do you see any potential conflicts between the Code's principles and current business models or industry practices?
8. What compliance mechanisms or enforcement strategies would help ensure effective implementation of the Code?

Table 2. XR4Human Code of Conduct's areas of impact, principles and corresponding articles.

Areas of impact	Principles	Articles
1. Health and well-being 2. Autonomy 3. Data and technology 4. Social 5. Environmental	1. Human-centred design 2. Diversity,inclusivity, accessibility, and equitability 3. Trustworthiness and transparency 4. Privacy and data governance 5. Safe experience 6. Identity and right to anonymity 7. Sustainability 8. Technical security and interoperability 9. Moral-dilemma resolution and Risk management	1. User transparency by design 2. Data protection and privacy by design 3. Risk management by design 4. Well-being by design 5. Identity, personas, and avatars 6. Shared spaces 7. Engagement with non-human resources

Normative analysis and synthesis of principles

Earlier, a description of the methodological approach resulting in the XR4Human CoC was outlined. This section examines in greater depth the normative reflection and synthesis that resulted in the identification of five areas of impact, nine principles, and seven practical articles (see Table 2). The project's collective outputs concerning the impact of XR technologies are grouped into five domains: health and well-being, autonomy, data and technology, social, and environmental. These domains were derived from an analysis of the empirical findings generated throughout the project, particularly the mapping of ethical and legal issues and the identification of risks associated with the development and use of XR, and how these may affect individuals and society. After identifying the ethically significant challenges of XR in relation to these domains, members of the consortium explored how these could be addressed through ethical principles. Through an iterative process of discussion, comparison, and revision, the consortium sought to achieve coherence between empirical evidence and the moral judgements of the experts and stakeholders. This adapted reflective equilibrium approach facilitated the identification of relevant principles and accompanying articles (Knight, 2025), which formed the basis of the first draft of the CoC. Stakeholder feedback was then solicited, followed by additional discussions on how to incorporate stakeholders' perspectives, then finally the refinement completion of the Code of Conduct. In the following section, we briefly explain how this approach was applied to each domain.

The first domain of significance was health and well-being. Given that the use of XR devices, or immersion in XR experiences, can lead to physical and psychological harm, health and wellbeing was considered a highly significant impact domain. Adopting the reflective framework, the ethical principles of non-maleficence (minimising harm) and beneficence (promoting well-being) were considered particularly relevant (Voinov *et al.*, 2024). Participants emphasized that developers of XR technologies should not only focus on the intended purpose of XR technology and its applications but also consider how best to minimise negative impacts on health and, where possible, promote well-being (Voinov *et al.*, 2024). During the discussions, it was noted that developers are not ethicists, and terminology should align with their context. Consequently, human-centred design was identified as a pertinent approach to mitigating potential physical, cognitive, and psychological risks. Human-centred design, a concept from the field of technology and engineering, is defined as "an approach to interactive systems development that aims to make systems usable and useful by focusing on the users, their needs and requirements, and by applying human factors/ergonomics, and usability knowledge and techniques" (ISO, 2019). This approach enhances effectiveness and efficiency, improves human well-being, user satisfaction, accessibility and sustainability; and counteracts possible adverse effects of use on human health, safety and performance (ISO, 2019; Bernabe *et al.*, 2025).

The goal is not merely to avoid harm but to guide developers to critically reflect on the design features of XR output devices and experiences, and to implement measures that proactively promote human well-being while deployed. In practice, a human-centred design means prioritising ergonomics, usability, accessibility, and safe immersion. The specific requirements for operationalising the principle of human centred design in XR are outlined in the accompanying article well-being by design (Bernabe *et al.*, 2025).

The second area of impact focuses on autonomy, with particular attention to issues of identity and control. Identity relates to the ability of users to create and maintain a unique expression of self in an XR environment, especially in shared spaces where their identity is personified through avatars. Autonomy in relation to control refers to the user's ability to make decisions without manipulation and of their own volition (Voinov *et al.*, 2024). This is also relevant to bystanders within an XR environment or experience (O'Hagan *et al.*, 2023). Reflecting on the issues of autonomy, the consortium adopted the principles of identity and right to anonymity, as well as trustworthiness and transparency. Together, these principles were considered important to support XR users' ability to exercise meaningful control over their digital representations and experiences within XR spaces (Bernabe *et al.*, 2025).

