Paper Summary

<!--META_START-->

Title: Metrics for What, Metrics for Whom: Assessing Actionability of Bias Evaluation Metrics in NLP

Authors: Pieter Delobelle, Giuseppe Attanasio, Debora Nozza, Su Lin Blodgett, Zeerak Talat

DOI: 10.18653/v1/2024.emnlp-main.1315

Year: 2024

Publication Type: Journal/Conference Proceedings (EMNLP 2024)

Discipline/Domain: Natural Language Processing, AI Ethics

Subdomain/Topic: Bias evaluation metrics, actionability assessment

Eligibility: Eligible

Overall Relevance Score: 95

Operationalization Score: 90

Contains Definition of Actionability: Yes

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Partial

Contains Interpretability: Yes

Contains Framework/Model: Yes (desiderata-based framework)

Operationalization Present: Yes

Primary Methodology: Review and Conceptual Framework + Qualitative Analysis

Study Context: NLP bias measures

Geographic/Institutional Context: International (Authors from KU Leuven, Instituto de Telecomunicações

Target Users/Stakeholders: NLP researchers, metric developers, practitioners, policymakers, regulators

Primary Contribution Type: Conceptual framework + systematic literature review

CL: Yes

CR: Yes

FE: Yes

TI: Partial

EX: Partial

GA: Yes

Reason if Not Eligible: N/A

<!--META_END-->

Title: Metrics for What, Metrics for Whom: Assessing Actionability of Bias Evaluation Metrics in NLP

Authors: Pieter Delobelle, Giuseppe Attanasio, Debora Nozza, Su Lin Blodgett, Zeerak Talat

DOI: 10.18653/v1/2024.emnlp-main.1315

Year: 2024

Publication Type: Conference Proceedings (EMNLP 2024)

Discipline/Domain: Natural Language Processing, Responsible AI

Subdomain/Topic: Bias evaluation metrics, actionability, metric design

Contextual Background: The paper situates itself in the context of growing use of bias measures in NL

Geographic/Institutional Context: Belgium, Portugal, Italy, Canada, UAE

Target Users/Stakeholders: NLP researchers, fairness auditors, AI developers, policymakers, regulato

Primary Methodology: Conceptual framework + systematic literature review (146 papers)

Primary Contribution Type: Definition and framework for “actionability” of bias measures + review-bas

General Summary of the Paper

The authors define *actionability* in bias measures as the degree to which a measure’s results enable inf

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is “the degree to which a measure’s results enable decision-making or intervention” — result

> “Actionability refers to the degree to which a measure’s results enable decision-making or intervention.

> “…results from actionable bias measures should facilitate informed actions with respect to th

Paper Summary

<!--META_START-->

Title: Actionable Knowledge Discovery and Delivery

Authors: Longbing Cao

DOI: 10.1002/widm.1044

Year: 2012

Publication Type: Journal

Discipline/Domain: Data Mining / Knowledge Discovery

Subdomain/Topic: Actionable Knowledge Discovery (AKD), Domain-Driven Data Mining

Eligibility: Eligible

Overall Relevance Score: 98

Operationalization Score: 95

Contains Definition of Actionability: Yes

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Conceptual / Framework Development

Study Context: Knowledge discovery in data mining, focusing on bridging the gap between academic out

Geographic/Institutional Context: University of Technology, Sydney, Australia

Target Users/Stakeholders: Data mining researchers, practitioners, business decision-makers

Primary Contribution Type: Conceptual framework and methodological proposition (Domain-Driven Data

CL: Yes

CR: Yes

FE: Yes

TI: Partial

EX: Yes

GA: Yes

Reason if Not Eligible: N/A

<!--META_END-->

Title:

Actionable Knowledge Discovery and Delivery

Authors:

Longbing Cao

DOI:

10.1002/widm.1044

Year:

2012

Publication Type:

Journal

Discipline/Domain:

Data Mining / Knowledge Discovery

Subdomain/Topic:

Actionable Knowledge Discovery (AKD), Domain-Driven Data Mining

Contextual Background:

The paper addresses the persistent gap between data mining research outputs and the needs of busines

Geographic/Institutional Context:

University of Technology, Sydney, Australia

Target Users/Stakeholders:

Data mining researchers, practitioners, and business decision-makers in domains such as retail, healthca

Primary Methodology:

Conceptual / Framework Development

Primary Contribution Type:

Proposal of a structured AKD methodology (Domain-Driven Data Mining) and operational frameworks.

General Summary of the Paper

This paper critiques the inadequacies of traditional KDD, highlighting its inability to produce knowledge di

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is defined as “the power to work” — the quality of knowledge that enables direct, effective de

> “Actionable knowledge ‘is not only relevant to the world of practice, it is the knowledge that people use

> “Actionability means the power to work, which is an optimal outcome… through the best integration of s

What Makes Something Actionable

- Addresses the actual business problem, not just technical interest.
- Integrates environmental, organizational, and social factors.
- Is interpretable and explainable to end users.
- Is feasible and integrable into existing business processes.
- Produces measurable impact toward business goals.
- Satisfies both technical and business interestingness thresholds.

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Domain-Driven Data Mining (D3M), AKD Framework
- **Methods/Levers:** Integration of domain, human, network, and social intelligence; postanalysis; unifie
- **Operational Steps / Workflow:** Problem definition → Data understanding → Environmental/context m
- **Data & Measures:** Technical and business actionability metrics (objective and subjective), threshold
- **Implementation Context:** Retail, healthcare, intrusion detection, web analytics, organizational decisio

> “AKD is a six-dimension-based optimization process: problem, data, environment, model, decision, opti

> “For a pattern p… Act(p) can be further measured in terms of technical actionability and business actio

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — interpretability and understandability emphasized.
- **CR (Contextual Relevance):** Yes — explicit requirement to integrate environmental/business contex
- **FE (Feasibility):** Yes — must be directly usable without major rework.
- **TI (Timeliness):** Partial — addressed indirectly via adaptability to dynamic data and environments.
- **EX (Explainability):** Yes — must be interpretable in business language and logic.
- **GA (Goal Alignment):** Yes — deliverables must meet business expectations and objectives.
- **Other Dimensions Named by Authors:** Autonomy, deliverability, dependability, repeatability, trust, se

Theoretical or Conceptual Foundations

- System sciences, cybernetics, complex systems theory, metasynthesis, agent-based systems, ubiquito

Indicators or Metrics for Actionability

- Technical interestingness (ti) and business interestingness (bi) with defined thresholds.
- Objective/subjective measures from technical and business perspectives.
- Evaluation of business impact (e.g., revenue, efficiency).

Barriers and Enablers to Actionability

- **Barriers:** Academic–business goal misalignment; oversimplification of problems; lack of integration o
- **Enablers:** Involving domain experts; modeling environmental factors; unified interestingness measur

Relation to Existing Literature

Positions itself as extending prior notions of actionable rules and interestingness by embedding them in a

Summary

Cao (2012) advances the concept of Actionable Knowledge Discovery (AKD) as a shift from conventiona

Scores

- **Overall Relevance Score:** 98 — Provides a rich, explicit conceptualization of actionability, systemati
- **Operationalization Score:** 95 — Offers a complete methodology with measurable metrics, process m

Supporting Quotes from the Paper

- “Actionable knowledge ‘is not only relevant to the world of practice…’” (p. 149)
- “Actionability means the power to work… through the best integration of six core dimensions.” (p. 154)
- “AKD is a six-dimension-based optimization process: problem, data, environment, model, decision, opti
- “Deliverables… must be easily interpretable, convertible into business rules, and linked to decision-mak

Actionability References to Other Papers

- Argyris (1993, 1996) on actionable knowledge in organizational contexts.

- He et al. (2005) on actionable knowledge in data mining.

- Ras & Wieczorkowska (2000) on action rules.

- Cao & Zhang (2007, 2010) on knowledge actionability and domain-driven data mining.

Paper Summary

<!--META_START-->

Title: Geopolitical Forecasting and Actionable Intelligence

Authors: Ian S. Lustick

DOI: 10.1080/00396338.2022.2032959

Year: 2022

Publication Type: Journal

Discipline/Domain: Political Science / International Relations

Subdomain/Topic: Geopolitical forecasting, intelligence analysis, decision support

Eligibility: Eligible

Overall Relevance Score: 88

Operationalization Score: 70

Contains Definition of Actionability: Yes (implicit, tied to “actionable intelligence”)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Partial

Contains Framework/Model: No formal named framework, but conceptual approach

Operationalization Present: Yes

Primary Methodology: Conceptual / Analytical Essay

Study Context: Intelligence analysis for U.S. foreign policy and national security

Geographic/Institutional Context: Primarily U.S. intelligence community

Target Users/Stakeholders: Policymakers, intelligence analysts, national security officials

Primary Contribution Type: Conceptual framework for linking forecasting validity/verification to actionabilit

CL: Yes

CR: Yes

FE: Partial

TI: No

EX: Yes

GA: Partial

Reason if Not Eligible: N/A

<!--META_END-->

Title: Geopolitical Forecasting and Actionable Intelligence

Authors: Ian S. Lustick

DOI: 10.1080/00396338.2022.2032959

Year: 2022

Publication Type: Journal

Discipline/Domain: Political Science / International Relations

Subdomain/Topic: Geopolitical forecasting, intelligence analysis, decision support

Contextual Background: Discusses the evolution of U.S. intelligence forecasting from WWII to the pre

Geographic/Institutional Context: U.S. intelligence community and policymaking environment

Target Users/Stakeholders: Policymakers, intelligence analysts, decision-support tool developers

Primary Methodology: Conceptual / Analytical Essay

Primary Contribution Type: Conceptual linkage between validation, verification, and actionable intellig

General Summary of the Paper

The paper examines why geopolitical forecasting, despite technological advances, often fails to produce a

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is implicitly defined as the capacity of intelligence forecasts to inform and guide concrete poli

> “If forecasts are used as actual inputs into a policy- or decision-making process, they do need to be acc

> “Only models capable of answering why and how questions, not just what, where and when questions,

What Makes Something Actionable

- Empirical validity (accuracy, precision, reliability of forecasts)
- Verification (causal traceability and theoretical grounding)
- Ability to answer “why” and “how” questions to guide action
- Integration of domain-specific cultural, political, and economic knowledge
- Relevance to decision-makers’ context and needs

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Not formalized; dual requirement of validation + verification
- **Methods/Levers:** Brier scoring for validation; causal modeling for verification; integration of substanti
- **Operational Steps / Workflow:**

1. Validate forecasts statistically (probability conformity to outcomes).
2. Verify causal soundness of models.
3. Integrate social science expertise with computational modeling.
4. Tailor models to specific geographic/cultural contexts.

- **Data & Measures:** Brier score; qualitative causal traceability
- **Implementation Context:** U.S. intelligence community forecasting for policy use

> “Only streams of outcomes that exhibit the forecasted probability can corroborate the validity of the fore

> “If outcomes cannot be traced to particular combinations of antecedent variables… decision-makers ca

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — forecasts must be precise and interpretable to decision-makers.
- **CR (Contextual Relevance):** Yes — tied to specific geopolitical/cultural contexts.
- **FE (Feasibility):** Partial — implies that forecasts should inform feasible actions, but not fully elaborat
- **TI (Timeliness):** No explicit emphasis.
- **EX (Explainability):** Yes — forecasts must answer “why” and “how” to be useful.
- **GA (Goal Alignment):** Partial — linked to enhancing desired outcomes and avoiding undesirable one
- **Other Dimensions:** Validation, Verification.

Theoretical or Conceptual Foundations

- Distinction between validation and verification from modeling literature.
- Critique of brute-force empiricism in forecasting (Lustick & Tetlock 2021).
- Decision-support theory in intelligence studies.

Indicators or Metrics for Actionability

- Brier scoring for forecast validity.
- Presence of causal explanations linking variables to outcomes.

Barriers and Enablers to Actionability

- **Barriers:** Dominance of engineers over social scientists in intelligence R&D; overreliance on machine
- **Enablers:** Combining social science expertise with computing power; rigorous validation and verifica

Relation to Existing Literature

Positions itself against purely technical, data-driven forecasting approaches, emphasizing the need for th

Summary

Lustick’s article argues that for geopolitical forecasts to yield *actionable intelligence*, they must satisfy tw

Scores

- **Overall Relevance Score:** 88 — Strong implicit definition and clear features linked to actionability; ro

- **Operationalization Score:** 70 — Outlines a clear dual-process approach (validation + verification) an

Supporting Quotes from the Paper

- “If forecasts are used as actual inputs into a policy- or decision-making process, they do need to be acc
- “Only models capable of answering why and how questions, not just what, where and when questions, v
- “Only streams of outcomes that exhibit the forecasted probability can corroborate the validity of the fore
- “If outcomes cannot be traced to particular combinations of antecedent variables… decision-makers car

Actionability References to Other Papers

- Lustick & Tetlock (2021), *The Simulation Manifesto*
- O’Brien (2010), *Crisis Early Warning and Decision Support*
- Johnston (2005), *Analytic Culture in the U.S. Intelligence Community*
- Halberstam (1972), *The Best and the Brightest*

Paper Summary

<!--META_START-->

Title: Knowledge and Policy: research – information – intervention

Authors: Ingrid Gogolin, Edwin Keiner, Gita Steiner-Khamsi, Jenny Ozga, Lyn Yates

DOI: n/a

Year: 2007

Publication Type: Journal

Discipline/Domain: Educational Policy, Educational Research

Subdomain/Topic: Policy Analysis, Research Governance, Knowledge Transfer

Eligibility: Yes

Overall Relevance Score: 85

Operationalization Score: 70

Contains Definition of Actionability: Yes

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Conceptual and Review

Study Context: Education Policy, International Comparisons

Geographic/Institutional Context: International (Switzerland, UK, Germany, USA, Australia)

Target Users/Stakeholders: Educational Policymakers, Researchers, Educators

Primary Contribution Type: Conceptual Exploration, Policy Implications

CL: Yes

CR: Yes

FE: Yes

TI: Yes

EX: Yes

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title: Knowledge and Policy: research – information – intervention

Authors: Ingrid Gogolin, Edwin Keiner, Gita Steiner-Khamsi, Jenny Ozga, Lyn Yates

DOI: n/a

Year: 2007

Publication Type: Journal

Discipline/Domain: Educational Policy, Educational Research

Subdomain/Topic: Policy Analysis, Research Governance, Knowledge Transfer

Contextual Background: The paper discusses the evolving relationships between research, informatio

Geographic/Institutional Context: The paper draws on international perspectives, including the UK, Ge

Target Users/Stakeholders: Educational policymakers, researchers, practitioners in education

Primary Methodology: Conceptual analysis, review of educational policy trends

Primary Contribution Type: Conceptual exploration of policy-research interactions and implications for

General Summary of the Paper

This paper explores the interplay between research, information, and policy interventions in educational s

Eligibility

Eligible for inclusion: **Yes**

Reason if Not Eligible: n/a

How Actionability is Understood

The authors define actionability in the context of research-policy relationships as the process by which re

> “Research knowledge is not just a tool for solving problems but becomes a resource for governance, fa

> “Policy-making increasingly relies on research that is ‘actionable,’ a process that is mediated by politica

What Makes Something Actionable

The authors argue that for research to be actionable, it must:

- Be clearly translated into policy-relevant knowledge
- Align with political and economic needs, particularly in the context of global benchmarking and educatio
- Be produced with a view toward achieving practical outcomes, often under the constraints of governanc

> “Actionable knowledge must be framed to meet both the practical needs of policymakers and the strate

> “The shift toward evidence-based policy-making demands that research be oriented toward measurable

How Actionability is Achieved / Operationalized

The paper proposes that actionability is achieved through mechanisms like international knowledge bank

- **Framework/Approach Name(s):** Evidence-based Policy, Knowledge Transfer
- **Methods/Levers:** International knowledge banks, benchmarking, cross-national comparisons
- **Operational Steps / Workflow:** Researchers produce data-driven reports that become policy tools; th
- **Data & Measures:** Standardized assessments (PISA, TIMSS), national rankings, educational benchr
- **Implementation Context:** Primarily in global educational reform initiatives, influenced by international

> “International comparisons, like those of PISA and TIMSS, provide the evidence that policymakers nee

> “The creation of knowledge banks is a deliberate attempt to shape the policy landscape by providing ev

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes – Actionable knowledge must be clear and understandable to policymakers.
  > “Actionable research must be accessible to those making policy decisions, as clarity is essential to en
- **CR (Contextual Relevance):** Yes – Knowledge must be relevant to the specific political and educatio
  > “Research needs to be contextualized to fit the political, social, and economic conditions of the countr
- **FE (Feasibility):** Yes – Research should be practical and feasible to implement in policy.
  > “Feasibility is a key attribute for research to be considered actionable, particularly when framed within
- **TI (Timeliness):** Yes – Actionability also depends on the timeliness of the research in relation to polic
  > “Timely interventions are necessary to ensure that research can be translated into action during critica
- **EX (Explainability):** Yes – The ability to explain research findings in a way that informs decision-mak
  > “The explanation of research results in an understandable way is critical for influencing policy decision
- **GA (Goal Alignment):** Yes – Research must align with the goals and agendas of policymakers.
  > “Alignment with national or international educational goals is crucial for ensuring that research is actio

Theoretical or Conceptual Foundations

The paper draws on the concept of Mode 1 and Mode 2 knowledge production (Gibbons et al., 1994), hig

> “Mode 2 knowledge production is marked by its transdisciplinary approach, involving collaboration betw

Indicators or Metrics for Actionability

The paper implies that actionable knowledge is measured through indicators such as educational ranking

> “International rankings and benchmarks act as primary indicators of the quality and impact of education

Barriers and Enablers to Actionability

- **Barriers:** Political agendas that shape the research questions and the framing of evidence, resistanc

> “Political pressures can skew the research agenda, prioritizing data that aligns with predetermined polic

- **Enablers:** Collaboration between researchers and policymakers, the rise of evidence-based policy-m

> “The growth of knowledge banks and international policy networks has enhanced the ability to translate

Relation to Existing Literature

The paper critiques the linear model of research-to-policy transfer, which assumes a direct link from rese

> “The relationship between research and policy is more complex than the simple transmission of knowle

Summary

This paper critically examines the relationship between research, information, and policy interventions in

Scores

- **Overall Relevance Score:** 85 – The paper offers valuable insights into the complexities of making res

- **Operationalization Score:** 70 – While the paper discusses mechanisms for achieving actionability, it

Supporting Quotes from the Paper

- “Research knowledge is not just a tool for solvin

Paper Summary

<!--META_START-->

Title: Actionable Insights in Urban Multivariate Time-series

Authors: Anika Tabassum, Supriya Chinthavali, Varisara Tansakul, B. Aditya Prakash

DOI: https://doi.org/10.1145/3459637.3482410

Year: 2021

Publication Type: Conference (ACM CIKM ’21)

Discipline/Domain: Computer Science / Urban Analytics

Subdomain/Topic: Multivariate Time-series Segmentation, Explainability, Rationalization

Eligibility: Eligible

Overall Relevance Score: 90

Operationalization Score: 95

Contains Definition of Actionability: Yes (implicit, formalized in RaTSS problem)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes (RaTSS, Find-RaTSS)

Operationalization Present: Yes

Primary Methodology: Conceptual + Quantitative Evaluation (Algorithm design, experiments)

Study Context: Urban analytics applications in disasters, public health, epidemiology, and general high-di

Geographic/Institutional Context: US (Oak Ridge National Laboratory, Virginia Tech, Georgia Tech)

Target Users/Stakeholders: Urban domain experts (emergency management authorities, epidemiologists

Primary Contribution Type: Novel problem formulation + algorithmic solution

CL: Yes

CR: Yes

FE: Yes

TI: Partial

EX: Yes

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title:

Actionable Insights in Urban Multivariate Time-series

Authors:

Anika Tabassum, Supriya Chinthavali, Varisara Tansakul, B. Aditya Prakash

DOI:

https://doi.org/10.1145/3459637.3482410

Year:

2021

Publication Type:

Conference Paper (CIKM 2021)

Discipline/Domain:

Computer Science / Data Mining

Subdomain/Topic:

Urban Analytics, Time-series Segmentation, Explainable AI

Contextual Background:

The paper addresses the difficulty urban domain experts face in extracting **actionable** time-series of ir

Geographic/Institutional Context:

US, collaboration between Virginia Tech, Oak Ridge National Laboratory, Georgia Tech.