The third area of impact is data and technology. This domain concerns the type and volume of data that can be extracted through XR output devices, and how this data is managed, stored, and potentially shared with third parties. XR devices rely on the collecting of highly sensitive information, including biometric and behavioural data. Consideration must therefore extend not only to the data of immediate users, but also to that of bystanders, whose data may be knowingly or unknowingly extracted with or without their consent. The normative principles applied to this domain are privacy by design and data governance (Bernabe *et al.*, 2025). It is well-established that XR technologies have the capability to extract substantial amounts of data through various output devices. Although many jurisdictions, especially in the European Union, are governed by strict data protection laws, ethical safeguards remain crucial for protecting the rights of users and bystanders, especially to prevent violation of trust (Voinov *et al.*, 2024; Cox *et al.*, 2025).

The remaining two areas of impact are social and environmental. The social impact of XR was considered highly significant, as the economic and didactic benefits are often emphasized while the challenges such as discriminating

against persons of varying abilities and ethnicities, as well as economic disparities commonly referred to as a digital or technology divide tend to be underreported. To address these issues, the consortium adopted the principles of diversity, inclusivity, accessibility, and equitability (Bernabe *et al.*, 2025). Another important consideration is that of shared XR spaces, such as virtual worlds, often referred to as the metaverse. These interconnected spaces, in which users interact through avatars to learn, socialise and collaborate, can be a double-edged sword: they offer substantial benefits but also entail risks, including harassment and bullying. After careful contemplation of the benefits and risks, the consortium identified the need for a safe experience in such shared spaces, to foster a respectful environment which minimises the potential for psychosocial harm (Bernabe *et al.*, 2025). Finally, the environmental impact of XR technologies encompasses the production, use, and disposal of devices. Accordingly, sustainability was adopted as the guiding principle, with an aim of reducing or mitigating, as far as reasonably possible, any long-term environmental damage associated with XR technologies (Bernabe *et al.*, 2025).

Synthesis of the Ethical Impact Assessment (EIA) and compliance checklist

Concurrent with the process of developing the CoC, a subgroup was formed to draft the Ethical Impact Assessment (EIA) and a compliance checklist. To achieve this, the principles and corresponding articles of the draft CoC were organized into five areas of impact to enhance comprehensiveness and ease of understanding. The deliverables from the XR4Human project were uploaded to Google Notebook LM (Model-Gemini 2.5 Flash) and a master prompt used to generate questions for ethically relevant risks under each area of impact, with the associated principles and articles noted. This ensured that the questions for the EIA were derived exclusively based on the outputs of the XR4Human project. The master prompt instructed the LM to generate impact descriptors with relevant questions for developers and end-users with emphasis on potential effects, risks, and harms of XR technologies. For each impact category, the questions were required to address risks, harms, safeguards, and individual user considerations, thereby promoting developer and user awareness and informing decision making. Following this initial use of the LM to generate a draft, weekly meetings were held to review the questions under each area of impact to ensure clarity and relevance. Any overlaps or ambiguities were discussed, then refined or removed based on consensus among the researchers. Once no further disagreements remained, the document was finalized, and the compliance checklist was created. The Google Notebook LM was used solely for initial generation of questions based on areas of impact, accompanying principles and related articles to ensure the questions were originating from the project deliverables. Google LM was selected because it is a more focused AI research tool and therefore considered less likely to produce hallucinations than general-purpose LLMs. Additionally, a human oversight approach was implemented through a multi-researcher review and refinement procedure. The EIA and checklist were subsequently shared with the members of the consortium via Microsoft Teams for feedback, further refinement and finalisation. Finally, the compliance checklist was designed as a one-page document that could be used as a quick reference tool for reflection.

In summary, the consortium's judgement supported by the feedback from key stakeholders, is that the XR4Human Code of Conduct's five areas of impact, nine principle domains and, seven corresponding articles provide a structured basis for designing, assessing, and iteratively improving XR technology products and experiences.

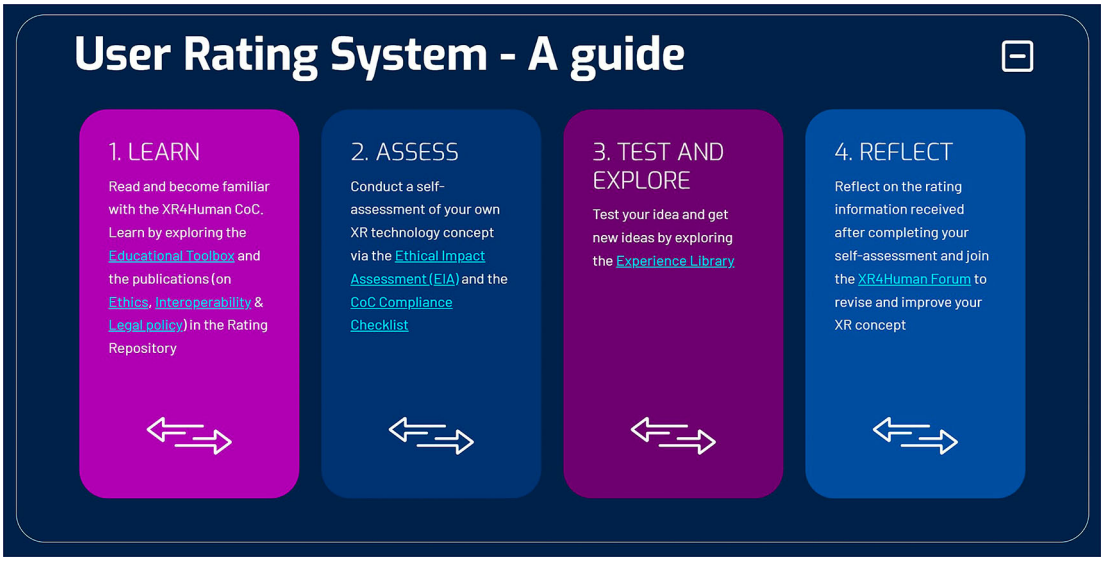


Figure 2. A stepwise approach to operationalise the XR4Human Code of Conduct.

Operationalisation and dissemination

An infographic was developed by applying learning by doing educational pedagogy (Morris, 2020). The infographic provides a stepwise approach to the developer/user to 1) Learn, 2) Assess, 3) Test and Explore, and 4) Reflect (Figure 2). Developers and users are encouraged to familiarise themselves with the project's educational outputs as well as the CoC, then conduct a self-assessment of their XR technology idea, product, or experience using the EIA and compliance checklist as part of the Rating Repository. The CoC may be applicable to healthcare, education and training, gaming/entertainment and ecommerce use cases. Where a product is in development, it can be tested and explored via submission to the XR4Human Experience library with optional engagement through the XR4Human forum. Insights from testing inform reflection and revision as deemed necessary by the developer. This iterative cycle operationalises the CoC and EIA and aligns with the reflective equilibrium approach (Knight, 2025).

Ethics and consent

Ethics and consent were not required as this is a paper proposing guidelines for developers and users of XR and as such did not involve research participants and personal identifiable data.

Contributors

Leon Kester, Faisal Mushtaq, Franziska Sörgel, Cristiana-Anca Voinov, Eleni Spyrakou.

Data availability

This article does not involve the collection, generation, or analysis of empirical data. It presents a code of conduct based on ethical analysis, existing standards, and professional norms. Data is available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0). The Code of Conduct, Ethical Impact Assessment and Compliance Checklist are available in the Zenodo repository: Bernabe, R., Baraas, R., Barngrover, M., Cox, S., Hagen, L. A., Kadlubsky, A., Kavouras, P., Krastina, I., Ladikas, M., Amoros Lark, M., Correa Pérez, M., Stephane, L., & Schreer, O. (2025). XR4HUMAN code of conduct for the human-centered and ethical development of immersive technologies (Version v1) [Standard]. Zenodo. https://doi.org/10.5281/zenodo.17035113.

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Siti Sahronih
Institut Prima Bangsa, Cirebon, Indonesia

The authors of this open letter present a research contribution related to the values and principles underlying the development of XR technology, resulting in a Code of Conduct, an Ethical Impact Assessment (EIA), and a Compliance Checklist designed for practical application. The development process, which utilized participatory co-design and involved experts from various multidisciplinary fields as well as appropriate consultation with stakeholders, adds significant value to the research.