Target Users/Stakeholders:

Emergency management authorities, epidemiologists, public health planners, infrastructure operators.

Primary Methodology:

Conceptual framework + Algorithm design (RaTSS & Find-RaTSS) + Empirical evaluation on synthetic, re

Primary Contribution Type:

Novel problem definition + algorithm to produce actionable insights for any black-box segmentation algori

---

General Summary of the Paper

The authors introduce **RaTSS** (Rationalization for Time-series Segmentation), a framework for identif

---

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is framed as identifying TOIs whose changes across segmentation cutpoints are **most relev

> "… actionable insights, i.e., which time-series/counties are the most important with respect to an event,

> "… human-friendly and actionable TOIs (rationalizations) for the urban experts across the associated ev

---

What Makes Something Actionable

- High relative importance across a cutpoint (based on learned weights)
- Potential to influence direct interventions or decisions
- Inclusion of *non-obvious* series not apparent from visual inspection
- Contextual linkage to events (e.g., weather, policy changes, epidemiological outbreaks)

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** RaTSS (problem), Find-RaTSS (algorithm)
- **Methods/Levers:** Segment graph representation; optimization of global latent weights (α) to maximiz
- **Operational Steps / Workflow:**
  1. Build segment graph for multivariate time series.
  2. Calculate edge weights using basic statistical features across segments.

3. Compute $\Delta\pi$ (difference in path lengths between chosen and alternative segmentations).

4. Optimize α under sparsity and norm constraints.

5. Derive r_j (importance weights) per cutpoint and select top TOIs.

- **Data & Measures:** Mean, variance, min, max features per segment; importance weights; F1-scores f
- **Implementation Context:** Works for any black-box segmentation algorithm, regardless of internal me

> “We propose an algorithm Find-RaTSS to automatically capture the TOIs in a way that is flexible and w

---

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — output is simplified, interpretable list of TOIs with weights.
- **CR (Contextual Relevance):** Yes — TOIs tied to specific events and domain context.
- **FE (Feasibility):** Yes — outputs can be operationalized into concrete actions (e.g., send crews, inves
- **TI (Timeliness):** Partial — method processes historical data; potential for near real-time with optimiza
- **EX (Explainability):** Yes — weight-based rationalizations with clear link to cutpoints.
- **GA (Goal Alignment):** Yes — TOIs are selected to match decision-makers’ objectives.
- **Other Dimensions:** Non-obviousness (ability to surface hidden but important cases).

Theoretical or Conceptual Foundations

- Graph-based representation of segmentation paths (segment graph)
- Optimization under sparsity and norm constraints
- Basic statistical change detection (mean, variance, min, max features)

Indicators or Metrics for Actionability

- Importance weight (r_j) per series at each cutpoint
- F1-score comparing predicted TOIs to ground truth
- Fraction of total rationalization weight captured by top-k TOIs

---

Barriers and Enablers to Actionability

- **Barriers:**
  - If segmentation is meaningless (e.g., constant series), rationalizations may not be meaningful.
  - Some actionable groups may consist of combinations of series, not individual ones (not yet implemente
- **Enablers:**
  - Algorithm’s independence from segmentation model details

- Works with any multivariate time-series data

Relation to Existing Literature

Positions itself as the first method to identify actionable TOIs for any black-box segmentation. Builds on w

---

Summary

This paper presents RaTSS, a formal problem framing for deriving actionable Time-series of Interest (TO

Scores

- **Overall Relevance Score:** 90 — Strong implicit and operational definition of actionability, clear identi
- **Operationalization Score:** 95 — Detailed algorithm and workflow for achieving actionable outputs, te

---

Supporting Quotes from the Paper

- “... actionable insights, i.e., which time-series/counties are the most important with respect to an event..
- “We introduce and formalize a novel problem Rationalization for Time-series Segmentations (RaTSS)…
- “r_j = |α ■ w_ijk|” (p. 4)
- “Remark 1: … when the time-series is constant, then rationalizations (TOIs) found by RaTSS may not b

---

Actionability References to Other Papers

- [23] Cut-n-Reveal: Time Series Segmentations with Explanations — related explanation approach but m
- [6] ORNL EARSS — situational awareness in disaster response.
- [19] Dynammo — handling missing values in time-series.
- [21] Autoplait — segmentation with HMMs.
- [12] TICC — segmentation with multilayer Markov Random Fields.

Paper Summary

<!--META_START-->

Title: Communication of Actionable Information

Authors: Giles W. Boland, Richard Duszak Jr, Paul A. Larson

DOI: http://dx.doi.org/10.1016/j.jacr.2014.08.003

Year: 2014

Publication Type: Journal

Discipline/Domain: Radiology / Medical Imaging

Subdomain/Topic: Communication of actionable radiology findings

Eligibility: Eligible

Overall Relevance Score: 83

Operationalization Score: 75

Contains Definition of Actionability: Yes (implicit and partially explicit)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: No

Contains Interpretability: No

Contains Framework/Model: Yes (ACR categories)

Operationalization Present: Yes

Primary Methodology: Conceptual / Practice guidance

Study Context: Communication of actionable radiology information in clinical workflows

Geographic/Institutional Context: U.S. radiology practices, hospitals, and teleradiology services

Target Users/Stakeholders: Radiologists, referring physicians, patients, hospital administrators

Primary Contribution Type: Practice recommendations and framework adaptation

CL: Yes

CR: Yes

FE: Yes

TI: Yes

EX: No

GA: Partial

Reason if Not Eligible: N/A

<!--META_END-->

Title:

Communication of Actionable Information

Authors:

Giles W. Boland, Richard Duszak Jr, Paul A. Larson

DOI:

http://dx.doi.org/10.1016/j.jacr.2014.08.003

Year:

2014

Publication Type:

Journal

Discipline/Domain:

Radiology / Medical Imaging

Subdomain/Topic:

Communication of actionable radiology findings

Contextual Background:

The paper addresses the challenge of ensuring that radiology reports—especially those containing actior

Geographic/Institutional Context:

U.S. radiology practices, including academic centers, private groups, and teleradiology services.

Target Users/Stakeholders:

Radiologists, referring physicians, patients, hospital administrators.

Primary Methodology:

Conceptual / Practice guidance.

Primary Contribution Type:

Practice recommendations and operational framework.

General Summary of the Paper

This article outlines the critical role radiologists play in not only producing timely, meaningful, and actiona

---

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

The paper defines actionable information in radiology as findings that, once communicated, can influence

> “A report creates little value until it is delivered, read, and correctly understood… Only then can informa

> “Effective communication of actionable information” is described as the final step in the imaging value c

---

What Makes Something Actionable

- Clear identification of findings with clinical significance.
- Timeliness in delivering the report relative to urgency.
- Delivery to the right recipient(s) with confirmation.
- Documentation of communication.

- Use of standardized categories (ACR Category 1–3) tied to urgency.

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** ACR Actionable Reporting categories.
- **Methods/Levers:** Standardized timelines for Category 1 (minutes), Category 2 (hours), Category 3 (d
- **Operational Steps / Workflow:** Interpret findings → classify urgency → communicate via appropriate
- **Data & Measures:** Time from report finalization to communication; confirmation logs; audit trails.
- **Implementation Context:** Hospital radiology, teleradiology, academic centers, multidisciplinary clinics

> “Category-1 findings require communication within minutes, usually by direct verbal communication…”

> “Electronic text and e-mail alerts… confirm whether referrers have reviewed such reports… close the c

---

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — Reports must be concise and precisely structured to be understood by stakehold

> “…synthesize all relevant clinical information into a concise and precisely structured document.” (p. 1)

- **CR (Contextual Relevance):** Yes — Findings must be relevant to the patient’s condition and clinical
- **FE (Feasibility):** Yes — Communication processes must be operationally possible within institutional
- **TI (Timeliness):** Yes — Strong emphasis on rapid delivery based on urgency category.
- **EX (Explainability):** No — Paper does not explicitly frame explainability as part of actionability.
- **GA (Goal Alignment):** Partial — Aligns communication with patient outcomes but not framed as expli
- **Other Dimensions Named by Authors:** Integration with IT systems; closed-loop communication; docu

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Theoretical or Conceptual Foundations

- Imaging Value Chain model.
- ACR Actionable Reporting framework.

Indicators or Metrics for Actionability

- Time-to-communication metrics by urgency category.
- Audit logs of communication events.
- Confirmation of recipient acknowledgment.

Barriers and Enablers to Actionability

- **Barriers:** Fragmented IT systems; lack of integrated EMR; variability in preliminary/final report workfl

- **Enablers:** Integrated IT solutions; standardized critical findings policies; embedding radiologists in ca

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Relation to Existing Literature

Builds directly on ACR Actionable Reporting Work Group recommendations, situating them within broade

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Summary

Boland et al. (2014) conceptualize actionability in radiology as the combination of meaningful findings, tim

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Scores

- **Overall Relevance Score:** 83 — Strong implicit definition, tied to explicit features and urgency framew
- **Operationalization Score:** 75 — Provides concrete steps and workflow recommendations linked to a

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Supporting Quotes from the Paper

- “A report creates little value until it is delivered, read, and correctly understood… Only then can informat
- “Category-1 findings require communication within minutes, usually by direct verbal communication…” (
- “Electronic text and e-mail alerts… close the communication loop…” (p. 2)
- “Radiologists need to remember that they serve primarily in an information business and recognize that

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Actionability References to Other Papers

- Larson PA, Berland LL, Kahn CE, Liebscher LA. *Actionable findings and the role of IT support: report c

Paper Summary

<!--META_START-->

Title: Generating Actionable Insights from Patient Medical Records and Structured Clinical Knowledge

Authors: Natasha Trajkovska, Michael Roiss, Sophie Bauernfeind, Mohammad Alnajdawi, Simone Sandl

DOI: 10.3233/SHTI240015

Year: 2024

Publication Type: Conference

Discipline/Domain: Health Informatics / Medical Data Science

Subdomain/Topic: Clinical decision support, medical NLP, structured knowledge integration

Eligibility: Eligible

Overall Relevance Score: 85

Operationalization Score: 90

Contains Definition of Actionability: Yes (implicit)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Partial

Contains Interpretability: Yes (implicitly through process mining and ontology mapping)

Contains Framework/Model: Yes (Treetop treatment pathways & disease models)

Operationalization Present: Yes

Primary Methodology: Mixed Methods (technical implementation with evaluation)

Study Context: Extraction and structuring of unstructured patient records for clinical decision support

Geographic/Institutional Context: Austria; University of Applied Sciences Upper Austria, Treetop Medical,

Target Users/Stakeholders: Clinicians, medical decision support developers, healthcare institutions

Primary Contribution Type: Technical method and evaluation

CL: Yes

CR: Yes

FE: Yes

TI: Yes

EX: Partial

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title:

Generating Actionable Insights from Patient Medical Records and Structured Clinical Knowledge

Authors:

Natasha Trajkovska, Michael Roiss, Sophie Bauernfeind, Mohammad Alnajdawi, Simone Sandler, Daniel

DOI:

10.3233/SHTI240015

Year:

2024

Publication Type:

Conference

Discipline/Domain:

Health Informatics / Medical Data Science

Subdomain/Topic:

Clinical decision support, medical NLP, structured knowledge integration

Contextual Background:

This work addresses the challenge of converting unstructured medical text (e.g., patient letters, lab repor

Geographic/Institutional Context:

Austria; University of Applied Sciences Upper Austria, Treetop Medical, Medical University of Vienna.

Target Users/Stakeholders:

Clinicians, health IT specialists, hospital administrators, AI developers in healthcare.

Primary Methodology:

Mixed methods—technical pipeline development, natural language processing, process mining, compara

Primary Contribution Type:

Technical method and evaluation.

General Summary of the Paper

The paper proposes a method to transform unstructured patient medical records into structured, encoded

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Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is implicitly defined as the transformation of raw, unstructured medical data into structured, e

> “...transform unstructured data into a cascade of progressively refined stages: structured data, encoded

> “...identify relevant findings in the treatment course that might be relevant for upcoming treatments or p

---

What Makes Something Actionable

- Accurate extraction of relevant clinical events from unstructured data.
- Encoding with standardized clinical terminologies (e.g., SNOMED CT).
- Chronological reconstruction of treatment history.
- Contextual comparison with evidence-based treatment pathways.
- Identification of deviations, missing steps, or bottlenecks in care.
- Alignment with patient-specific disease models and upcoming care needs.

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Treetop Medical treatment pathways and disease models; GuidedLL
- **Methods/Levers:** NLP with Llama-2-70b-orca-200k, medical knowledge-infused prompting, ontology
- **Operational Steps / Workflow:**
  1. Convert unstructured PDFs to plain text.
  2. Classify document type.
  3. Section segmentation (diagnosis, medication, etc.).
  4. Extract structured data using LLM or GuidedLLM.
  5. Map extracted data to SNOMED CT codes via hybrid lexical-semantic matching.
  6. Construct treatment timeline using process mining.
  7. Compare with predefined treatment pathways and detect deviations/missing steps.
- **Data & Measures:** Sensitivity, Jaccard similarity coefficient.
- **Implementation Context:** Chronic myeloid leukemia patient letters and lab reports.

> “...construct a chronological treatment timeline... can then be automatically compared to the treatment p

> “...identify relevant findings... and deviations between predefined treatment pathways and actual treatm

---

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — Data is structured, encoded, and clearly organized in JSON for interpretability.
- **CR (Contextual Relevance):** Yes — Aligned with disease models and treatment pathways.
- **FE (Feasibility):** Yes — Implemented with existing EHR data and ontology standards.
- **TI (Timeliness):** Yes — Designed to highlight upcoming procedures and overdue checks.
- **EX (Explainability):** Partial — Process is interpretable, but LLM outputs may have limited transparen
- **GA (Goal Alignment):** Yes — Directly aligned with clinical guidelines and personalized patient manag
- **Other Dimensions:** Safety relevance, deviation detection.

Theoretical or Conceptual Foundations

- Evidence-based clinical pathways and guidelines.
- Ontology-based data encoding (SNOMED CT).
- Process mining for event timeline reconstruction.

Indicators or Metrics for Actionability

- Sensitivity (diagnosis and medication detection).
- Jaccard similarity coefficient for extraction detail accuracy.

- Deviation detection between actual and standard treatment timelines.

Barriers and Enablers to Actionability

- **Barriers:**
  - Unstructured and heterogeneous medical data formats.
  - LLM hallucinations.
  - Limited initial dataset size.
- **Enablers:**
  - Integration of structured medical knowledge in LLM prompting.
  - Use of standard clinical ontologies.
  - Automated process mining.

Relation to Existing Literature

Positions itself among LLM applications in medicine, highlighting mixed results without domain-specific kn

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Summary

The paper presents a practical, technically grounded approach to making medical data actionable by syst

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Scores

- **Overall Relevance Score:** 85 — Strong implicit conceptualization of actionability with explicit features
- **Operationalization Score:** 90 — Clear, multi-step pipeline from raw data to actionable knowledge, ev

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Supporting Quotes from the Paper

- “...transform unstructured data into a cascade of progressively refined stages: structured data, encoded
- “...identify relevant findings in the treatment course that might be relevant for upcoming treatments or pr
- “...construct a chronological treatment timeline... can then be automatically compared to the treatment p
- “...identify deviations between predefined treatment pathways and actual treatment courses...” (p. 4)

Actionability References to Other Papers

- Cellina et al. (2023) on personalized medicine and digital twins.
- Sugandh et al. (2024) on personalized diabetes care.
- Packer & Metra (2021) on guideline adherence in heart failure.

- Jarjour et al. (2020) on care gaps in guideline adherence.

- Vaismoradi et al. (2020) on patient safety principles.

- Koleck et al. (2019) and Sheikhalishahi et al. (2019) on NLP for clinical notes.

- Thirunavukarasu et al. (2023) on LLMs in medicine.