The introduction to this research paper also provides a solid background on XR. It identifies various risks, such as privacy, manipulation, health, inclusion, security, and social impact. Additionally, it connects these issues to the deliverables of the XR4Human project.

However, there are several areas the authors need to improve regarding a brief comparison of the proposed framework with other XR related research frameworks. This would help clarify the research gaps and ensure this article serves as a well positioned contribution to the literature for future researchers. This is because there is already a significant body of research on XR ethics frameworks, IEEE, XRSI, EU AI governance, and so on. The authors also merely list **codes of conduct exist** without providing any practical analysis. Adding brief discussions of practical examples regarding XR applications evaluated using the EIA and Compliance Checklist would enhance clarity, reproducibility, and ease of use.

Thus, overall, the following points could be revised:
(1) there is a need for more in depth research gap on existing ethical and governance frameworks for XR; (2) provide a more detailed explanation of stakeholder participation and the consensus building process; (3) include concrete examples demonstrating how conflicting ethical considerations are resolved using the reflective equilibrium approach; (4) add a brief description of examples illustrating the application of an Ethical Impact Assessment (EIA) and a Compliance Checklist in representative XR use cases.

Is the rationale for the Open Letter provided in sufficient detail? (Please consider whether

existing challenges in the field are outlined clearly and whether the purpose of the letter is explained)
Partly

Does the article adequately reference differing views and opinions?
Yes

Are all factual statements correct, and are statements and arguments made adequately supported by citations?
Yes

Is the Open Letter written in accessible language? (Please consider whether all subject-specific terms, concepts and abbreviations are explained)
Yes

Where applicable, are recommendations and next steps explained clearly for others to follow? (Please consider whether others in the research community would be able to implement guidelines or recommendations and/or constructively engage in the debate)
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Augmented reality, immersive technologies, mixed reality, virtual reality.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 06 August 2026

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Catherine Flick
Staffordshire University, Stoke-on-Trent, England, UK

I thank the authors for their significant updates - I am now more satisfied with the purpose of this article and understand the underlying work that has gone into it.

I remain significantly concerned about the lack of participant consent in the development of this work, however - you say you requested feedback from LinkedIn and your forum outside of your existing team. While I appreciate that the Norwegian Health Research Act has no specific requirements for this kind of activity for health-related research, I would argue that this project

would not fall within that scope as it is not health-related. Additionally, there are several existing standards across the research space (especially in human-centred technology research) that would require such consent procedures to take place, many of which are listed here: https://research-and-innovation.ec.europa.eu/strategy/support-policy-making/scientific-support-eu-policies/research-ethics-and-integrity_en

I really hesitate to change my review on this as it feels very problematic for the development of a code of conduct/ethics to not hold itself to the highest of ethical procedures itself. We cannot pick and choose the parts that are most amenable to us when we develop these approaches lest we be seen as hypocritical.

More detail and a reflection on the processes could help to mitigate this; as it is, it is done and perhaps some lessons could be learned from this.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: I am an ethicist of emerging technologies, currently specialising in games technologies with experience having helped to rewrite the ACM's Code of Ethics in 2018. I have also contributed to the construction of several Codes of Ethics and Codes of Conduct for smaller projects and events. I serve as Vice-Chair of the ACM Committee on Professional Ethics.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 03 August 2026

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Moses Adeleke ADEOYE
Al-Hikmah University, Ilorin, Nigeria

This Open Letter describes the development of the XR4Human Code of Conduct for the human-centered and ethical development of immersive technologies, together with its associated Ethical Impact Assessment (EIA) and Compliance Checklist. The manuscript explains the participatory co-design process used to develop the Code, the normative reasoning that translated empirical findings into ethical principles, and the intended operationalization of the Code through practical assessment tools. Compared with the concerns raised during the first round of peer review, this revised version substantially strengthens the methodological description, clarifies the rationale for the work, and provides greater transparency regarding stakeholder engagement and the

development process. Overall, this is a timely and valuable contribution that bridges ethical theory and practical guidance for XR developers. The manuscript is scientifically sound, although several areas could be further strengthened to improve transparency and scholarly value.
The revised manuscript clearly explains both the challenges motivating the work and the purpose of the Open Letter. The introduction outlines major ethical, legal, social, accessibility, privacy, interoperability, and governance challenges associated with XR technologies before explaining why these findings needed to be translated into a practical Code of Conduct. The manuscript also explicitly states that the purpose of the Open Letter is to describe the development of the Code, the Ethical Impact Assessment, and the Compliance Checklist rather than merely presenting the final guidance. However, the discussion primarily presents a consensus-oriented perspective rather than engaging with alternative viewpoints or competing ethical approaches. For example: competing governance models (voluntary codes versus regulatory approaches); differing ethical frameworks that may prioritize autonomy, justice, innovation, or precaution differently; existing international XR governance initiatives from industry and standards organizations are only briefly acknowledged rather than critically compared. Including a concise discussion comparing the XR4Human approach with other existing XR ethics frameworks or standards would strengthen the manuscript and better demonstrate why this particular framework represents an advancement. This is an improvement rather than a scientific deficiency and does not undermine the manuscript's overall validity.
One minor suggestion would be to provide additional references where statements refer broadly to current industry practice (e.g., the claim that legislation and interoperability standards are lagging) by citing more recent regulatory or standards developments. However, this is a minor enhancement rather than a substantive concern. One possible enhancement would be to include a brief worked example illustrating how a hypothetical XR application progresses through the EIA and Compliance Checklist. Such an example would improve reproducibility and facilitate uptake by practitioners.
Points that should be addressed
None of the following issues prevent the manuscript from being scientifically sound, but addressing them would improve its impact:

1. Include a brief comparison with other prominent XR ethics and governance frameworks to better situate the contribution within the existing landscape.
2. Expand discussion of alternative ethical perspectives or governance approaches rather than presenting only the consortium's consensus framework.
3. Include a practical worked example demonstrating application of the Ethical Impact Assessment and Compliance Checklist to a representative XR use case.
4. Where feasible, provide slightly more detail regarding how disagreements during stakeholder consultation were resolved, beyond consensus-based decision making, to further enhance methodological transparency.

Is the rationale for the Open Letter provided in sufficient detail? (Please consider whether existing challenges in the field are outlined clearly and whether the purpose of the letter is explained)

Yes

Does the article adequately reference differing views and opinions?

Partly

Are all factual statements correct, and are statements and arguments made adequately

supported by citations?
Yes

Is the Open Letter written in accessible language? (Please consider whether all subject-specific terms, concepts and abbreviations are explained)
Yes

Where applicable, are recommendations and next steps explained clearly for others to follow? (Please consider whether others in the research community would be able to implement guidelines or recommendations and/or constructively engage in the debate)
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Educational Leadership, Research Method, ICT in Education

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 30 July 2026

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Joshua A Fisher
Ball State University, Muncie, Indiana, USA

I thank the authors for their revisions.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: XR UX, XR design and development, XR Interactive Storytelling, and XR Ethics

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 25 March 2026

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Catherine Flick
Staffordshire University, Stoke-on-Trent, England, UK

This open letter describes the production of a code of conduct developed by the XR4Human project for extended, augmented, mixed, and virtual reality and other immersive technologies.

While constructing a code of conduct is a highly useful exercise it's difficult to understand what this open letter actually contributes. If it is to contribute information about the code of conduct, then it is far too brief and needs fleshing out of the Principles, Articles, and Impact sections. If it is to describe the process then it needs far more information about the process involved - how many participants, specifics of the workshops and other interactions, which experts contributed, etc. It feels like these are available elsewhere, in other papers, so it's difficult to understand the purpose of this article.

As it is, it is difficult to know what one actually *does* with this article, given there is no detail for what those reading it should do outside of simple headings.

I also find it quite surprising that the authors claim there is no need for ethics and consent when they describe a human research activity with several rounds of feedback gathered throughout the process from different stakeholders. There is also no critical assessment of the use of large language models in the work which are known for their inaccuracies. LLM use is controversial in research methods, so an uncritical use of it is worth questioning the usefulness of that over human work.