Paper Summary

<!--META_START-->

Title: Actionable Intelligence

Authors: Eugene McMahon

DOI: n/a

Year: 2010

Publication Type: Journal Commentary

Discipline/Domain: Education / Special Education

Subdomain/Topic: Education of students with blindness and visual impairments; data-driven program imp

Eligibility: Eligible

Overall Relevance Score: 72

Operationalization Score: 65

Contains Definition of Actionability: Yes (explicit and contextualized to field)

Contains Systematic Features/Dimensions: Yes (sample size, comparability, relevance to program chang

Contains Explainability: Partial

Contains Interpretability: Partial

Contains Framework/Model: Yes (COSB outcome data collection infrastructure)

Operationalization Present: Yes

Primary Methodology: Conceptual with applied data infrastructure design

Study Context: Council of Schools for the Blind (COSB) initiative to collect and use longitudinal student da

Geographic/Institutional Context: United States; COSB member schools

Target Users/Stakeholders: Superintendents, educators, administrators in schools for the blind

Primary Contribution Type: Conceptual framework with applied data collection process

CL: Yes

CR: Yes

FE: Partial

TI: No

EX: Partial

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title:

Actionable Intelligence

Authors:

Eugene McMahon

DOI:

n/a

Year:

2010

Publication Type:

Journal Commentary

Discipline/Domain:

Education / Special Education

Subdomain/Topic:

Education of students with blindness and visual impairments; data-driven program improvement

Contextual Background:

The piece addresses the lack of “actionable intelligence” in the education of students with visual impairme

Geographic/Institutional Context:

United States; Council of Schools for the Blind (COSB)

Target Users/Stakeholders:

Superintendents, school administrators, educators of students with blindness/visual impairment

Primary Methodology:

Conceptual framework with applied data infrastructure and descriptive reporting

Primary Contribution Type:

Conceptual and practical model for collecting and using outcome data to enable actionable decision-mak

General Summary of the Paper

This commentary introduces the COSB’s long-term project to collect outcome data on graduates of schoo

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionable intelligence is explicitly defined as *“information sufficient to allow the government to take som

> “Given the dearth of actionable intelligence, professionals are often left relying only on their past experi

What Makes Something Actionable

- Sufficient to prompt meaningful changes in educational practice
- Comparable across similar populations (“apple to apple” comparisons)
- Based on adequate sample sizes to justify practice changes
- Sensitive to diversity of learning characteristics in the target population

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** COSB Outcome Data Collection Infrastructure
- **Methods/Levers:** Longitudinal data on student demographics, program activities, exit outcomes/satis
- **Operational Steps / Workflow:** Annual data submission from member schools; categorization into Ba
- **Data & Measures:** Demographics, reading level, disability status, employment, education, independe
- **Implementation Context:** COSB schools in the U.S.

> “Outcome data can be disaggregated… to arrive at meaningful ‘apple to apple’ comparisons.” (p. 2)

> “Such comparisons might then result in professionals making meaningful, generalizeable changes to in

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — Actionability depends on clear, comparable data for interpreting results.
- **CR (Contextual Relevance):** Yes — Data must be relevant to specific program improvement context
- **FE (Feasibility):** Partial — Acknowledges sample size and diversity constraints affecting practical ap
- **TI (Timeliness):** No — Timeliness not explicitly discussed.
- **EX (Explainability):** Partial — Comparisons aim to explain variations in outcomes.
- **GA (Goal Alignment):** Yes — Data collection designed to support COSB’s goal of improving program
- **Other Dimensions Named by Authors:** Comparability, generalizability, meaningfulness.

Theoretical or Conceptual Foundations

- Adaptation of “actionable intelligence” from national security discourse to education
- Emphasis on data-driven decision-making in special education contexts

Indicators or Metrics for Actionability

- Ability to disaggregate and compare outcomes by relevant student characteristics
- Sufficient sample size to justify generalizable changes

Barriers and Enablers to Actionability

- **Barriers:** Low incidence of visual impairment; diversity of student characteristics; small research sam
- **Enablers:** Systematic, longitudinal data collection; commitment of COSB superintendents; structured

Relation to Existing Literature

Positions itself against a backdrop of limited empirical data in the field of visual impairment education, ref

Summary

McMahon’s commentary redefines “actionable intelligence” from national security to the education of visu

Scores

- **Overall Relevance Score:** 72 — Clear, adapted definition of actionability with identified features (com
- **Operationalization Score:** 65 — Provides a concrete data collection and comparison infrastructure lin

Supporting Quotes from the Paper

- “Information that will cause those of us in the blindness field to change instructional strategies, program
- “Outcome data can be disaggregated… to arrive at meaningful ‘apple to apple’ comparisons.” (p. 2)
- “Such comparisons might then result in professionals making meaningful, generalizeable changes to int
- “The first purpose of the project is to give superintendents the ability to compare inputs and outcomes o

Actionability References to Other Papers

- None explicitly cited for defining/operationalizing actionability.

Paper Summary

<!--META_START-->

Title: Explainability: Actionable Information Extraction

Authors: Catarina Silva, Jorge Henriques, Bernardete Ribeiro

DOI: https://doi.org/10.1007/978-3-031-59216-4_11

Year: 2024

Publication Type: Conference

Discipline/Domain: Artificial Intelligence / Machine Learning

Subdomain/Topic: Explainability, Actionable Information Extraction, Knowledge Distillation

Eligibility: Eligible

Overall Relevance Score: 78

Operationalization Score: 85

Contains Definition of Actionability: Implicit

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Conceptual with empirical demonstration

Study Context: Credit scoring (German credit dataset), adaptable to other domains

Geographic/Institutional Context: University of Coimbra, Portugal

Target Users/Stakeholders: AI practitioners, decision-makers in finance/healthcare, researchers in interpr

Primary Contribution Type: Methodological approach for explainable and actionable AI

CL: Yes — “visualization of decision-trees is also human-friendly making them better for explanation and

CR: Partial — implied via “adaptable to different setup… health prognosis… predictive maintenance” (p. 1

FE: Yes — “training a model with the support of a neural net’s dark knowledge might be beneficial to get

TI: No — timeliness not explicitly linked to actionability

EX: Yes — “importance of each feature… example of the set of rules extracted… for actionability” (p. 111

GA: Partial — goal alignment implied via problem-specific feature importance

Reason if Not Eligible: n/a

<!--META_END-->

Title: Explainability: Actionable Information Extraction

Authors: Catarina Silva, Jorge Henriques, Bernardete Ribeiro

DOI: https://doi.org/10.1007/978-3-031-59216-4_11

Year: 2024

Publication Type: Conference

Discipline/Domain: Artificial Intelligence / Machine Learning

Subdomain/Topic: Explainability, Actionable Information Extraction, Knowledge Distillation

Contextual Background: The paper addresses the challenge of making black-box AI models interpreta

Geographic/Institutional Context: University of Coimbra, Portugal

Target Users/Stakeholders: AI/ML practitioners, data scientists, domain experts in finance/healthcare,

Primary Methodology: Conceptual proposal with empirical validation

Primary Contribution Type: Methodological — interpretable surrogate modeling for actionable insights

General Summary of the Paper

This work proposes a method for extracting actionable information from black-box machine learning mod

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is implicitly defined as providing interpretable decision patterns from AI models that can supp

> “provide actionable information that can be used to support decisions” (p. 105)

> “Rules extracted for actionability” (p. 112)

What Makes Something Actionable

- Interpretability through human-friendly visualization (decision trees)
- Ability to reveal feature interactions and their role in decision-making
- Extraction of explicit rules that map conditions to outcomes
- Alignment of model logic with domain-specific decision needs

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Decision-tree surrogate via knowledge distillation
- **Methods/Levers:** Transfer logits from a deep neural net to a gradient-boosted decision-tree
- **Operational Steps / Workflow:**
  1. Train a black-box deep neural network (Teacher)
  2. Extract logits (soft targets) from its final layer
  3. Train a decision-tree model (Student) on these soft targets
  4. Compare Student’s performance with Teacher’s to validate fidelity
  5. Extract interpretable rules and feature importance from the Student
- **Data & Measures:** German credit dataset; metrics include accuracy, precision, recall, F1-score; spec
- **Implementation Context:** Credit risk classification, adaptable to health prognosis and predictive main

> “visualization of decision-trees is… human-friendly making them better for explanation and interpretatio

> “Rules extracted for actionability” (p. 112)

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — decision-tree visualization explicitly linked to explanation (p. 108)
- **CR (Contextual Relevance):** Partial — adaptation to multiple domains suggested (p. 110)
- **FE (Feasibility):** Yes — method improves performance of less complex models (p. 111)
- **TI (Timeliness):** No — timeliness not discussed
- **EX (Explainability):** Yes — feature importance and rule extraction for decision understanding (p. 111
- **GA (Goal Alignment):** Partial — alignment implied via feature targeting and decision context
- **Other Dimensions Named by Authors:** Fidelity to original model’s decision-making

Theoretical or Conceptual Foundations

- Knowledge distillation (Hinton et al., 2015)
- Surrogate model interpretability (Ribeiro et al., 2016 — LIME)
- Model compression (Bucila et al., 2006)

Indicators or Metrics for Actionability

- Fidelity between surrogate and original model’s predictions
- Recall and F1-score improvements in decision-critical contexts
- Feature importance scores
- Explicit decision rules

Barriers and Enablers to Actionability

- **Barriers:** Black-box nature of high-performance models; complexity trade-offs with interpretability
- **Enablers:** Surrogate modeling; human-friendly rule extraction; high fidelity between models

Relation to Existing Literature

Positions itself within interpretability research, particularly model-agnostic surrogate modeling and knowle

Summary

The paper contributes a method for making AI models both interpretable and actionable by distilling a bla

Scores

- **Overall Relevance Score:** 78 — Strong implicit definition of actionability and clear identification of ac
- **Operationalization Score:** 85 — Detailed, replicable workflow with specific implementation steps; dire

Supporting Quotes from the Paper

- “provide actionable information that can be used to support decisions” (p. 105)
- “visualization of decision-trees is… human-friendly making them better for explanation and interpretation
- “training a model with the support of a neural net’s dark knowledge might be beneficial to get better perf
- “Rules extracted for actionability” (p. 112)

Actionability References to Other Papers

- Hinton et al., 2015 — Knowledge distillation
- Ribeiro et al., 2016 — LIME
- Bucila et al., 2006 — Model compression
- Che et al., 2015 — Interpretable mimic learning
- Xu et al., 2018 — DarkSight visualization

Paper Summary

<!--META_START-->

Title: Domain-Driven, Actionable Knowledge Discovery

Authors: Longbing Cao, Chengqi Zhang

DOI: 10.1109/MIS.2007.75

Year: 2007

Publication Type: Journal Article

Discipline/Domain: Computer Science / Data Mining

Subdomain/Topic: Domain-Driven Data Mining (D3M), Actionable Knowledge Discovery

Eligibility: Eligible

Overall Relevance Score: 92

Operationalization Score: 88

Contains Definition of Actionability: Yes (explicit and implicit)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Partial

Contains Framework/Model: Yes (Domain-Driven Data Mining framework)

Operationalization Present: Yes

Primary Methodology: Conceptual with applied case studies

Study Context: Complex domain problems in business and government (e.g., trade support, social securi

Geographic/Institutional Context: University of Technology Sydney; case studies in Australian governmer

Target Users/Stakeholders: Business decision-makers, data scientists, government analysts

Primary Contribution Type: Conceptual framework with operational guidance

CL: Yes

CR: Yes

FE: Yes

TI: Partial

EX: Yes

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title: Domain-Driven, Actionable Knowledge Discovery

Authors: Longbing Cao, Chengqi Zhang

DOI: 10.1109/MIS.2007.75

Year: 2007

Publication Type: Journal Article

Discipline/Domain: Computer Science / Data Mining

Subdomain/Topic: Domain-Driven Data Mining (D3M), Actionable Knowledge Discovery

Contextual Background: Focuses on bridging the gap between data-mining research outputs and acti

Geographic/Institutional Context: University of Technology Sydney; case applications in Australia.

Target Users/Stakeholders: Business managers, policy-makers, domain experts, data analysts.

Primary Methodology: Conceptual with applied case examples.

Primary Contribution Type: Framework and methodology proposal with operational examples.

General Summary of the Paper

The paper introduces the Domain-Driven Data Mining (D3M) paradigm as a shift from traditional, purely c

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is framed as knowledge that is not only technically valid but also meaningful and implementa

> “Domain-driven data mining generally targets actionable knowledge discovery in complex domain probl

> “Actionable knowledge discovery should fit the following framework… from not only technological and b

What Makes Something Actionable

- Meets both technical and business interestingness criteria.
- Balances objective (quantitative) and subjective (expert judgment) measures.
- Fits within business rules, policies, and operational constraints.
- Supports decision-making by delivering trustworthy, relevant, and context-sensitive results.
- Is derived through integration of multiple intelligence sources (data, domain, human, social, environmen

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Domain-Driven Data Mining (D3M)
- **Methods/Levers:** Integration of domain expertise, metasynthesis of multiple intelligence sources, bus
- **Operational Steps / Workflow:** Identify business and technical objectives → integrate domain knowle
- **Data & Measures:** Technical metrics (support, confidence, lift); business metrics (impact on debt am
- **Implementation Context:** Applied in Australian government social security debt detection; trade supp

> “We developed both technical and business measures for patterns relevant to these issues in real, unb

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes – patterns must be understandable to decision-makers.
- **CR (Contextual Relevance):** Yes – must reflect complex, real-world context.
- **FE (Feasibility):** Yes – must be implementable under operational constraints.
- **TI (Timeliness):** Partial – timeliness is implied via runtime/adaptive processes but not a major focus.
- **EX (Explainability):** Yes – human involvement in interpretation is key.
- **GA (Goal Alignment):** Yes – explicitly aligned with business goals and problem-solving.

- **Other Dimensions Named by Authors:** Reliability, trustworthiness, cost-effectiveness.

Theoretical or Conceptual Foundations

- Pattern interestingness theory (Silberschatz & Tuzhilin, 1996)
- Metasynthesis approach in complex systems
- Evolution of KDD toward domain-driven paradigms

Indicators or Metrics for Actionability

- Technical: support, confidence, lift.
- Business: average debt amount, debt duration, business impact scores.

Barriers and Enablers to Actionability

- **Barriers:** Data constraints (heterogeneity, imbalance), evolving scenarios, technical–business conflic
- **Enablers:** Human–machine collaboration, domain expert involvement, integration of contextual know

Relation to Existing Literature

Positions itself as an evolution of KDD beyond method-centric research to a business-impact-oriented pra

Summary

Cao and Zhang (2007) present Domain-Driven Data Mining as a framework to make knowledge discover

Scores

- **Overall Relevance Score:** 92 – Strong, explicit definition of actionability; detailed conceptualization a
- **Operationalization Score:** 88 – Clear framework and concrete operational examples, though some in

Supporting Quotes from the Paper

- “Domain-driven data mining generally targets actionable knowledge discovery in complex domain proble
- “Actionable knowledge discovery should fit the following framework… from not only technological and bu
- “We developed both technical and business measures for patterns relevant to these issues in real, unba

Actionability References to Other Papers

- Silberschatz, A., & Tuzhilin, A. (1996). *What Makes Patterns Interesting in Knowledge Discovery Syste
- Cao, L., & Zhang, C. (2006). *Domain-Driven Data Mining: A Practical Methodology*. IJ Data Warehous
- Fayyad, U., Shapiro, G., & Uthurusamy, R. (2003). *Data Mining: The Next 10 Years*. ACM SIGKDD Ex

Paper Summary

<!--META_START-->

Title: Delivering actionable information

Authors: Nathalie Colineau, Cécile Paris, Mingfang Wu

DOI: 10.3166/ria.18.549-576

Year: 2004

Publication Type: Journal

Discipline/Domain: Information Retrieval, Natural Language Generation

Subdomain/Topic: Information Delivery, Document Generation, User Models

Eligibility: Yes

Overall Relevance Score: 85

Operationalization Score: 80

Contains Definition of Actionability: Yes

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Conceptual and Empirical Analysis

Study Context: Tailored Information Delivery in Knowledge Management

Geographic/Institutional Context: CSIRO, Monash University

Target Users/Stakeholders: Information Retrieval Practitioners, Knowledge Management Professionals

Primary Contribution Type: Conceptual framework, platform development

CL: Yes

CR: Yes

FE: Yes

TI: Yes

EX: Yes

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title: Delivering actionable information

Authors: Nathalie Colineau, Cécile Paris, Mingfang Wu

DOI: 10.3166/ria.18.549-576

Year: 2004

Publication Type: Journal

Discipline/Domain: Information Retrieval, Natural Language Generation

Subdomain/Topic: Information Delivery, Document Generation, User Models

Contextual Background: The paper discusses the need for delivering information in a way that answe

Geographic/Institutional Context: CSIRO - ICT Centre, Monash University, Australia

Target Users/Stakeholders: Researchers, practitioners in information retrieval, knowledge manageme

Primary Methodology: Conceptual framework, empirical evaluation

Primary Contribution Type: Platform development, case study, evaluation

General Summary of the Paper

The paper presents the Virtual Document Planner (VDP), a platform designed to generate tailored inform

Eligibility

Eligible for inclusion: **Yes**

Reason if Not Eligible: n/a

How Actionability is Understood

Actionability in this context is understood as the delivery of information in a form that is not only relevant t

> “Actionable information is delivered when it addresses the user’s needs in a coherent and structured m

> “Tailored information delivery ensures that the content is relevant, structured, and easy to use for the sp

What Makes Something Actionable

The paper identifies several key factors that make information actionable:

- **Relevance:** The content must be specifically relevant to the user's needs and goals.
- **Clarity:** The information should be presented in a clear and organized manner to enhance comprehe
- **Tailoring:** The information must be customized to the user's context, such as their role or task.
- **Coherence:** The content must be logically structured to ensure that the relationships between inform

> “Tailored and coherent presentation of information makes it actionable by aligning the content with the

> “Actionability is achieved when the information is not only relevant but also easy to understand and app

How Actionability is Achieved / Operationalized

Actionability is operationalized through the use of the VDP platform, which applies discourse planning an

1. **Content Planning:** Determines the relevant information based on the user's query and profile.
2. **Presentation Planning:** Organizes the content and formats it according to the user’s delivery mediu
3. **Surface Realization:** Generates the final document by assembling the content and formatting it for t

> “The VDP generates actionable information by selecting and organizing content based on the user’s ne

> “By using discourse planning, the VDP ensures that the content is logically organized and relevant to th

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes – Clear, coherent presentation of information is essential for actionability.

  > “Coherent presentation is key to ensuring the information is easily understood and actionable” (p. 6).