Is the rationale for the Open Letter provided in sufficient detail? (Please consider whether existing challenges in the field are outlined clearly and whether the purpose of the letter is explained)
Yes

Does the article adequately reference differing views and opinions?
Partly

Are all factual statements correct, and are statements and arguments made adequately supported by citations?
Yes

Is the Open Letter written in accessible language? (Please consider whether all subject-specific terms, concepts and abbreviations are explained)
Yes

Where applicable, are recommendations and next steps explained clearly for others to follow? (Please consider whether others in the research community would be able to

implement guidelines or recommendations and/or constructively engage in the debate)
No

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: I am an ethicist of emerging technologies, currently specialising in games technologies with experience having helped to rewrite the ACM's Code of Ethics in 2018. I have also contributed to the construction of several Codes of Ethics and Codes of Conduct for smaller projects and events. I serve as Vice-Chair of the ACM Committee on Professional Ethics.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Author Response 29 Jun 2026

Shereen Cox

The open letter serves as an introduction to the Code of Conduct which is linked to the letter. The intention of the letter is to give an overview of the process of development of the Code, while the intent is to draw attention to the Code of Conduct document. With regards to ethics approval/waiver, according to Norwegian Health Research Act, stakeholder workshops are not classified as a research-based activities. This was intended to be a strictly consultative process with stakeholders. However, GDPR measures would take priority when processing personal identifiable information. The activities surrounding the Code development were mainly expert meetings and stakeholder engagement. Details for this have been added to the letter.

Competing Interests: No competing interests were disclosed.

Reviewer Report 25 March 2026

https://doi.org/10.21956/openreseurope.24064.r69504

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Frank Ursin
Hannover Medical School, Hanover, Germany

This Open Letter describes how the XR4Human consortium developed a Code of Conduct for human-centered and ethical Extended Reality (XR) and how it was operationalised through an Ethical Impact Assessment (EIA) and a Compliance Checklist. The paper is relevant because XR governance currently has many high-level principles and comparatively few concrete instruments that developers and deployers can use from ideation to deployment. This manuscript aims to

convert ethical ambition into usable practice.

Major points

Translation from empirical evidence to principles to normative claims: The manuscript asserts a move from project deliverables and stakeholder inputs to nine principle domains, seven articles, and operational tools. In order to establish concrete guidelines for action, it is necessary to spell out ethical principles. The ambition is right. The paper does not stop at listing values and principles but offers specific obligations that can foster reflection and inform practice. However, there is always the risk to obscure the translation pathway, i.e. that the reader cannot easily see which project findings generated which principles, which articles, and which questions for the EIA. By providing a comprehensive appendix (Bernabe et al., 2025), this methodological procedure becomes clear. The translation pathway could be improved by disclosure of so-called bridge principles (Kuelmeyer et al, 2022), i.e. explicating the normative principles that bridge empirical findings and normative claims.

NotebookLM-supported generation of EIA questions: The manuscript states that project deliverables were uploaded to NotebookLM and prompts were used to generate questions for ethically relevant risks under each area of impact. The approach is efficient and fits the translational aim. I do not deem it necessary to make the prompt strategy and outputs from NotebookLM transparent since the outputs underwent an iterative human review and represent just a starting point for the method of reflective equilibrium.

Reflective equilibrium as a method: The paper states that drafting and revision were guided by reflective equilibrium. This is an appropriate methodological choice for reconciling empirical inputs, normative principles, and practical constraints. However, the manuscript does not show reflective equilibrium in operation. Without an example, the method could be read as a legitimating phrase rather than a documented procedure. If the authors would provide a specific example of a revision and outline the rules for resolving conflicts, this would make the paper even more convincing.

Participation of different stakeholder groups: The manuscript reports consultations via email, targeted meetings, the XR4human forum, and LinkedIn, with feedback logged weekly and incorporated iteratively. The multi-channel design is well-suited to reach heterogeneous stakeholders and to test clarity and practicality.
Minor points

Terminology and scope: Authors could define early what counts as XR in this document, especially with respect to mixed reality, virtual worlds, and metaverse-adjacent systems.

Domains of application: Authors could give a hint on the different domains of application of their work, e.g. healthcare, industry, entertainment etc.
Overall recommendation

The paper is in very good shape; the contribution is timely and practically oriented. The paper could be improved by disclosing some minor methodological issues.