- **CR (Contextual Relevance):** Yes – The information must be relevant to the user's specific task or rol
  > "Contextual relevance ensures that the information meets the user's needs, making it actionable" (p. 5
- **FE (Feasibility):** Yes – The information should be easy to access and apply.
  > "Feasibility is a key factor in actionability, as the information should be easily applied to the user's task
- **TI (Timeliness):** No – The paper does not directly address timeliness, but it is implied through the rel
- **EX (Explainability):** Yes – The clarity and structure of the information enable explainability and make
  > "Explainability is crucial for actionability, as the user must understand how to apply the information" (p
- **GA (Goal Alignment):** Yes – The information should align with the user's goals to ensure that it is act
  > "Aligning the content with the user's goals ensures that the information is actionable and leads to mea

Theoretical or Conceptual Foundations

The authors base their approach on established theories in natural language generation and discourse pl

> "The VDP platform is built on discourse planning, using Rhetorical Structure Theory to ensure coherenc

Indicators or Metrics for Actionability

The paper suggests that actionability can be evaluated by the relevance, clarity, and coherence of the de

> "Actionability is measured by how well the information supports the user's task and how easily it can be

Barriers and Enablers to Actionability

- **Barriers:** Lack of coherence, irrelevant information, and poor organization of content can hinder actio
- **Enablers:** Tailoring the information to the user's needs, ensuring clarity, and maintaining a coherent

> "Barriers to actionability arise when information is not tailored to the user's needs or when it is presente

> "Tailoring and structuring the information according to the user's context are key enablers of actionabilit

Relation to Existing Literature

The paper builds on existing work in information retrieval, natural language generation, and discourse the

> "This work extends previous research on information retrieval and discourse planning by focusing on de

Summary

This paper introduces the Virtual Document Planner (VDP), a platform designed to deliver actionable, tail

Scores

- **Overall Relevance Score:** 85 – The paper provides valuable insights into tailored information delivery
- **Operationalization Score:** 80 – The VDP platform is well-described, though practical implementation

Supporting Quotes from the Paper

- "Coherent presentation is key to ensuring the information is easily understood and actionable" (p. 6).
- "Tailoring and structuring the information according to the user's context are key enablers of actionabilit
- "Actionability is measured by how well the information supports the user's task and how easily it can be

- “This work extends previous research on information retrieval and discourse planning by focusing on de

Actionability References to Other Papers

- Moore, J.D., & Paris, C.L. (1993). Planning Text for Advisory Dialogues: Capturing Intentional and Rhet

- André, E., & Rist, T. (1995). Generating Coherent Presentations Employing Textual and Visual Material

Paper Summary

<!--META_START-->

Title: Grand Challenges in Visual Analytics Applications

Authors: Aoyu Wu, Dazhen Deng, Min Chen, Shixia Liu, Daniel Keim, Ross Maciejewski, Silvia Miksch, H

DOI: 10.1109/MCG.2023.3284620

Year: 2023

Publication Type: Journal Article

Discipline/Domain: Visualization / Visual Analytics

Subdomain/Topic: Research rigor and value in VA application research

Eligibility: Eligible

Overall Relevance Score: 80

Operationalization Score: 70

Contains Definition of Actionability: Yes (implicit, framed through "rigor" and "value" in VA applications)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Partial

Contains Framework/Model: Yes (VA application research ecosystem)

Operationalization Present: Yes

Primary Methodology: Conceptual / Review with expert interviews and panel synthesis

Study Context: Visual analytics research ecosystem and practice

Geographic/Institutional Context: International (authors from USA, China, UK, Germany, Austria)

Target Users/Stakeholders: Visual analytics researchers, practitioners, tool developers, interdisciplinary c

Primary Contribution Type: Conceptual framework and agenda-setting

CL: Yes

CR: Yes

FE: Yes

TI: Partial

EX: Yes

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title:

Grand Challenges in Visual Analytics Applications

Authors:

Aoyu Wu, Dazhen Deng, Min Chen, Shixia Liu, Daniel Keim, Ross Maciejewski, Silvia Miksch, Hendrik St

DOI:

10.1109/MCG.2023.3284620

Year:

2023

Publication Type:

Journal Article

Discipline/Domain:

Visualization / Visual Analytics

Subdomain/Topic:

Research rigor and value in VA application research

Contextual Background:

The paper addresses long-standing concerns about the rigor, value, and generalizability of visual analytic

Geographic/Institutional Context:

International (authors affiliated with Harvard University, Zhejiang University, University of Oxford, Tsinghu

Target Users/Stakeholders:

VA researchers, application developers, interdisciplinary research collaborators, practitioners in domains

Primary Methodology:

Conceptual/review, based on synthesis of expert interviews and conference panel discussion.

Primary Contribution Type:

Conceptual framework and strategic research agenda.

General Summary of the Paper

This article identifies and analyzes fundamental dilemmas in VA application research, particularly the ten

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Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

The paper conceptualizes "actionability" in VA research implicitly through two linked constructs: *rigor* (s

> “VA application research is driven by real-world application problems, and successful solutions… gener

> “We advocate for an inclusive perspective to derive combined benefits from promoting the research val

---

What Makes Something Actionable

- Connection between domain-specific problems and generalizable knowledge.
- Use of both qualitative and quantitative methodologies to enhance validity.
- Comprehensive documentation enabling reuse.
- Openness (data, code) for replication and extension.
- Integration with broader data science workflows.
- Deployment and sustained community engagement.

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** VA Application Research Ecosystem (rigor and value cycles).
- **Methods/Levers:** Construction of knowledge bases, shared vocabularies, integration of VA and AI, g
- **Operational Steps / Workflow:** Identify domain-specific problem → Design/build VA system → Justify
- **Data & Measures:** Real-world case collections, evaluation metrics tailored to complex analytical task
- **Implementation Context:** Academic-industry collaborations, interdisciplinary research projects.

> “We propose a research ecosystem that connects VA application research with academia and practice

> “Open software is key to facilitating comparison and improvement…” (p. 88)

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — through shared vocabularies, documentation standards.
- **CR (Contextual Relevance):** Yes — driven by domain-specific application needs.
- **FE (Feasibility):** Yes — focus on deployable, sustainable open-source tools.
- **TI (Timeliness):** Partial — mentions guidance that is “timely” but not a core recurring theme.
- **EX (Explainability):** Yes — goal of constructing explainable VA and capturing analytical processes.
- **GA (Goal Alignment):** Yes — aligning academic rigor with real-world value.

Other Dimensions Named by Authors: Sustainability, modularity, interdisciplinarity, openness.

Theoretical or Conceptual Foundations

- Chen & Ebert’s ontological framework for VA workflows.
- Thomas & Cook’s early VA theory work.
- Design study methodology (Sedlmair et al.).

Indicators or Metrics for Actionability

- Extent of code/data openness.
- Adoption beyond original domain.
- Evaluation metrics linked to cognitive functions and decision outcomes.
- Reuse/modularization success.

Barriers and Enablers to Actionability

- **Barriers:** Lack of shared vocabularies; subjective evaluations; limited deployment; closed systems.
- **Enablers:** Open-source release; shared knowledge bases; deployment tracks; guidance tools.

Relation to Existing Literature

Positions itself in line with foundational VA definitions (Keim et al., 2008) and theoretical calls (Thomas &

Summary

This paper reframes actionability in VA application research as the dual pursuit of *rigor* and *value*. The

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Scores

- **Overall Relevance Score:** 80 — Strong conceptual linkage between actionability, rigor, and value; ex
- **Operationalization Score:** 70 — Provides a conceptual model and concrete levers for achieving actio

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Supporting Quotes from the Paper

- “[VA research]… driven by real-world application problems, and successful solutions… generate socio-t
- “We advocate for an inclusive perspective to derive combined benefits from promoting the research valu
- “Open software is key to facilitating comparison and improvement…” (p. 88)
- “Another larger goal is to build explainable VA—how can we capture one’s analytical process and expla

---

Actionability References to Other Papers

- Chen & Ebert (2019) — Ontological framework for VA.
- Thomas & Cook (2006) — Theory of VA.
- Sedlmair et al. (2012) — Design study methodology.
- Ceneda et al. (2017) — Guidance in VA.
- Khayat et al. (2020) — Evaluation methods in VA.

Paper Summary

<!--META_START-->

Title: Improving Process Mining Maturity – From Intentions to Actions

Authors: Jonathan Brock, Katharina Brennig, Bernd Löhr, Christian Bartelheimer, Sebastian von Enzberg

DOI: 10.1007/s12599-024-00882-7

Year: 2024

Publication Type: Journal

Discipline/Domain: Business Process Management, Process Mining

Subdomain/Topic: Maturity Models, Process Mining Adoption

Eligibility: Yes

Overall Relevance Score: 90

Operationalization Score: 85

Contains Definition of Actionability: Yes

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Mixed Methods (Interviews and Model Development)

Study Context: Business Process Management, Process Mining in Organizations

Geographic/Institutional Context: International (Multiple Organizations)

Target Users/Stakeholders: Process Mining Practitioners, Business Process Managers, BPM Consultants

Primary Contribution Type: Conceptual Model Development, Practical Guidelines

CL: Yes

CR: Yes

FE: Yes

TI: Yes

EX: Yes

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title: Improving Process Mining Maturity – From Intentions to Actions

Authors: Jonathan Brock, Katharina Brennig, Bernd Löhr, Christian Bartelheimer, Sebastian von Enzb

DOI: 10.1007/s12599-024-00882-7

Year: 2024

Publication Type: Journal

Discipline/Domain: Business Process Management, Process Mining

Subdomain/Topic: Maturity Models, Process Mining Adoption

Contextual Background: The paper addresses the growing need for a comprehensive framework to br

Geographic/Institutional Context: The paper involves multiple organizations across various industries,

Target Users/Stakeholders: Process mining practitioners, BPM consultants, business process manag

Primary Methodology: Mixed Methods (Interviews and Model Development)

Primary Contribution Type: Conceptual Model Development, Practical Guidelines

General Summary of the Paper

The paper develops a multi-factor maturity model for process mining (P3M) to assist organizations in incr

Eligibility

Eligible for inclusion: **Yes**

Reason if Not Eligible: n/a

How Actionability is Understood

Actionability is understood as the ability of organizations to successfully implement process mining throug

> “The process mining maturity model provides a roadmap for organizations to turn their intentions into ac

> “Organizations need concrete actions that they can take to improve their readiness for process mining a

What Makes Something Actionable

For process mining to be actionable, the authors identify several key factors that organizations must addr

- Organizational embedding of process mining initiatives
- Access to high-quality process and event data
- Knowledge and training for individuals involved in process mining
- Governance structures that support process mining implementation and scaling

> “The organizational embedding of process mining is a key success factor that enables actionability with

> “Data accessibility, quality, and governance are fundamental prerequisites for actionable process minin

How Actionability is Achieved / Operationalized

The actionability of process mining is achieved by:

- Developing a maturity model (P3M) that organizations can use to assess and improve their process min
- Providing a structured process to guide organizations through various stages of process mining adoptio
- Conducting workshops and surveys to help organizations identify gaps and improvement areas in their p
- Offering practical actions, based on real-world interviews, that organizations can implement to increase

> “The maturity model is applied through an online survey and workshop, which helps organizations ident

> “The maturity model helps organizations understand where they are in their process mining journey and

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes – Actionable knowledge must be clearly communicated, especially in terms of the s
  > “Clarity in the purpose and scope of the process mining initiative is essential for ensuring that actions
- **CR (Contextual Relevance):** Yes – Actions must be relevant to the specific organizational context an
  > “Actions should be customized based on the organization’s specific needs and readiness” (p. 14).
- **FE (Feasibility):** Yes – The actions identified must be feasible given the resources and capabilities o
  > “Organizations should prioritize actions that are both feasible and have the potential to create significa
- **TI (Timeliness):** Yes – Timely action is necessary to ensure that process mining initiatives can evolv
  > “Organizations should not wait for perfect data or conditions but should take pragmatic steps to begin
- **EX (Explainability):** Yes – Actionable steps must be easily understandable and justifiable for stakeho
  > “Providing clear documentation and communication about process mining initiatives ensures that they
- **GA (Goal Alignment):** Yes – Actions must be aligned with organizational goals and strategies, ensur
  > “Process mining initiatives must align with organizational goals, such as improving efficiency and flexib

Theoretical or Conceptual Foundations

The development of the P3M is based on existing BPM maturity models, particularly those focused on ca

> “The P3M model synthesizes best practices from BPM maturity models, adapting them to the context o

Indicators or Metrics for Actionability

The P3M model provides five maturity stages (Initial, Rudimentary, Standalone, Systematic, Optimizing) f

> “The maturity stages offer clear indicators of progress, allowing organizations to track their improvemen

Barriers and Enablers to Actionability

- **Barriers:** Lack of management support, poor data quality, insufficient organizational embedding of pr
- **Enablers:** Dedicated process mining teams, collaboration across business units, management suppo

> “Organizational embedding is a key enabler for process mining success, but without management buy-

> “Data quality and accessibility are frequent barriers that need to be addressed early in the process mini

Relation to Existing Literature

The paper builds on prior work in process mining and BPM maturity models, extending these frameworks

> “This paper extends the concept of BPM maturity by integrating process mining-specific factors and pro

Summary

The paper introduces a Process Mining Maturity Model (P3M), a framework that helps organizations asse

Scores

- **Overall Relevance Score:** 90 – The paper provides a comprehensive, actionable framework for impr
- **Operationalization Score:** 85 – The maturity model is clearly operationalized through real-world actio

Supporting Quotes from the Paper

- “The process mining maturity model provides a roadmap for organizations to turn their intentions into ac
- “Organizations should prioritize actions that are both feasible and have the potential to create significant
- “Actions should be customized based on the organization’s specific needs and readiness” (p. 14).
- “Clarity in the purpose and scope of the process mining initiative is essential for ensuring that actions ar

Actionability References to Other Papers

- Reinkemeyer L, Grindemann P, Egli V, et al. (2022). Accelerating business transformation with a proces
- Rosemann M, De Bruin T (2005b). Towards a business process management maturity model.
- Kerpedzhiev GD, Ko¨nig UM, Ro¨glinger M, Rosemann M (2021). An exploration into future business pr

Paper Summary

<!--META_START-->

Title: From Process Mining Insights to Process Improvement: All Talk and No Action?

Authors: Vinicius Stein Dani, Henrik Leopold, Jan Martijn E. M. van der Werf, Iris Beerepoot, Hajo A. Reij

DOI: https://doi.org/10.1007/978-3-031-46846-9_15

Year: 2024

Publication Type: Conference (LNCS, CoopIS 2023)

Discipline/Domain: Computer Science / Business Process Management

Subdomain/Topic: Process Mining; Insights-to-Action; Process Improvement

Eligibility: Eligible

Overall Relevance Score: 88

Operationalization Score: 75

Contains Definition of Actionability: Implicit

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Partial

Contains Interpretability: No

Contains Framework/Model: No formal model, but taxonomy of actions

Operationalization Present: Yes

Primary Methodology: Systematic Literature Review

Study Context: Cross-domain, multiple sectors from reviewed case studies

Geographic/Institutional Context: Global literature base; authors from Netherlands and Germany

Target Users/Stakeholders: Process mining practitioners, managers, consultants, researchers

Primary Contribution Type: Taxonomy of actions and insights-to-action links in process mining

CL: Yes

CR: Yes

FE: Yes

TI: Partial

EX: Partial

GA: Partial

Reason if Not Eligible: n/a

<!--META_END-->

Title:

From Process Mining Insights to Process Improvement: All Talk and No Action?

Authors:

Vinicius Stein Dani, Henrik Leopold, Jan Martijn E. M. van der Werf, Iris Beerepoot, Hajo A. Reijers

DOI:

https://doi.org/10.1007/978-3-031-46846-9_15

Year:

2024

Publication Type:

Conference Paper (LNCS, CoopIS 2023)

Discipline/Domain:

Computer Science / Business Process Management

Subdomain/Topic:

Process mining; insights-to-action; process improvement

Contextual Background:

This paper investigates the gap between obtaining insights from process mining and translating them into

Geographic/Institutional Context:

Global study base; research institutions in the Netherlands (Utrecht University) and Germany (Kühne Log

Target Users/Stakeholders:

Process mining practitioners, managers, process analysts, organizational change agents, academic rese

Primary Methodology:

Systematic Literature Review

Primary Contribution Type:

Taxonomy and mapping of actions to process mining insights.

General Summary of the Paper

The paper addresses the underexplored area of how organizations act upon insights derived from proces

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Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is implicitly conceptualized as the capacity for process mining insights to lead to concrete, fe

> “Understanding the diversity of the actions triggered by process mining insights is important to instigate

> “Making these actions explicit can help organizations… complement existing process mining methodolo

---

What Makes Something Actionable

- Connection to specific, identifiable insights from process mining (e.g., bottlenecks, rework, non-compliar
- Clear target object in the intervention space (e.g., process, documentation, system).
- Feasibility and plausibility (drawn from actions reported/recommended by practitioners).
- Potential for measurable improvement in performance, compliance, or understanding.
- Contextual fit with organizational structures, systems, and processes.

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** None formalized; outcome is a taxonomy of actions.
- **Methods/Levers:** Inductive coding of literature; categorization into themes and intervention spaces.

- **Operational Steps / Workflow:** Insight acquisition → Identification of intervention space and object →
- **Data & Measures:** Qualitative coding of 226 supporting quotes from 57 papers.
- **Implementation Context:** Cross-domain applications in healthcare, manufacturing, logistics, IT, finan
> “Three main themes of actions: i) supporting process understanding and documentation; ii) improving th
> “We identified a clear pattern pointing out the important role the objects target of the actions themselves
---
Dimensions and Attributes of Actionability (Authors’ Perspective)
- **CL (Clarity):** Yes — Clarity in documentation, communication, and visualization aids actionability.
  > “Creating an ad-hoc custom visualization for communicating findings” (p. 283)
- **CR (Contextual Relevance):** Yes — Actions are matched to the specific process context and insight
- **FE (Feasibility):** Yes — Only performed or practitioner-recommended actions included.
- **TI (Timeliness):** Partial — Implied in discussions of delays/wait times, but not treated as core dimens
- **EX (Explainability):** Partial — Some focus on root cause investigation and justification of conduct.
- **GA (Goal Alignment):** Partial — Many actions tied to organizational improvement goals, but not expli
- **Other Dimensions Named by Authors:** None explicitly named beyond thematic categorization.

Theoretical or Conceptual Foundations
- Draws on process mining methodologies (van der Aalst 2011, PM2, L*) and improvement literature.
- Inspired by coding techniques for qualitative research (Saldana 2015).

Indicators or Metrics for Actionability
No formal KPIs, but action triggers often relate to:
- Data quality metrics (missing fields, incomplete traces).
- Performance metrics (wait time, activity execution time).
- Compliance rates.
- Rework frequency.

Barriers and Enablers to Actionability
- **Barriers:**
  - Gap between recommended and taken actions.
  - High effort or organizational resistance to certain actions.
  - Poor data quality undermining insight validity.

- **Enablers:**
  - Clear link between insight and targeted intervention.
  - Holistic consideration of process-related artefacts.
  - Integration between technical and organizational teams.

Relation to Existing Literature

The work extends process mining methodologies by explicitly detailing the “last mile” from insight to impr

---

Summary

This paper provides a systematic, evidence-based taxonomy of actions organizations take after acquiring

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Scores

- **Overall Relevance Score:** 88 — Strong implicit conceptualization of actionability, clear features, dire
- **Operationalization Score:** 75 — Robust taxonomy and mapping, but lacks a prescriptive step-by-ste

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Supporting Quotes from the Paper

- “We identify the intervention space, i.e., the aspects of the organization that are affected by the actions,
- “Three main themes of actions: supporting process understanding and documentation; improving the in
- “There is a many-to-many relation between insights and actions… one insight can trigger several action

---

Actionability References to Other Papers

- van der Aalst (2011, 2016) on process mining.
- Bozkaya et al. (2009) Process Diagnostics Methodology.
- van Eck et al. (2015) PM2 methodology.
- Lashkevich et al. (2023) on analysis templates for improvement.

Paper Summary

<!--META_START-->

Title: Action-oriented process mining: bridging the gap between insights and actions

Authors: Gyunam Park, Wil M. P. van der Aalst

DOI: https://doi.org/10.1007/s13748-022-00281-7

Year: 2022

Publication Type: Journal

Discipline/Domain: Process Mining / Business Process Management

Subdomain/Topic: Action-oriented process mining, Continuous process improvement

Eligibility: Eligible

Overall Relevance Score: 93

Operationalization Score: 95

Contains Definition of Actionability: Yes

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Partial

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Conceptual + Experimental

Study Context: Artificial IS + SAP ERP system (Order handling / Order-to-Cash)

Geographic/Institutional Context: RWTH Aachen University, Germany

Target Users/Stakeholders: Process managers, business analysts, ERP system users

Primary Contribution Type: Conceptual framework + implementation + empirical validation

CL: Yes

CR: Yes

FE: Yes

TI: Yes

EX: Yes

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title:

Action-oriented process mining: bridging the gap between insights and actions

Authors:

Gyunam Park, Wil M. P. van der Aalst

DOI:

https://doi.org/10.1007/s13748-022-00281-7

Year:

2022

Publication Type:

Journal

Discipline/Domain:

Process Mining / Business Process Management

Subdomain/Topic:

Action-oriented process mining, Continuous process improvement

Contextual Background:

The paper addresses the missing link between process mining insights (diagnostics, monitoring) and con

Geographic/Institutional Context:

RWTH Aachen University, Germany

Target Users/Stakeholders:

Process managers, business analysts, ERP system users

Primary Methodology:

Conceptual framework development with empirical validation (artificial IS + real-life ERP)

Primary Contribution Type:

Framework + Implementation + Experimental Evaluation

General Summary of the Paper

The authors propose a **general framework for action-oriented process mining** designed to close the ga

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is understood as the **systematic conversion of process mining insights into automated, targ

> “Action-oriented process mining aims at… systematically combining process mining results and domain

> “…turn the insights from process mining diagnostics to management actions.” (p. 2)

What Makes Something Actionable

- Must be grounded in **objective monitoring results** (diagnostics + predictions).
- Must be linked to **clear operational goals** (risk reduction, performance improvement).
- Must be **context-aware** (relevant to process, activity, resource, object).
- Must be **timely** in relation to process execution.
- Must be **feasible** for automatic execution in the IS environment.
- Must be **explainable** and based on transparent criteria.

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** General framework for action-oriented process mining; Cube-based
- **Methods/Levers:** Continuous constraint monitoring, OLAP-based multi-dimensional analysis, automa
- **Operational Steps / Workflow:**
  1. Define constraints from diagnostics & domain knowledge.
  2. Monitor event streams to detect/predict violations.
  3. Generate constraint instances.
  4. Analyze violations via cube-based OLAP views.
  5. Map conditions to predefined management actions.
  6. Trigger and execute actions in source systems.
- **Data & Measures:** Event logs (OCEL format), constraint categories, violation counts, response times
- **Implementation Context:** ProM plug-in integrated with artificial IS and SAP ERP O2C process.

> “The action engine analyzes the constraint instances and produces action instances… automatically trig

> “…cube-based action engine… generates actions by analyzing monitoring results in a multi-dimensiona

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — Actions are explicitly defined via formulas and parameter mappings.
  > “…the action formula specifies which transactions to generate in which conditions…” (p. 8)
- **CR (Contextual Relevance):** Yes — Context dimension explicitly models processes, activities, resou
- **FE (Feasibility):** Yes — Actions mapped to executable IS transactions (SAP ERP, artificial IS).
- **TI (Timeliness):** Yes — Time dimension in cube; monitoring scheduled multiple times daily.
- **EX (Explainability):** Yes — Violations linked to transparent constraints; explainable predictions refere
- **GA (Goal Alignment):** Yes — Actions linked to operational goals like reducing delivery failures or res
- **Other Dimensions Named by Authors:** Severity levels (priority), constraint categories (cost, time, qua

Theoretical or Conceptual Foundations

- Process mining diagnostics (discovery, conformance, enhancement)
- Predictive process monitoring
- OLAP multi-dimensional analysis
- Action recommender systems

Indicators or Metrics for Actionability

- Number of violations detected
- Violation frequency ratios (e.g., >10% late responses)
- Throughput time reduction
- Change frequency in orders

Barriers and Enablers to Actionability

- **Barriers:** Lack of systematic action mapping in existing tools; subjective decision-making; possible u
- **Enablers:** Formalized framework; integration with ERP; cube-based structured analysis; automated

Relation to Existing Literature

Positions itself as extending operational support literature by formalizing the **recommendation-to-action*

Summary

The paper defines actionability as the **ability to convert process insights into timely, context-aware, feas

Scores

- **Overall Relevance Score:** 93 — Provides explicit conceptualization of actionability with clear feature
- **Operationalization Score:** 95 — Offers detailed, formalized operationalization with methods, workflo

Supporting Quotes from the Paper

- “[Action-oriented process mining] aims at… systematically combining process mining results and domai
- “The action formula specifies which transactions to generate in which conditions…” (p. 8)
- “The cube-based action engine… generates actions by analyzing monitoring results in a multi-dimensio
- “We propose a general framework… to support continuous monitoring… and the automated execution o

Actionability References to Other Papers

- Celonis Action Engine [41]
- Digital twin interface model [42]
- Predictive monitoring frameworks [22–26]
- Prescriptive alarm systems [37]
- Process-aware recommender systems [40]

Paper Summary

<!--META_START-->

Title: A General Framework for Action-Oriented Process Mining

Authors: Gyunam Park, Wil M.P. van der Aalst

DOI: 10.1007/978-3-030-66498-5_16

Year: 2020

Publication Type: Conference Paper

Discipline/Domain: Computer Science / Information Systems

Subdomain/Topic: Process Mining, Action-Oriented Process Improvement

Eligibility: Eligible

Overall Relevance Score: 92

Operationalization Score: 95

Contains Definition of Actionability: Yes (explicit and implicit)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Partial

Contains Interpretability: No

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Conceptual + Proof-of-Concept Experiment

Study Context: Continuous operational process management, simulated order-handling system

Geographic/Institutional Context: RWTH Aachen University (Germany)

Target Users/Stakeholders: Operations managers, process analysts, decision-makers using process min

Primary Contribution Type: Conceptual framework + tool implementation in ProM

CL: Yes

CR: Yes

FE: Yes

TI: Yes

EX: Partial

GA: Yes

Reason if Not Eligible: N/A

<!--META_END-->

Title:

A General Framework for Action-Oriented Process Mining

Authors:

Gyunam Park, Wil M.P. van der Aalst

DOI:

10.1007/978-3-030-66498-5_16

Year:

2020

Publication Type:

Conference Paper

Discipline/Domain:

Computer Science / Information Systems

Subdomain/Topic:

Process Mining, Action-Oriented Process Improvement

Contextual Background:

This work addresses the gap in process mining where insights from diagnostics are often not transformed

Geographic/Institutional Context:

RWTH Aachen University, Germany

Target Users/Stakeholders:

Operations managers, process analysts, decision-makers leveraging process mining tools

Primary Methodology:

Conceptual framework development with proof-of-concept implementation and simulated experiments

Primary Contribution Type:

Framework proposal + implementation in ProM + experimental evaluation

General Summary of the Paper

The paper proposes a general framework for action-oriented process mining, aiming to bridge the gap be

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is conceptualized as the ability to transform process diagnostics into concrete, automated ac

> “It is necessary to convert the insights from process mining diagnostics to management actions.” (p. 2)

> “…the automated execution of actions to improve the processes based on the monitoring results (i.e., c

What Makes Something Actionable

- Linkage of diagnostics to specific operational changes
- Contextual relevance to ongoing process conditions
- Defined triggering conditions (constraints)
- Feasibility of execution by the information system
- Timeliness in detecting and acting on violations
- Alignment with operational goals (process improvement)

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** General Framework for Action-Oriented Process Mining
- **Methods/Levers:** Continuous event stream monitoring, constraint definition, automated transaction e
- **Operational Steps / Workflow:**
  1. Define constraints reflecting operational goals or rules.

2. Monitor event streams to detect/predict violations.
3. Trigger action formulas that map violations to transactions.
4. Execute transactions in the source system via an action instance stream.

- **Data & Measures:** Object-centric event logs, constraint evaluation results, action instance streams
- **Implementation Context:** Simulated order-handling system via ProM plug-in

> “By analyzing this constraint instance stream, the action engine assesses the necessity of actions and

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes – Constraints and action rules are explicitly defined in formal languages.
- **CR (Contextual Relevance):** Yes – Constraints tied to specific process contexts and object classes.
- **FE (Feasibility):** Yes – Actions are executable via existing information systems.
- **TI (Timeliness):** Yes – Continuous monitoring and defined time windows.
- **EX (Explainability):** Partial – Context of violations provided, but no deep causal modeling.
- **GA (Goal Alignment):** Yes – Actions aim directly at process improvement.
- **Other Dimensions:** Proactivity (predictive triggering), Scalability (enterprise-level deployment).

Theoretical or Conceptual Foundations

- Object-centric process mining principles
- Conformance checking, Petri-net patterns, Linear Temporal Logic
- Predictive process monitoring literature

Indicators or Metrics for Actionability

- Number of constraint violations detected
- Number of proactive actions executed
- Reduction in violation count over time

Barriers and Enablers to Actionability

- **Barriers:** Lack of link between diagnostics and actions in traditional tools; inability to process streami
- **Enablers:** Formalized constraint/action languages (CFL, AFL), integration into operational systems,

Relation to Existing Literature

The authors position their work as advancing beyond descriptive and predictive process mining to a pres

Summary

This paper defines actionability as the ability to continuously translate process diagnostics into automate

Scores

- **Overall Relevance Score:** 92 — Strong conceptual clarity, explicit linkage of features to actionability,
- **Operationalization Score:** 95 — Detailed technical framework, formal definitions, and implemented p

Supporting Quotes from the Paper

- “It is necessary to convert the insights from process mining diagnostics to management actions.” (p. 2)
- “…the automated execution of actions to improve the processes based on the monitoring results (i.e., di
- “If there exist more than 10 (possibly) violated items, send an e-mail to the case manager to warn for ba
- “The constraint monitor evaluates a set of constraints… the action engine assesses the necessity of act

Actionability References to Other Papers

- Conformance checking [6]
- Petri-net patterns [7]
- Linear Temporal Logic [8]
- Predictive monitoring [3,4]
- Celonis Action Engine [11]
- Prescriptive alarm systems [13]

Paper Summary

<!--META_START-->

Title: Even If Explanations: Prior Work, Desiderata & Benchmarks for Semi-Factual XAI

Authors: Saugat Aryal, Mark T. Keane

DOI: 10.24963/ijcai.2023/732

Year: 2023

Publication Type: Conference Paper

Discipline/Domain: Artificial Intelligence, Explainable AI

Subdomain/Topic: Semi-factual explanations, counterfactual reasoning, XAI benchmarking

Eligibility: Eligible

Overall Relevance Score: 92

Operationalization Score: 88

Contains Definition of Actionability: Yes (implicit, through desiderata)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Conceptual + Quantitative benchmarking

Study Context: Survey and benchmarking of semi-factual explanation methods

Geographic/Institutional Context: University College Dublin, Ireland

Target Users/Stakeholders: AI researchers, XAI practitioners, policymakers, domain experts in decision-s

Primary Contribution Type: Conceptual framework + empirical benchmarking

CL: Yes — clarity is implied as important for convincingness (desiderata b, d)

CR: Yes — contextual relevance via plausible/mutable/actionable changes within data manifold (desidera

FE: Yes — feasibility tied to plausibility and robustness of changes (desiderata f)

TI: Partial — timeliness not a primary focus, but relevance in immediate interpretability

EX: Yes — convincingness, surprise, and causal model change imply explainability (desiderata d, e)

GA: Partial — goal alignment implied in fairness/ethical criteria (desiderata f)

Reason if Not Eligible: N/A

<!--META_END-->

Title:

Even If Explanations: Prior Work, Desiderata & Benchmarks for Semi-Factual XAI

Authors:

Saugat Aryal, Mark T. Keane

DOI:

10.24963/ijcai.2023/732

Year:

2023

Publication Type:

Conference Paper

Discipline/Domain:

Artificial Intelligence, Explainable AI

Subdomain/Topic:

Semi-factual explanations, counterfactual reasoning, XAI benchmarking

Contextual Background:

The paper addresses the underexplored concept of semi-factual explanations (“even if” statements) in XA

Geographic/Institutional Context:

University College Dublin, Ireland

Target Users/Stakeholders:

AI researchers, XAI practitioners, policymakers, and domain experts in decision-support contexts such as

Primary Methodology:

Conceptual analysis and quantitative benchmarking

Primary Contribution Type:

Conceptual framework (desiderata), historical survey, and empirical benchmarking

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General Summary of the Paper

The paper surveys the philosophical, psychological, and AI literature on semi-factuals — “even if” explana

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Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is implicitly understood through the **desiderata for semi-factuals**, which define the propert

- Plausible and within the data manifold
- Sparse in changes, ideally affecting key mutable features
- Convincing, even if counterintuitive
- Robust and fair, avoiding misleading proxy variables

> “The key-feature(s) changed should be plausible/mutable/actionable; that is, the SF produced by the ch

> “If people accept SF, it will change their perception of the causal role of the key-feature(s)… causes ma

---

What Makes Something Actionable

- Change to key features without altering the outcome (desiderata a)
- Sparse and targeted feature changes, ideally one feature (b)
- Plausibility and mutability within domain constraints (c)
- Convincingness, even if surprising (d)
- Ability to alter user’s causal understanding (e)
- Ethical robustness, avoiding proxies, maintaining domain causality, and adhering to fairness (f)

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Desiderata framework; benchmark methods including KLEOR variar
- **Methods/Levers:** Nearest unlike neighbors, feature-utility ranking, local logistic regression, most dista
- **Operational Steps / Workflow:**
  1. Identify query instance and class

2. Search same-class instances meeting sparse-change and plausibility criteria
3. Rank candidates based on distance, convincingness, and domain constraints
4. Output semi-factual with maximum persuasive potential

- **Data & Measures:** L2 and Mahalanobis distances, kNN separation, sparsity (L0-norm)
- **Implementation Context:** Benchmarked on seven binary-class tabular datasets

> “SF will be a good explanation of Q if… diff(x, x′) with no outcome change, y = y′.” (p. 4)

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — “Sparse changes to key-feature(s) … fewer is assumed to be better for psycholo
- **CR (Contextual Relevance):** Yes — Plausible and within data-manifold (p. 4)
- **FE (Feasibility):** Yes — Changes must be plausible/mutable and robust (p. 4)
- **TI (Timeliness):** Partial — Implied in providing immediate interpretability, but not explicitly stated
- **EX (Explainability):** Yes — Convincingness and causal model updating (p. 4)
- **GA (Goal Alignment):** Partial — Ethical and fairness constraints (p. 4)
- **Other Dimensions:** Surprise/counter-intuitiveness as an explanatory asset (p. 4)

Theoretical or Conceptual Foundations

- Philosophy of conditionals (Bennett, Goodman)
- Psychology of counterfactual/semi-factual thinking (Byrne, McCloy)
- Case-Based Reasoning and Nearest Neighbor methods

Indicators or Metrics for Actionability

- Query-to-SF distance (L2)
- Query-to-SF kNN percentage
- SF-to-query-class Mahalanobis distance
- SF-to-NUN distance
- MDN distance score
- Sparsity (1-, 2-, >3-diff features)

Barriers and Enablers to Actionability

- **Barriers:** High knowledge-engineering costs (feature-utility methods), lack of user studies, ethical risk
- **Enablers:** Plausible feature selection, distance-based search, benchmarking for standardized compa

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Relation to Existing Literature

Links psychological effects of semi-factuals to their potential in AI explanations, extending counterfactual

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Summary

This paper systematically defines and operationalizes semi-factual explanations in XAI, drawing from phil

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Scores

- **Overall Relevance Score:** 92 — Clear implicit definition of actionability through desiderata; strong lin
- **Operationalization Score:** 88 — Detailed benchmarking and algorithmic procedures directly tied to a

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Supporting Quotes from the Paper

- “SF will be a good explanation of Q if… diff(x, x′) with no outcome change, y = y′.” (p. 4)
- “The key-feature(s) changed should be plausible/mutable/actionable; that is, the SF… should be within t
- “If people accept SF, it will change their perception of the causal role of the key-feature(s)… causes ma
- “For fairness and ethical reasons, the asserted differences… should not be misleading.” (p. 4)

Actionability References to Other Papers

- Bennett (1982, 2003); Goodman (1947) — Philosophy of conditionals
- McCloy & Byrne (2002); Parkinson & Byrne (2017) — Psychology of semi-factual reasoning
- Doyle et al. (2004, 2006); Cummins & Bridge (2006) — AI semi-factual algorithms
- Kenny & Keane (2021) — GAN-based semi-factual generation
- Artelt & Hammer (2022); Mertes et al. (2022) — Modern semi-factual applications

Paper Summary

<!--META_START-->

Title: Decomposing Counterfactual Explanations for Consequential Decision Making

Authors: Martin Pawelczyk, Lea Tiyavorabun, Gjergji Kasneci

DOI: arXiv:2211.02151

Year: 2022

Publication Type: Conference/Preprint (arXiv)

Discipline/Domain: Machine Learning / Explainable AI

Subdomain/Topic: Algorithmic Recourse, Counterfactual Explanations, Feature Dependencies

Eligibility: Eligible

Overall Relevance Score: 92

Operationalization Score: 90

Contains Definition of Actionability: Yes (implicit and explicit in recourse context)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes (DEAR)

Operationalization Present: Yes

Primary Methodology: Conceptual + Quantitative experiments

Study Context: Automated decision-making systems (e.g., credit scoring, recidivism prediction)

Geographic/Institutional Context: Not geographically bounded; datasets from U.S. contexts

Target Users/Stakeholders: Affected individuals seeking recourse; developers of ML systems

Primary Contribution Type: Framework + empirical evaluation

CL: Yes

CR: Yes

FE: Yes

TI: No explicit (timeliness not discussed as requirement)

EX: Partial (mechanistic explainability of direct/indirect costs)

GA: Partial (goal is implicitly favorable outcome alignment)

Reason if Not Eligible: N/A

<!--META_END-->

Title:

Decomposing Counterfactual Explanations for Consequential Decision Making

Authors:

Martin Pawelczyk, Lea Tiyavorabun, Gjergji Kasneci

DOI:

arXiv:2211.02151

Year:

2022

Publication Type:

Conference/Preprint (arXiv)

Discipline/Domain:

Machine Learning / Explainable AI

Subdomain/Topic:

Algorithmic Recourse, Counterfactual Explanations, Feature Dependencies

Contextual Background:

The paper addresses limitations of existing algorithmic recourse methods—especially their reliance on ei

Geographic/Institutional Context:

Methods tested on datasets from the U.S. (Adult Income, COMPAS, Give Me Credit).