References

Refer to reference no. 1

References

1. Kuehlmeyer K, Mertz M, Haltaufderheide J, Kremling A, et al.: Empirical Research and Recommendations for Moral Action: A Plea for the Transparent Reporting of Bridge Principles in Public Health Research. *Public Health Ethics*. 2022; **15** (2): 147-159 Publisher Full Text

Is the rationale for the Open Letter provided in sufficient detail? (Please consider whether existing challenges in the field are outlined clearly and whether the purpose of the letter is explained)

Yes

Does the article adequately reference differing views and opinions?

Yes

Are all factual statements correct, and are statements and arguments made adequately supported by citations?

Yes

Is the Open Letter written in accessible language? (Please consider whether all subject-specific terms, concepts and abbreviations are explained)

Yes

Where applicable, are recommendations and next steps explained clearly for others to follow? (Please consider whether others in the research community would be able to implement guidelines or recommendations and/or constructively engage in the debate)

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: ethical issues of XR in surgery, data ethics, AI ethics, research ethics, digital bioethics, medical ethics, history of medicine

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 29 Jun 2026

Shereen Cox

We thank the reviewer for this thoughtful input and for pointing us to Kuehlmeyer et al. (2022), which we found highly insightful. We agree that making the “translation pathway” between empirical findings and normative recommendations more transparent by distinguishing descriptive claims, bridge principles, and normative conclusions, can substantially strengthen the methodological clarity of empirical ethics work. At the same time, providing a fully explicit mapping for all nine principle domains, seven articles, and all EIA questions would require us to reconstruct, in detail, the reasoning

across multiple work-package deliverables, numerous internal workshops, and stakeholder consultations over several years. This is methodologically valuable but, in our view, not practically feasible within the format and purpose of this Open Letter, which is to give a concise account of the process and resulting tools rather than an exhaustive reconstruction of every inferential step. Kuehlmeyer et al. themselves note that such reconstruction becomes particularly complex in guideline-like outputs that integrate findings from multiple studies and involve collaborative, multi-stage deliberation: “guidelines ... often integrate findings from multiple studies, their methodology is based on a collaborative process involving experts in a certain field and they include more complex processes of reasoning and deliberation”. This is precisely the situation for the Code of Conduct and its operationalization. We have revised to include definition of XR terminologies. This was also included in the glossary of terms of the Code of Conduct. We have included different use cases that may be relevant for the application of the Code of
Conduct in the operationalisation and dissemination section. We have added a section on normative reflection and synthesis, explaining with examples how reflective equilibrium was applied to the different impact domains as to a middle ground. We believe this has improved the open letter.

Competing Interests: No competing interests were disclosed.

Reviewer Report 24 February 2026

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Joshua A Fisher
Ball State University, Muncie, Indiana, USA

The authors of this open letter present a pressing issue and their participatory process for meeting the challenge of creating ethical XR experiences. I concur with their work and am generally appreciative of the code of conduct as detailed on the initiative’s website. My suggestions for revisions are meant to clarify the stakes and to integrate some of the diligent work this group has done into the letter. In this draft, this work is pointed to or gestured to, and a more descriptive and, while not analytical, propositional summary might achieve more constructive ends for this letter.

Within the introduction, I strongly suggest that the authors reference the distinct ethical challenges addressed by XR4Human. Provide readers with examples so that future researchers might have a better understanding of the ethical stakes of immersive technologies. I would not cut any of the discussion of the process or the goal, but I would add more details to the initiative. Please cite the key peer-reviewed publications and/or flagship deliverables that directly informed the Code, rather than only pointing generally to the website. This information enhances the

project's credibility. The authors might also expand on or place Wright's work in conversation with industry groups such as XRSI and with academic white papers from IEEE. I expect such discussions occurred in XR4Human's process for developing their Code, and elevating them to this letter strengthens the perception of deliberation and multiperspectivity, crucial to ethics and technology.

The approach section could be greatly strengthened by providing more details and examples of the deliberations that occurred. Future researchers in the space would best learn by a guiding example that demonstrates how brainstorming and stakeholder consultations proceed. Were any design methods used? What approaches to ethics were explored? Who were the groups that were most present in deliberations (industry, nationality, etc.)? What kinds of engagement did the researchers get on LinkedIn? Please report the scale and composition of consultation (approximate N, stakeholder categories, countries/sectors where feasible) and describe at a high level how feedback was categorized and incorporated. How did they review that information? How was it dismissed or integrated? As a reader, I am left with more questions than answers. Providing some of this information strengthens the perception of the approach and enables future researchers to replicate it.

In the synthesis section, since the researchers utilized NotebookLM, it would be beneficial to know which Gemini model was used. Further, what prompts were used and during what time period? Were they the same prompts from information gathering? How were humans involved in the loop? What information verification protocols were implemented? How were the weekly meetings run? It is good to see deliberation, but what was the standard for consensus?

Each principle, article, and key impact area should include at least a short definition and an example. This will help researchers pick up the authors' work and continue.

While I appreciate that the infographic is meant to motivate readers to engage with the XR4HUMAN site, the authors might consider adding XR4HUMAN's *Human-Centered and Ethical Development of Immersive Technologies Checklist*, as it is more directly actionable. Alternatively, the authors could include a graphic that helps readers identify common categories of ethical issues and points them to the relevant parts of the Code of Conduct on the site.

I recommend Approved with Reservations. The initiative and outputs are timely and potentially valuable for XR researchers and practitioners; however, the Open Letter currently reads more as a pointer to external resources than a self-contained scholarly communication. Adding concrete examples of the ethical stakes addressed, minimal reporting of the consultation process (who/roughly how many and how feedback was synthesized), and transparency about the NotebookLM-supported drafting workflow would substantially strengthen credibility, reuse, and replicability.

Is the rationale for the Open Letter provided in sufficient detail? (Please consider whether existing challenges in the field are outlined clearly and whether the purpose of the letter is explained)

Partly

Does the article adequately reference differing views and opinions?

No

Are all factual statements correct, and are statements and arguments made adequately supported by citations?
Yes

Is the Open Letter written in accessible language? (Please consider whether all subject-specific terms, concepts and abbreviations are explained)
Yes

Where applicable, are recommendations and next steps explained clearly for others to follow? (Please consider whether others in the research community would be able to implement guidelines or recommendations and/or constructively engage in the debate)
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: XR UX, XR design and development, XR Interactive Storytelling, and XR Ethics

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 29 Jun 2026

Shereen Cox

We thank the reviewer for the detailed, relevant and constructive feedback.
The intent was to introduce the Code of Conduct and give an overview of the process, hence the choice of an open letter. However, the reviewer's comments and interest in the credibility, transparency of the process are well received, and changes made to reflect this. The introduction section has been expanded to elaborate on some of the main ethical issues of XR especially the key findings of WP2 deliverables. This is an attempt to address the reviewer's comments on clarifying the stakes. We also note some of the legal implications and risks of XR. The XR4Human Code of Conduct was developed using a participatory co-design methodology facilitated through expert-led workshops as well as stakeholder and public consultations. In the approach section, we have now included the different professional expertise of the working group, how brainstorming and stakeholder consultations were conducted. The design method is participatory co-design while applying reflective equilibrium for identification and synthesis of principles.
LinkedIn and XR4Human forum were used strictly as stakeholder engagement and dissemination platforms. The draft Code of Conduct was posted, feedback invited by way of comments and direct feedback on draft materials, which were logged, reviewed during weekly meetings, and considered during iterative document revisions. The methods section has been updated to include the process of integration, the stakeholder/industry categories/countries and sectors. A master prompt was
inputted into Google Notebook LM (Gemini 2.5 Flash). It was only used for

the initial drafting of questions relevant to areas of impact. Thereafter no LM was involved and only human review, refinement and finalisation. This was different from the prompts used in the consultative phase.
Two researchers did the initial drafting of impact descriptors. This was done over several months in weekly meetings. The draft EIA and Compliance checklist were shared with four members of the consortium (WP on interoperability and WP on Experience Library) for feedback and refinement before submission to the working group. Consensus was achieved when there was no more disagreement among team members.
A section has been included with a summary of the five areas of impact, the relevant principles and articles. These have been defined or elaborated further to facilitate better understanding by the reader.
With regard to the graphic, we thank the reviewer for this suggestion. Please note, we reflected on the implications of using a risk-based framing, as done in one of our previous papers and decided that placing emphasis on areas of impact rather than risks would be more constructive and accessible for both developers and end-users, while still capturing the potential ethical concerns associated with XR technologies. The impact graphic is therefore included in the Ethical Impact Assessment.

Competing Interests: No competing interests were disclosed.