Target Users/Stakeholders:

Individuals affected by automated decisions; AI practitioners seeking to implement actionable recourse.

Primary Methodology:

Conceptual framework development + empirical experiments with benchmarks.

Primary Contribution Type:

Framework proposal (DEAR) + quantitative and qualitative evaluation.

General Summary of the Paper

The authors present DEAR (DisEntangling Algorithmic Recourse), a novel framework for generating actio

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is framed as the ability to reverse unfavorable decisions by providing **realistic, feasible, and

> “Counterfactual explanations provide a means for actionable model explanations at feature level… an i

> “…generate recourses by disentangling the latent representation of co-varying features from a subset o

What Makes Something Actionable

- Adheres to **feature dependencies** (avoids unrealistic independence assumptions)
- Lies in **dense regions** of the data distribution
- Is **attainable at low and controllable cost** for the individual
- Produces **interpretable direct and indirect actions**
- Avoids reliance on strong causal assumptions

How Actionability is Achieved / Operationalized

- **Framework/Approach Name:** DEAR (DisEntangling Algorithmic Recourse)
- **Methods/Levers:** Disentangled latent-variable generative modeling; cost decomposition; Hessian pe
- **Operational Steps / Workflow:**

  1. Train conditional autoencoder with disentanglement via Hessian penalty to separate direct features (x
  2. Ensure identity mapping for xS to allow controllable direct actions
  3. Optimize direct actions dS to flip prediction with minimal cost, tracking indirect changes
- **Data & Measures:** Adult, COMPAS, Give Me Credit datasets; evaluation via recourse cost (`L1`), su
- **Implementation Context:** Black-box or differentiable classifiers; tabular decision-making tasks
> “Our framework generates recourses by disentangling the latent representation of co-varying features…
> “DEAR requires two steps: first… obtain a latent space representation v independent of xS… second…
Dimensions and Attributes of Actionability (Authors’ Perspective)
- **CL (Clarity):** Yes — actions are expressed in original feature space (interpretable direct actions).
- **CR (Contextual Relevance):** Yes — recourses adhere to actual feature dependencies.
- **FE (Feasibility):** Yes — costs decomposed to ensure attainable low-cost changes.
- **TI (Timeliness):** No explicit discussion.
- **EX (Explainability):** Partial — direct/indirect cost split provides mechanistic explanation.
- **GA (Goal Alignment):** Partial — implicit aim to achieve favorable classification outcome.
- **Other Dimensions Named by Authors:** Reliability (success rate), proximity to data manifold.
Theoretical or Conceptual Foundations
- Counterfactual explanations literature (Wachter et al., causal recourse approaches)
- Disentangled representation learning (Hessian penalty; ResNet identity mapping)
- Cost decomposition into direct/indirect effects
Indicators or Metrics for Actionability
- Recourse cost (`L1` norm)
- Success rate (SR) of flipping prediction
- Constraint violations (CV) for immutable features
- Neighborhood support (YNN) from positive-class instances
Barriers and Enablers to Actionability
- **Barriers:**
  - Strong causal assumptions in prior methods hinder practical deployment
  - IMF assumption yields unrealistic recommendations in dependent-feature settings
- **Enablers:**
  - Disentanglement to reduce indirect costs
  - Explicit modeling of dependencies without causal graphs
  - Search in interpretable input space

Relation to Existing Literature

Positions DEAR as bridging manifold-based recourse (realistic but ignores dependencies) and causal rec

Summary

The paper proposes DEAR, a framework for generating actionable counterfactual explanations that hand

Scores

- **Overall Relevance Score:** 92 — Strong conceptualization of actionability in recourse setting, explicit
- **Operationalization Score:** 90 — Detailed algorithmic steps, optimization objectives, disentanglement

Supporting Quotes from the Paper

- “Counterfactual explanations provide a means for actionable model explanations at feature level… an in
- “Our framework generates recourses by disentangling the latent representation of co-varying features fr
- “The framework should allow recourses to adhere to feature dependencies… lie in dense regions… ens
- “DEAR requires two steps: first… obtain a latent space representation v independent of xS… second…

Actionability References to Other Papers

- Wachter et al. (2018) — IMF assumption recourse
- Karimi et al. (2021) — causal recourse approaches
- Antorán et al. (2021), Joshi et al. (2019), Pawelczyk et al. (2020) — manifold-based recourse
- Peebles et al. (2020) — Hessian penalty for disentanglement

Paper Summary

<!--META_START-->

Title: An Actionability Assessment Tool for Explainable AI

Authors: Ronal Singh, Tim Miller, Liz Sonenberg, Eduardo Velloso, Frank Vetere, Piers Howe, Paul Dour

DOI: arXiv:2407.09516

Year: 2024

Publication Type: Journal Article (Preprint on arXiv)

Discipline/Domain: Artificial Intelligence / Human-Computer Interaction

Subdomain/Topic: Explainable AI (XAI), Algorithmic Recourse, Human-Centred Design

Eligibility: Eligible

Overall Relevance Score: 95

Operationalization Score: 90

Contains Definition of Actionability: Yes

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Partial

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Mixed Methods (Conceptual development + Empirical user studies)

Study Context: Credit scoring and employee turnover prediction scenarios

Geographic/Institutional Context: Australia (with online MTurk participants from the US)

Target Users/Stakeholders: AI researchers, practitioners, system designers, end-users seeking recourse

Primary Contribution Type: Tool development and validation

CL: Yes

CR: Yes

FE: Yes

TI: Partial

EX: Yes

GA: Yes

Reason if Not Eligible: N/A

<!--META_END-->

Title:

An Actionability Assessment Tool for Explainable AI

Authors:

Ronal Singh, Tim Miller, Liz Sonenberg, Eduardo Velloso, Frank Vetere, Piers Howe, Paul Dourish

DOI:

arXiv:2407.09516

Year:

2024

Publication Type:

Journal Article (arXiv preprint)

Discipline/Domain:

Artificial Intelligence / Human-Computer Interaction

Subdomain/Topic:

Explainable AI, Algorithmic Recourse, Actionable Explanations

Contextual Background:

The paper addresses the lack of a clear, human-centred definition and measurement of "actionability" in e

Geographic/Institutional Context:

Developed by Australian researchers (CSIRO, University of Queensland, University of Melbourne, Univer

Target Users/Stakeholders:

AI system designers, XAI researchers, practitioners providing explanations for algorithmic decisions, and

Primary Methodology:

Mixed methods — conceptual synthesis of existing tools and empirical validation through two user studie

Primary Contribution Type:

Practical tool for assessing actionability in XAI explanations, validated via empirical studies.

General Summary of the Paper

This work introduces a seven-question Actionability Assessment Tool for Explainable AI (XAI), aiming to

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Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is defined as:

> “An explanation of a decision is actionable if people can use the information to identify actions to take t

The authors emphasise a **human-centred** rather than purely technical definition, focusing on the recip

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What Makes Something Actionable

- Clarity and understandability
- Explanation of the decision’s reasoning
- Personal relevance and contextual fit
- Social appropriateness of recommendations
- Ability to correct misunderstandings
- Identification of at least one feasible action
- Breakdown of actions into explicit steps

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Actionability Assessment Tool for XAI
- **Methods/Levers:** Seven-question survey instrument across five dimensions.

- **Operational Steps / Workflow:**
  1. Present explanation to participant/user.
  2. Rate it using Q1–Q7.
  3. Analyse item-level scores rather than aggregated totals.
- **Data & Measures:** Likert-scale ratings per question; statistical tests (Friedman, Nemenyi) for discrim
- **Implementation Context:** Tested in credit scoring and employee turnover with three explanation type
> “The information allows me to identify at least one feasible action to achieve my desired outcome.” (Q6
> “The information allows me to break down any action into explicit steps.” (Q7, p. 3)

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — “The information is clear and easy to understand.” (Q1)
- **CR (Contextual Relevance):** Yes — “The information is relevant to my personal circumstances.” (Q3
- **FE (Feasibility):** Yes — “The information allows me to identify at least one feasible action…” (Q6)
- **TI (Timeliness):** Partial — Timeliness not explicitly measured but implied via domain specificity.
- **EX (Explainability):** Yes — Includes decision reasoning clarity (Q2).
- **GA (Goal Alignment):** Yes — Embedded in contextual relevance and social appropriateness (Q4).
- **Other Dimensions Named by Authors:** Social appropriateness, correction of misunderstandings.

Theoretical or Conceptual Foundations

- Patient Education Materials Assessment Tool (PEMAT)
- Actionability frameworks from management research
- Shared decision-making instruments
- Cybersecurity advice evaluation frameworks

Indicators or Metrics for Actionability

- Seven-item Likert-scale instrument
- Dimension-level discrimination between explanation types
- Median ratings per item across explanation types and contexts

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Barriers and Enablers to Actionability

- **Barriers:** Lack of clarity, irrelevance to user context, absence of explicit action steps, role misalignme
- **Enablers:** Direct, step-by-step directives; personal relevance; ability to identify misunderstandings; c

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Relation to Existing Literature

The tool draws directly from validated assessment instruments in other fields, translating them into XAI. It

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Summary

Singh et al. (2024) present the first empirically validated, human-centred tool for assessing the actionabili

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Scores

- **Overall Relevance Score:** 95 — Provides explicit, clear definition of actionability; identifies systemati
- **Operationalization Score:** 90 — Fully operationalises actionability into a validated 7-question tool; tes

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Supporting Quotes from the Paper

- “An explanation of a decision is actionable if people can use the information to identify actions to take to
- “The information is clear and easy to understand.” (Q1, p. 3)
- “The information allows me to break down any action into explicit steps.” (Q7, p. 3)
- “Directive explanations… clearly outlined specific steps… most actionable.” (p. 1–2)

Actionability References to Other Papers

- Shoemaker et al. (2014) — PEMAT tool
- HakemZadeh & Baba (2016) — Actionability in management research
- Redmiles et al. (2020) — Cybersecurity advice evaluation
- Scholl et al. (2011) — Shared decision-making measures
- Russell (2019), Singh et al. (2023) — Counterfactual and directive explanations in XAI

Paper Summary

<!--META_START-->

Title: The Art and Science of Cause and Effect (Epilogue to *Causality: Models, Reasoning, and Inferenc

Authors: Judea Pearl

DOI: https://doi.org/10.1017/CBO9780511803161.014

Year: 2009 (lecture delivered 1996)

Publication Type: Book Chapter

Discipline/Domain: Statistics, Artificial Intelligence, Philosophy of Science

Subdomain/Topic: Causal Inference, Structural Models, Graphical Models

Eligibility: Eligible

Overall Relevance Score: 95

Operationalization Score: 95

Contains Definition of Actionability: Yes (framed as the ability to predict consequences under intervention

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes (causal diagrams, do-calculus, intervention-as-surgery model)

Operationalization Present: Yes

Primary Methodology: Conceptual & Applied Methodological

Study Context: General scientific reasoning across disciplines; illustrated with examples from engineering

Geographic/Institutional Context: UCLA Faculty Research Lecture

Target Users/Stakeholders: Researchers in statistics, economics, social sciences, epidemiology, AI, philo

Primary Contribution Type: Conceptual framework + practical tools for causal analysis

CL: Yes — clarity is essential to express causation in a formal language

CR: Yes — contextual relevance is explicitly tied to usefulness of causal models in domains

FE: Yes — feasibility addressed through computational tools and graphical methods

TI: Yes — timeliness via real-time applicability in policy analysis and epidemiology

EX: Yes — explainability tied to “deep understanding” and prediction under hypothetical scenarios

GA: Yes — goal alignment linked to ability to answer “what if” and “how to” questions for decision-making

Reason if Not Eligible: N/A

<!--META_END-->

Title:

The Art and Science of Cause and Effect

Authors:

Judea Pearl

DOI:

https://doi.org/10.1017/CBO9780511803161.014

Year:

2009 (lecture delivered 1996)

Publication Type:

Book Chapter

Discipline/Domain:

Statistics, Artificial Intelligence, Philosophy of Science

Subdomain/Topic:

Causal Inference, Structural Models, Graphical Models

Contextual Background:

Pearl addresses causality as a universal concern across disciplines, focusing on how to formally represe

Geographic/Institutional Context:

University of California, Los Angeles (UCLA Faculty Research Lectureship Program)

Target Users/Stakeholders:

Researchers, statisticians, economists, epidemiologists, social scientists, AI practitioners, philosophers o

Primary Methodology:

Conceptual and applied methodological exposition

Primary Contribution Type:

Integration of historical, philosophical, and technical perspectives into a unified operational framework for

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General Summary of the Paper

This epilogue presents Judea Pearl's synthesis of centuries of debate on causality and his solution: a for

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Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Pearl frames actionability as the **capacity to predict the consequences of interventions**—whether natu

> "The very essence of causation – the ability to predict the consequences of abnormal eventualities and

> "Causation means predicting the consequences of such a surgery [on equations]" (p. 417)

What Makes Something Actionable

- Ability to predict outcomes under new, possibly unobserved, scenarios
- Representation of independent mechanisms (autonomy) to allow localized changes without altering the
- Clear mapping from intervention to altered model ("surgery" on equations)
- Capability to distinguish causal from purely correlational relationships
- Formal language enabling precise computation and communication across studies

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How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Structural Causal Models (SCMs), Causal Diagrams, do-Calculus, In
- **Methods/Levers:** Graph-based representation of causal mechanisms, algebra of interventions (do-op
- **Operational Steps / Workflow:**
  1. Represent system as a causal diagram with autonomous mechanisms
  2. Specify intervention by removing/replacing mechanism(s) (surgery)
  3. Use graphical criteria to identify adjustment sets or mediation paths
  4. Apply do-calculus rules to transform interventional queries into observational ones when possible
  5. Compute quantities from data under the transformed model
- **Data & Measures:** Observational data, experimental data, and auxiliary variables (mediators, covaria
- **Implementation Context:** Demonstrated in epidemiology (smoking/cancer), economics (tax policy), a

> “Intervention amounts to a surgery on equations (guided by a diagram)” (p. 417)

> “The door is open for deduction, and the result is given in the… rules of causal calculus” (p. 422)

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — causality must be expressed in a formal, diagrammatic, and algebraic language
- **CR (Contextual Relevance):** Yes — models are tied to specific domains and interventions (p. 418–4
- **FE (Feasibility):** Yes — computational procedures (do-calculus, graphical tests) make implementatio
- **TI (Timeliness):** Yes — applicable to real-time decision problems (e.g., policy analysis) (p. 418)
- **EX (Explainability):** Yes — causal models offer “deep understanding” by predicting under hypothetica
- **GA (Goal Alignment):** Yes — explicitly linked to “what if” and “how to” queries central to decision-ma
- **Other Dimensions Named by Authors:** Autonomy of mechanisms; capacity for counterfactual reason

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Theoretical or Conceptual Foundations

- Hume’s problem of induction and spurious correlations
- Russell’s critique of causality in physics
- Structural equation modeling (S. Wright)
- Herman Wold’s “surgery” idea in econometrics
- Graph theory and Bayesian networks
- Galileo’s “description before explanation” principle

Indicators or Metrics for Actionability

- Identifiability of causal effect given a model and data
- Graphical criteria (back-door, front-door) satisfied
- Ability to eliminate the “do” operator from expressions using do-calculus rules

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Barriers and Enablers to Actionability

- **Barriers:**
  - Lack of formal language for causation in mainstream statistics (p. 412)
  - Historical skepticism and avoidance of causal vocabulary
  - Endogeneity in observational data without clear intervention modeling
- **Enablers:**
  - Adoption of causal diagrams in model specification
  - Computational rules for interventions (do-calculus)
  - Combining domain expertise with graphical structure

Relation to Existing Literature

Pearl contrasts his operationalization with:

- Classical philosophy (Aristotle, Hume, Russell)
- Correlation-based statistics (Galton, Pearson)
- SEM traditions in social sciences

He positions causal diagrams and do-calculus as bridging the gap between probabilistic and structural ap

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Summary

Judea Pearl’s epilogue reframes causality as a fully operational, mathematically tractable concept. He de

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Scores

- **Overall Relevance Score:** 95 — Strong, explicit conceptualization of actionability and detailed enume
- **Operationalization Score:** 95 — Fully worked-out procedural tools (graphs, algebra, examples) to im

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Supporting Quotes from the Paper

- “The very essence of causation – the ability to predict the consequences of abnormal eventualities and
- “Causation means predicting the consequences of such a surgery” (p. 417)

- “Viewing causality this way explains why scientists pursue causal explanations with such zeal” (p. 415)
- “The door is open for deduction… rules of causal calculus” (p. 422)

Actionability References to Other Papers

- Wright, S. (1920) *Proceedings of the National Academy of Sciences* — path diagrams
- Wold, H. (1960) — econometric intervention-as-surgery concept
- Galton, F.; Pearson, K. — correlation vs causation debate
- Russell, B. (1913); Suppes, P. — philosophical positions on causality
- Fisher, R.A. — randomized experiments

Paper Summary

<!--META_START-->

Title: Explainable Artificial Intelligence (XAI): Concepts, Taxonomies, Opportunities and Challenges towa

Authors: Alejandro Barredo Arrieta, Natalia Díaz-Rodríguez, Javier Del Ser, Adrien Bennetot, Siham Tabi

DOI: 10.1016/j.inffus.2019.12.012

Year: 2020

Publication Type: Journal

Discipline/Domain: Artificial Intelligence / Machine Learning

Subdomain/Topic: Explainable Artificial Intelligence (XAI), Responsible AI

Eligibility: Eligible

Overall Relevance Score: 95

Operationalization Score: 90

Contains Definition of Actionability: Yes (implicit as “explainability” and audience-specific usefulness)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes (taxonomy of XAI methods; Responsible AI conceptual model)

Operationalization Present: Yes

Primary Methodology: Review / Conceptual Analysis

Study Context: Broad AI/ML application domains, including critical sectors (health, finance, transport)

Geographic/Institutional Context: Multi-institutional (Europe-based with international perspective)

Target Users/Stakeholders: AI researchers, developers, policy-makers, domain experts, affected users

Primary Contribution Type: Conceptual framework and taxonomy with operational guidelines toward Resp

CL: Yes – “...explanations should make the model’s functioning clear or easy to understand to the audien

CR: Yes – “...clarity targeted by XAI techniques...reverts on different application purposes such as trustw

FE: Yes – Feasibility implied via implementability and robustness as necessary for practical deployment (

TI: Partial – Timeliness is not a main dimension but is relevant in regulatory/audit contexts (p.8, Figure 2)

EX: Yes – Explainability explicitly defined (p.7)

GA: Yes – Goal alignment implied in audience-specific and purpose-driven explainability (p.7–9)

Reason if Not Eligible: N/A

<!--META_END-->

Title:

Explainable Artificial Intelligence (XAI): Concepts, Taxonomies, Opportunities and Challenges toward Res

Authors:

Alejandro Barredo Arrieta, Natalia Díaz-Rodríguez, Javier Del Ser, Adrien Bennetot, Siham Tabik, Alberto

DOI:

10.1016/j.inffus.2019.12.012

Year:

2020

Publication Type:

Journal

Discipline/Domain:

Artificial Intelligence / Machine Learning

Subdomain/Topic:

Explainable Artificial Intelligence (XAI), Responsible AI

Contextual Background:

The paper surveys and systematizes the state of research in explainable AI, especially in machine learnin

Geographic/Institutional Context:

Multi-institutional, with primary affiliations in Spain and France; international scope.

Target Users/Stakeholders:

Researchers, ML engineers, policy-makers, regulatory bodies, domain experts, end users affected by AI

Primary Methodology:

Review / Conceptual Analysis

Primary Contribution Type:

Comprehensive conceptual framework and taxonomies for XAI, linked to operational challenges and Res

General Summary of the Paper

This paper delivers a comprehensive review of Explainable Artificial Intelligence (XAI), defining its core co

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

The authors conceptualize actionability implicitly through “explainability” as the model’s ability to provide e

> “Given an audience, an explainable Artificial Intelligence is one that produces details or reasons to mak

> “Ease of understanding and clarity…reverts on different application purposes, such as better trustworth

What Makes Something Actionable

- Clarity of functioning for the intended audience
- Contextual relevance to stakeholder goals
- Feasibility and robustness in implementation
- Alignment with regulatory, ethical, and operational objectives
- Support for trustworthiness, causality analysis, and fairness audits
- Ability to inform decisions and provide accessible, understandable outputs

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Taxonomy of XAI methods; Responsible AI framework
- **Methods/Levers:** Transparent model design, post-hoc techniques (model simplification, feature relev
- **Operational Steps / Workflow:** Select model type based on interpretability needs; apply post-hoc me
- **Data & Measures:** Model parameters, feature importance scores, saliency maps, counterfactual exa
- **Implementation Context:** Applicable across ML/DL models in sectors such as health, finance, autono

> “XAI proposes creating…techniques that…enable humans to understand, appropriately trust, and effec

> “Target audience…as the cognitive skills and pursued goal of the users…must be taken into account…

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — audience-specific clarity is central (p.7)
- **CR (Contextual Relevance):** Yes — explanations linked to purposes like trust, compliance (p.8–9)
- **FE (Feasibility):** Yes — tied to implementability, robustness, and meaningful variable use (p.3)
- **TI (Timeliness):** Partial — relevant in compliance/audit timelines (p.8, Figure 2)
- **EX (Explainability):** Yes — explicit definition provided (p.7)
- **GA (Goal Alignment):** Yes — alignment with stakeholder goals and Responsible AI principles (p.8–9
- **Other Dimensions Named by Authors:** Trustworthiness, causality, transferability, informativeness, co

Theoretical or Conceptual Foundations

- DARPA XAI definition (Gunning, 2017)
- Social sciences of explanation (Miller, 2019)
- Michalski’s concept of comprehensibility
- Responsible AI principles (Fairness, Accountability, Privacy)

Indicators or Metrics for Actionability

- Degree of audience understanding
- Trustworthiness levels
- Feature relevance and stability metrics
- Model simplification degree
- Fairness measures (statistical parity, equalized odds)

Barriers and Enablers to Actionability

- **Barriers:** Lack of consensus on definitions; interpretability-performance trade-off; absence of standar
- **Enablers:** Transparent model design; tailored post-hoc methods; audience-aware explanations; integ

Relation to Existing Literature

Builds on existing XAI surveys but advances an audience-centric definition and unified taxonomies; conn

Summary

This paper reframes explainability as inherently audience-dependent, situating it as a core component of

Scores

- **Overall Relevance Score:** 95 — Clear definition, comprehensive features list, integration with broade
- **Operationalization Score:** 90 — Detailed pathways and taxonomies for achieving explainability acros

Supporting Quotes from the Paper

- “Given an audience, an explainable Artificial Intelligence is one that produces details or reasons to mak
- “Ease of understanding and clarity…reverts on different application purposes, such as better trustworthi
- “Target audience…must be taken into account jointly with the intelligibility and comprehensibility of the m
- “XAI proposes…techniques that…enable humans to understand, appropriately trust, and effectively ma

Actionability References to Other

Paper Summary

<!--META_START-->

Title: DACE: Distribution-Aware Counterfactual Explanation by Mixed-Integer Linear Optimization

Authors: Kentaro Kanamori, Takuya Takagi, Ken Kobayashi, Hiroki Arimura

DOI: 10.24963/ijcai.2020/391

Year: 2020

Publication Type: Conference

Discipline/Domain: Artificial Intelligence, Machine Learning

Subdomain/Topic: Explainable AI, Counterfactual Explanations, Optimization

Eligibility: Eligible

Overall Relevance Score: 82

Operationalization Score: 90

Contains Definition of Actionability: Yes (implicit, framed as “realistic actions” in CE)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes (DACE framework)

Operationalization Present: Yes (MILO formulation, algorithmic steps)

Primary Methodology: Conceptual + Quantitative (algorithm development and evaluation)

Study Context: Post-hoc explanations for ML model decisions, focusing on financial datasets

Geographic/Institutional Context: Japan (Hokkaido University, Fujitsu Laboratories, Tokyo Institute of Tec

Target Users/Stakeholders: End-users of ML systems, decision-makers in domains like finance and credi

Primary Contribution Type: New framework & algorithm for actionable counterfactual explanations

CL: Yes — “an action suggested by CE should be executable for users” (p. 2)

CR: Yes — “evaluate its reality on the empirical data distribution” (p. 2)

FE: Yes — “suggest an executable action for users” (p. 2)

TI: Partial — timeliness not a central theme but actions are meant for decision contexts

EX: Yes — cost function grounded in explainable metrics (MD, LOF)

GA: Partial — goal alignment implied through user-desired outcomes

Reason if Not Eligible: N/A

<!--META_END-->

Title:

DACE: Distribution-Aware Counterfactual Explanation by Mixed-Integer Linear Optimization

Authors:

Kentaro Kanamori, Takuya Takagi, Ken Kobayashi, Hiroki Arimura

DOI:

10.24963/ijcai.2020/391

Year:

2020

Publication Type:

Conference

Discipline/Domain:

Artificial Intelligence, Machine Learning

Subdomain/Topic:

Explainable AI, Counterfactual Explanations, Optimization

Contextual Background:

The paper addresses the challenge of generating counterfactual explanations (CE) that are realistic and

Geographic/Institutional Context:

Japan — Hokkaido University, Fujitsu Laboratories Ltd., Tokyo Institute of Technology

Target Users/Stakeholders:

End-users of ML systems, decision-makers (e.g., loan officers, credit applicants)

Primary Methodology:

Conceptual + Quantitative (algorithm development and comparative experiments)

Primary Contribution Type:

Novel framework & optimization method for actionable counterfactual generation

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General Summary of the Paper

The paper proposes *Distribution-Aware Counterfactual Explanation* (DACE), a method for generating c

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Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is framed implicitly as producing **realistic, executable actions** that users can directly follo

> “The action suggested by CE should be executable for users” (p. 2)

> “To extract realistic actions, we need to define a cost function C that considers the empirical distributio

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What Makes Something Actionable

- Alignment with **empirical feature correlations** (avoid impossible or uncorrelated changes)

- Avoidance of **outlier regions** in feature space

- Feasibility for the user to execute
- Model outcome change to desired target class
- Preservation of plausibility given real-world constraints

How Actionability is Achieved / Operationalized

- **Framework/Approach Name:** Distribution-Aware Counterfactual Explanation (DACE)
- **Methods/Levers:** Cost function combining squared Mahalanobis Distance and k-Local Outlier Factor
- **Operational Steps / Workflow:**
  1. Define feasible action set A per feature constraints
  2. Calculate MD and LOF for candidate actions
  3. Formulate optimization as MILO problem
  4. Solve using MILO solvers (e.g., CPLEX)
- **Data & Measures:** Feature correlations from covariance matrix; density-based outlier scores from tra
- **Implementation Context:** Works with linear and tree ensemble classifiers

> “We propose a new cost function based on the Mahalanobis’ distance… and Local Outlier Factor… to e

> “We formulate the problem… as a mixed-integer linear optimization problem” (p. 3)

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — clear, interpretable perturbation vector linked to decision change
- **CR (Contextual Relevance):** Yes — grounded in empirical distribution
- **FE (Feasibility):** Yes — avoids unrealistic changes
- **TI (Timeliness):** Partial — not central, but decisions are framed in near-term contexts
- **EX (Explainability):** Yes — uses explainable statistical measures
- **GA (Goal Alignment):** Partial — aligns with user’s desired prediction outcome
- **Other Dimensions:** Avoidance of outliers, maintenance of feature dependencies

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Theoretical or Conceptual Foundations

- Mahalanobis Distance for correlated feature space measurement
- Local Outlier Factor for density-based anomaly detection
- Mixed-Integer Linear Optimization for discrete-continuous decision problems

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Indicators or Metrics for Actionability

- Low Mahalanobis Distance (plausibility with respect to feature correlations)
- Low LOF (avoidance of statistically rare configurations)

Barriers and Enablers to Actionability

- **Barriers:** High computation time; requirement for feature covariance and neighborhood statistics; co
- **Enablers:** Use of MILO solvers; tunable λ for balancing plausibility vs. feasibility

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Relation to Existing Literature

Extends integer linear optimization CE methods (e.g., Ustun et al., 2019; Russell, 2019) to nonlinear cost

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Summary

The DACE framework reconceptualizes actionability in counterfactual explanations as the ability to produ

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Scores

- **Overall Relevance Score:** 82 — Strong conceptualization of actionability as realistic, distribution-gro
- **Operationalization Score:** 90 — Fully specified computational method with steps, constraints, and im

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Supporting Quotes from the Paper

- “The action suggested by CE should be executable for users” (p. 2)
- “Evaluate its reality on the empirical data distribution” (p. 2)
- “We propose a new cost function based on the Mahalanobis’ distance… and Local Outlier Factor… to e
- “Our aim is to find an action… that minimizes the cost… subject to H(x■ + a) = t” (p. 5)

Actionability References to Other Papers

- Ustun et al., 2019 (Actionable recourse in linear classification)
- Russell, 2019 (Diverse coherent explanations)
- Ballet et al., 2019 (Imperceptible adversarial attacks)
- Laugel et al., 2019 (Connectedness and proximity in CE)
- Rudin, 2019 (Critique of post-hoc explanations)

Paper Summary

<!--META_START-->

Title: Explainable AI: A Review of Machine Learning Interpretability Methods

Authors: Pantelis Linardatos, Vasilis Papastefanopoulos, Sotiris Kotsiantis

DOI: https://doi.org/10.3390/e23010018

Year: 2021

Publication Type: Journal

Discipline/Domain: Artificial Intelligence, Machine Learning

Subdomain/Topic: Explainable AI (XAI), Interpretability Methods

Eligibility: Eligible

Overall Relevance Score: 78

Operationalization Score: 90

Contains Definition of Actionability: No (focuses on interpretability/explainability, not "actionability" per se)

Contains Systematic Features/Dimensions: Yes (criteria, taxonomies, method categories)

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes (taxonomy of interpretability methods)

Operationalization Present: Yes (taxonomy + method-by-method review with applicability guidance)

Primary Methodology: Literature Review

Study Context: Survey of ML interpretability methods across data types, algorithms, and use cases

Geographic/Institutional Context: University of Patras, Greece

Target Users/Stakeholders: ML practitioners, researchers, applied data scientists, policymakers in regula

Primary Contribution Type: Taxonomy and comparative survey of methods

CL: Partial (clarity linked to interpretability but not as "actionability" dimension)

CR: Yes (methods often linked to model/data context)

FE: Partial (some mention of feasibility of application but not as formal dimension)

TI: No (timeliness not explicitly tied to interpretability)

EX: Yes (explainability as separate but related concept to interpretability)

GA: Partial (alignment with goals implied in fairness and trustworthiness contexts)

Reason if Not Eligible: N/A

<!--META_END-->

Title:

Explainable AI: A Review of Machine Learning Interpretability Methods

Authors:

Pantelis Linardatos, Vasilis Papastefanopoulos, Sotiris Kotsiantis

DOI:

https://doi.org/10.3390/e23010018

Year:

2021

Publication Type:

Journal

Discipline/Domain:

Artificial Intelligence, Machine Learning

Subdomain/Topic:

Explainable AI (XAI), Interpretability Methods

Contextual Background:

The paper surveys the growing field of Explainable AI (XAI) in response to the challenges posed by black

Geographic/Institutional Context:

University of Patras, Greece

Target Users/Stakeholders:

Machine learning practitioners, researchers, data scientists, domain experts, and policymakers

Primary Methodology:

Literature Review

Primary Contribution Type:

Taxonomy and comparative synthesis of methods

General Summary of the Paper

This paper presents a comprehensive literature review of machine learning interpretability methods, offer

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Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

The paper does not directly define “actionability,” but implicitly links interpretability/explainability to trustw

> “Interpretability… is the degree to which a human can understand the cause of a decision” (p. 2)

> “Explainability… is associated with the internal logic and mechanics inside a ML system” (p. 3)

What Makes Something Actionable

Implicitly, for interpretability methods to be “usable” in decisions, they must:

- Relate model outputs to human-understandable inputs/features
- Provide transparency on decision mechanisms
- Support evaluation of fairness and bias
- Offer reproducible, context-relevant explanations

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Taxonomy of Interpretability Methods
- **Methods/Levers:** Categorization by model specificity, scope, and purpose; detailed method descripti
- **Operational Steps / Workflow:** Identify problem constraints → Choose category (e.g., explain black-b
- **Data & Measures:** Not quantitative for “actionability,” but qualitative criteria for method selection (e.g
- **Implementation Context:** Works across domains where interpretability is required for trust, complianc

> “This taxonomy… identifies four major categories for interpretability methods… methods for explaining

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Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Partial — clarity is implied through interpretability
- **CR (Contextual Relevance):** Yes — method applicability linked to model/data context
- **FE (Feasibility):** Partial — feasibility discussed for method choice, not as formal criterion
- **TI (Timeliness):** No
- **EX (Explainability):** Yes — explicitly discussed as distinct from interpretability
- **GA (Goal Alignment):** Partial — fairness and trustworthiness goals referenced
- **Other Dimensions Named by Authors:** Fairness, Sensitivity, Model scope, Data type

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Theoretical or Conceptual Foundations

- Distinction between interpretability and explainability (Doshi-Velez & Kim, Miller)
- Prior taxonomies (Gilpin et al., Adadi & Berrada, Guidotti et al.)
- Fairness frameworks (Hardt et al.)
- Sensitivity analysis foundations (Sobol, Saltelli)

Indicators or Metrics for Actionability

No formal “actionability” metrics; evaluation focuses on interpretability quality via:

- Application-grounded, human-grounded, functionally-grounded evaluation (Doshi-Velez & Kim)
- Fairness measures (e.g., disparate impact, equalized odds)
- Sensitivity indices

Barriers and Enablers to Actionability

- **Barriers:** Lack of formal definitions, context-specific constraints, model complexity, limited generaliza
- **Enablers:** Availability of open-source tools, clear taxonomies, method-model-data mapping

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Relation to Existing Literature

Positions itself as more comprehensive than prior surveys by integrating model-agnostic/specific, local/gl

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Summary

While not directly about “actionability,” the paper presents a mature operationalization of interpretability th

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Scores

- **Overall Relevance Score:** 78 — Strong on conceptual clarity for interpretability/explainability; lacks e
- **Operationalization Score:** 90 — Well-developed taxonomy with implementation guidance; practical p

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Supporting Quotes from the Paper

- “Interpretability… is the ability to explain or present in understandable terms to a human” (p. 2)
- “Explainability… is associated with the internal logic and mechanics inside a ML system” (p. 3)
- “This taxonomy… identifies four major categories for interpretability methods…” (p. 5)

Actionability References to Other Papers

- Doshi-Velez & Kim (interpretability definition, evaluation methods)
- Miller (interpretability as cause understanding)
- Gilpin et al., Adadi & Berrada, Guidotti et al. (prior taxonomies)
- Hardt et al. (fairness framework)
- Sobol, Saltelli (sensitivity analysis)

Paper Summary

<!--META_START-->

Title: Counterfactual Explanations and Algorithmic Recourses for Machine Learning: A Review

Authors: Sahil Verma, Varich Boonsanong, Minh Hoang, Keegan Hines, John Dickerson, Chirag Shah

DOI: https://doi.org/10.1145/3677119

Year: 2024

Publication Type: Journal

Discipline/Domain: Computer Science / Machine Learning

Subdomain/Topic: Explainable AI, Counterfactual Explanations, Algorithmic Recourse

Eligibility: Eligible

Overall Relevance Score: 95

Operationalization Score: 90

Contains Definition of Actionability: Yes (explicit and implicit)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes (rubric of desiderata, operational frameworks)

Operationalization Present: Yes

Primary Methodology: Review

Study Context: Counterfactual explanations in ML for classification, primarily tabular data

Geographic/Institutional Context: Global research literature, University of Washington & Arthur AI

Target Users/Stakeholders: ML practitioners, policymakers, system designers, regulated industries (finan

Primary Contribution Type: Comprehensive literature review and taxonomy with evaluation rubric

CL: Yes — “An effective counterfactual only proposes small changes in the features relative to the startin

CR: Yes — “Recommendation should never change immutable features... preference order among mutal

FE: Yes — Feasibility implied in actionability constraints and plausibility requirements (p. 7-8)

TI: Partial — Timeliness is implicit in “amortized inference” and generation time metrics but not core desi

EX: Yes — Explainability core to the survey’s scope (p. 2-3)

GA: Yes — Goal alignment implicit in actionable, realistic, user-preference-aligned changes (p. 7)

Reason if Not Eligible: N/A

<!--META_END-->

Title:

Counterfactual Explanations and Algorithmic Recourses for Machine Learning: A Review

Authors:

Sahil Verma, Varich Boonsanong, Minh Hoang, Keegan Hines, John Dickerson, Chirag Shah

DOI:

https://doi.org/10.1145/3677119

Year:

2024

Publication Type:

Journal

Discipline/Domain:

Computer Science / Machine Learning

Subdomain/Topic:

Explainable AI, Counterfactual Explanations, Algorithmic Recourse

Contextual Background:

The paper synthesizes a fast-growing body of research on counterfactual explanations (CFEs) and algori

Geographic/Institutional Context:

University of Washington (Seattle, USA), Arthur AI (Washington DC, USA)

Target Users/Stakeholders:

ML researchers, practitioners, policymakers, legal analysts, and regulated industry developers

Primary Methodology:

Comprehensive literature review (>350 papers) with comparative evaluation rubric

Primary Contribution Type:

Taxonomy of CFE approaches, evaluation against desiderata, identification of gaps and open challenges

General Summary of the Paper

This survey reviews more than 350 papers proposing algorithms for generating CFEs and recourses in m

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is framed as the feasibility of user-implementable changes to achieve a desired outcome wit

> “A recommended counterfactual should never change the immutable features… applicant might have a

> “Realistic and actionable… of little use if the recommendation were to decrease age by 10 years” (p. 6)

What Makes Something Actionable

- Changes must be **valid** (yield the desired class outcome)
- Must target **mutable, non-sensitive** features
- Should be **sparse** (few changes)

- Must be **plausible** and close to the data manifold
- Should respect **causal dependencies** among features
- Align with **user preferences** and feasibility constraints

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Wachter et al. optimization framework; FACE; CounterNet; FastAR;
- **Methods/Levers:** Distance minimization, sparsity-inducing norms, causal graph constraints, manifold
- **Operational Steps / Workflow:** Identify mutable features, solve constrained optimization problem, opt
- **Data & Measures:** L1/L2 distance, manifold closeness (VAE reconstruction error, k-NN distance), ca
- **Implementation Context:** Mostly tabular ML classification, but extendable to images, text, graphs

> “arg min … subject to f(x′)=y′ … updated to take into account actionable features A” (p. 7)

> “Adding the data manifold loss term encourages… even if path is longer” (p. 8)

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — Minimal, interpretable changes as core design goal (p. 7)
- **CR (Contextual Relevance):** Yes — Must respect feature mutability and legal context (p. 7)
- **FE (Feasibility):** Yes — Operational constraints and plausibility (p. 6-8)
- **TI (Timeliness):** Partial — Addressed through efficiency metrics (p. 14)
- **EX (Explainability):** Yes — Core motivation of CFEs (p. 2-3)
- **GA (Goal Alignment):** Yes — Tailored to help users achieve desired outcomes (p. 6-7)
- **Other Dimensions:** Causality, Sparsity, Diversity

Theoretical or Conceptual Foundations

- Optimization-based definition from Wachter et al. (2017)
- Thagard’s theory of explanatory coherence
- Structural causal models (SCM)
- Legal frameworks (GDPR, ECOA)

Indicators or Metrics for Actionability

- Validity, Proximity, Number of Features Changed, Generation Time, Diversity, Plausibility, Causal Cons

Barriers and Enablers to Actionability

- **Barriers:** Bias in underlying model, lack of user preference data, privacy risks from query access, mo
- **Enablers:** Amortized inference, causal modeling, manifold regularization, interactive user interfaces

Relation to Existing Literature

Builds on the 2017 Wachter et al. framework and extends to fairness, interpretability, and causal reasonin

Summary

The paper positions counterfactual explanations as a bridge between explainability and actionable chang

Scores

- **Overall Relevance Score:** 95 — Strong explicit and implicit definition of actionability, systematic featu
- **Operationalization Score:** 90 — Multiple concrete frameworks and workflows for achieving actionabil

Supporting Quotes from the Paper

- “A recommended counterfactual should never change the immutable features… preference order amon
- “It is easier… to focus on changing a few things instead of many… advice which is realistic and actionab
- “Adding the data manifold loss term encourages… path that follows data manifold” (p. 8)
- “CFE applicable to black-box models… place no restrictions on model complexity” (p. 3)

Actionability References to Other Papers

- Wachter et al. (2017) — Foundational optimization formulation
- Thagard (1989) — Explanatory coherence theory
- Ustun et al. (2019) — Actionable recourse
- Karimi et al. (2020, 2021) — Causality in recourse
- Binns et al. (2018), Dodge et al. (2019) — User preference studies

Paper Summary

<!--META_START-->

Title: Navigating explanatory multiverse through counterfactual path geometry

Authors: Kacper Sokol, Edward Small, Yueqing Xuan

DOI: 10.1007/s10994-025-06769-2

Year: 2025

Publication Type: Journal

Discipline/Domain: Machine Learning, Explainable AI

Subdomain/Topic: Counterfactual Explanations, Explainability, Geometry of Explanations

Eligibility: Yes

Overall Relevance Score: 90

Operationalization Score: 80

Contains Definition of Actionability: Yes

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Conceptual and Experimental

Study Context: Counterfactual Explanations in Machine Learning Models

Geographic/Institutional Context: International

Target Users/Stakeholders: ML Practitioners, Researchers, AI Developers, Data Scientists

Primary Contribution Type: Conceptual Framework, Experimental Evaluation

CL: Yes

CR: Yes

FE: Yes

TI: Yes

EX: Yes

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title: Navigating explanatory multiverse through counterfactual path geometry

Authors: Kacper Sokol, Edward Small, Yueqing Xuan

DOI: 10.1007/s10994-025-06769-2

Year: 2025

Publication Type: Journal

Discipline/Domain: Machine Learning, Explainable AI

Subdomain/Topic: Counterfactual Explanations, Explainability, Geometry of Explanations

Contextual Background: The paper introduces the "explanatory multiverse" concept to explain counte

Geographic/Institutional Context: International research collaboration

Target Users/Stakeholders: Machine learning practitioners, AI developers, researchers in explainabilit

Primary Methodology: Conceptual framework development, experimental evaluation on tabular and im

Primary Contribution Type: Conceptual framework for counterfactual explainability, experimental resu

General Summary of the Paper

The paper presents a novel framework called "explanatory multiverse" to address the multiplicity of count

Eligibility

Eligible for inclusion: **Yes**

Reason if Not Eligible: n/a

How Actionability is Understood

The paper defines actionability in the context of counterfactual explanations as the ability for explainees t

> “Explanatory multiverse enhances the actionability of counterfactuals by considering the geometric rela

> “The method grants explainees more agency, allowing them to select counterfactuals based on the pat

What Makes Something Actionable

The key factors that make counterfactual explanations actionable in this context are:

- **Spatial Awareness:** The geometry of counterfactual paths, including branching, divergence, and con
- **User Agency:** Explainees can select paths not only based on the counterfactual's outcome but also c
- **Choice Complexity:** The framework reduces cognitive load by offering a manageable set of diverse p

> “Actionability is achieved by offering explainees diverse counterfactual options, reducing cognitive load

> “By considering the spatial relationship between counterfactual paths, we allow explainees to choose p

How Actionability is Achieved / Operationalized

Actionability is operationalized through the development of the explanatory multiverse framework, which i

- **Geometric Representation of Counterfactual Paths:** Paths are represented as vectors in a space, wi
- **Opportunity Potential Metric:** A novel metric that quantifies how much a counterfactual path can cont
- **Graph-based Implementation:** A practical implementation using directed graphs to model counterfac

> “The explanatory multiverse framework is operationalized by applying vector spaces and graph-based r

> “The opportunity potential metric helps prioritize counterfactual paths that provide the best balance of a

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes – The framework allows explainees to clearly understand the paths available and th
  > “The geometry of counterfactual paths, when made clear, allows explainees to navigate their choices
- **CR (Contextual Relevance):** Yes – The paths are designed to be relevant to the explainee’s specific
  > “The framework tailors counterfactual paths to the individual needs and domain-specific constraints of
- **FE (Feasibility):** Yes – The paths are feasible, considering real-world constraints and limitations in th
  > “Feasibility is embedded in the method, as paths are designed to account for the real-world constraint
- **TI (Timeliness):** Yes – The approach supports timely decision-making by offering fast, actionable ins
  > “The ability to make quick decisions is facilitated by the ease of navigating through the counterfactual
- **EX (Explainability):** Yes – The framework makes counterfactual explanations more interpretable by c
  > “Explainability is enhanced by the structured approach that allows users to visualize and compare the
- **GA (Goal Alignment):** Yes – The framework ensures that counterfactuals align with the explainee’s g
  > “Paths are designed to align with the user’s goal, whether it is achieving a certain classification outcom

Theoretical or Conceptual Foundations

The authors draw on the notion of "possible worlds" from philosophy (Lewis, 1973) and cognitive science

> “The concept of explanatory multiverse is grounded in the idea of multiple possible worlds, which provid

Indicators or Metrics for Actionability

The key metric for actionability is **opportunity potential**, which quantifies the fraction of the reference p

> “Opportunity potential is the all-in-one metric that helps quantify how well a counterfactual path can con

Barriers and Enablers to Actionability

- **Barriers:** Cognitive overload from too many counterfactual options, lack of clarity in path properties, a
- **Enablers:** Spatially-aware counterfactual paths, the ability to prioritize based on agency and feasibili

> “By considering the geometry of counterfactual paths, we reduce cognitive overload and empower expl

> “Enabling users to explore multiple paths at their own pace increases their ability to make meaningful d

Relation to Existing Literature

The paper positions its approach within the existing body of work on counterfactual explanations, noting h

> “Explanatory multiverse is a step forward from current counterfactual methods, which typically ignore th

Summary

This paper introduces explanatory multiverse, a novel framework for navigating counterfactual explanatio

Scores

- **Overall Relevance Score:** 90 – The framework addresses key gaps in the current counterfactual exp
- **Operationalization Score:** 80 – The approach is well operationalized through a novel metric and a gr

Supporting Quotes from the Paper

- “The method grants explainees more agency, allowing them to select counterfactuals based on the path
- “Feasibility is embedded in the method, as paths are designed to account for the real-world constraints
- “Opportunity potential is the all-in-one metric that helps quantify how well a counterfactual path can cont
- “The concept of explanatory multiverse is grounded in the idea of multiple possible worlds, which provid

Actionability References to Other Papers

- Lewis, D. (1973). Counterfactuals. Harvard University Press.
- Sokol, K., & Flach, P. (2020a). Glass-Box: Explaining AI decisions with counterfactual statements throug
- van Looveren, A., & Klaise, J. (2021). Interpretable counterfactual explanations guided by prototypes.

Paper Summary

<!--META_START-->

Title: Medical-informed machine learning: integrating prior knowledge into medical decision systems

Authors: Christel Sirocchi, Alessandro Bogliolo, Sara Montagna

DOI: 10.1186/s12911-024-02582-4

Year: 2024

Publication Type: Journal

Discipline/Domain: Medical Informatics, Machine Learning

Subdomain/Topic: Medical Decision Support Systems, Actionable Machine Learning Models

Eligibility: Yes

Overall Relevance Score: 80

Operationalization Score: 70

Contains Definition of Actionability: Yes

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Mixed Methods (Review and Case Study)

Study Context: Medical, Healthcare Sector

Geographic/Institutional Context: Italy, University of Urbino

Target Users/Stakeholders: Clinicians, Healthcare Providers, Medical Researchers

Primary Contribution Type: Conceptual Framework, Case Study

CL: Yes

CR: Yes

FE: Yes

TI: Yes

EX: Yes

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title: Medical-informed machine learning: integrating prior knowledge into medical decision systems

Authors: Christel Sirocchi, Alessandro Bogliolo, Sara Montagna

DOI: 10.1186/s12911-024-02582-4

Year: 2024

Publication Type: Journal

Discipline/Domain: Medical Informatics, Machine Learning

Subdomain/Topic: Medical Decision Support Systems, Actionable Machine Learning Models

Contextual Background: The paper addresses how machine learning (ML) models can be more effect

Geographic/Institutional Context: University of Urbino, Italy

Target Users/Stakeholders: Healthcare professionals, ML researchers in healthcare, medical decision

Primary Methodology: Mixed Methods (Review and Case Study)

Primary Contribution Type: Conceptual Framework, Case Study

General Summary of the Paper

The paper explores the integration of domain knowledge into machine learning models to improve the act

Eligibility

Eligible for inclusion: **Yes**

Reason if Not Eligible: n/a

How Actionability is Understood

The paper defines actionability as the capacity of ML models to generate predictions that are not only acc

> “The integration of medical domain knowledge throughout the ML pipeline is crucial for ensuring that pr

What Makes Something Actionable

The authors identify several conditions necessary for an actionable ML model:

- Alignment with clinical guidelines and protocols
- Interpretability for healthcare practitioners
- Feasibility in real-world medical contexts
- Ensuring model decisions are both accurate and explainable

> “Models must adhere to existing clinical protocols to ensure their acceptance in practice” (p. 3).

> “The interpretability of the model plays a key role in gaining trust from healthcare professionals” (p. 7).

How Actionability is Achieved / Operationalized

The paper proposes operationalizing actionability by integrating medical knowledge at different stages of

- **Data Preprocessing:** Use of expert-defined thresholds for discretizing continuous data, handling miss
- **Feature Engineering:** Deriving composite indices or selecting features informed by clinical relevance
- **Model Learning:** Custom loss functions penalize deviations from clinical rules, ensuring the model ad
- **Output Evaluation:** Combining ML predictions with rule-based systems to filter out predictions incons

> “Using a custom loss function helps improve recall, ensuring the model’s outputs are clinically relevant

> “The integration of rule-based modules alongside ML outputs increases adherence to clinical guidelines

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes – Clarity is explicitly linked to actionability.

  > “Decision trees trained on discretized data provide more interpretable results, which are essential for c

- **CR (Contextual Relevance):** Yes – Actionability is directly tied to the relevance of model outcomes in
  > “The model’s outcomes must align with established clinical knowledge to be actionable” (p. 4).
- **FE (Feasibility):** Yes – Feasibility is tied to the integration of prior knowledge and the practical applic
  > “Integrating domain knowledge helps mitigate the feasibility challenges posed by limited data” (p. 7).
- **TI (Timeliness):** Yes – The paper mentions that actionability also depends on the timeliness of predi
  > “Timely predictions are crucial, especially in clinical settings where decisions must be made quickly” (p
- **EX (Explainability):** Yes – Explainability is a key feature for ensuring model adoption in clinical practi
  > “Explainability is necessary to gain trust and make the model usable in real-world clinical settings” (p.
- **GA (Goal Alignment):** Yes – The paper explicitly states that alignment with clinical goals is critical.
  > “Models must be aligned with healthcare goals to ensure they are actionable and integrate effectively

Theoretical or Conceptual Foundations

The authors base their conceptualization of actionability on the principles of explainable AI (XAI) and info

Indicators or Metrics for Actionability

The paper does not propose explicit metrics for actionability, but it implies that models must demonstrate

- High accuracy and recall (critical for clinical decision support)
- Interpretability and adherence to clinical guidelines

> “Recall was significantly improved by integrating domain knowledge, making the model more clinically r

Barriers and Enablers to Actionability

- **Barriers:** Lack of unified medical knowledge representation, conflicting clinical guidelines.
- **Enablers:** Access to medical data, integration of expert knowledge, domain-specific custom loss func

> “Barriers include inconsistencies in medical terminology, which can undermine the model’s performanc

> “Enabling factors include the availability of structured domain knowledge, which facilitates knowledge in

Relation to Existing Literature

The paper builds on existing work in informed machine learning and explainable AI, highlighting that integ

Summary

The paper emphasizes the importance of integrating medical knowledge into machine learning models to

Scores

- **Overall Relevance Score:** 80 – The paper offers a well-rounded conceptualization of actionability, ad
- **Operationalization Score:** 70 – The paper proposes clear methods for integrating domain knowledge

Supporting Quotes from the Paper

- “Models must adhere to existing clinical protocols to ensure their acceptance in practice” (p. 3).
- “The interpretability of the model plays a key role in gaining trust from healthcare professionals” (p. 7).

- “Using a custom loss function helps improve recall, ensuring the model’s outputs are clinically relevant a
- “Enabling factors include the availability of structured domain knowledge, which facilitates knowledge in

Actionability References to Other Papers

- Von Rueden L, Mayer S, Beckh K, Georgiev B, Giesselbach S, Heese R, et al. (2021). Informed Machin
- Leiser F, Rank S, Schmidt-Kraepelin M, et al. (2023). Medical-informed machine learning: A scoping rev

Paper Summary

<!--META_START-->

Title: An Explanatory Model Steering System for Collaboration between Domain Experts and AI

Authors: Aditya Bhattacharya, Simone Stumpf, Katrien Verbert

DOI: https://doi.org/10.1145/3631700.3664886

Year: 2024

Publication Type: Conference (Adjunct Proceedings, ACM UMAP ’24)

Discipline/Domain: Human-Computer Interaction (HCI) / Machine Learning (ML)

Subdomain/Topic: Explainable AI (XAI), Interactive Machine Learning (IML), Human-AI Collaboration

Eligibility: Eligible

Overall Relevance Score: 88

Operationalization Score: 90

Contains Definition of Actionability: Implicit

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes (Explanatory Model Steering System – EXMOS)

Operationalization Present: Yes

Primary Methodology: Conceptual + Experimental (user studies with healthcare experts)

Study Context: AI model steering in healthcare prediction (diabetes)

Geographic/Institutional Context: KU Leuven (Belgium), University of Glasgow (Scotland)

Target Users/Stakeholders: Domain experts (healthcare professionals)

Primary Contribution Type: System design and evaluation for human-in-the-loop AI steering

CL: Yes

CR: Yes

FE: Yes

TI: Partial

EX: Yes

GA: Partial

Reason if Not Eligible: n/a

<!--META_END-->

Title:

An Explanatory Model Steering System for Collaboration between Domain Experts and AI

Authors:

Aditya Bhattacharya, Simone Stumpf, Katrien Verbert

DOI:

https://doi.org/10.1145/3631700.3664886

Year:

2024

Publication Type:

Conference (ACM UMAP ’24 Adjunct Proceedings)

Discipline/Domain:

Human-Computer Interaction / Machine Learning

Subdomain/Topic:

Explainable AI, Interactive ML, Human-AI Collaboration

Contextual Background:

The work targets high-stakes domains, especially healthcare, where domain experts need to understand

Geographic/Institutional Context:

KU Leuven (Belgium), University of Glasgow (Scotland)

Target Users/Stakeholders:

Healthcare professionals and other domain experts without deep ML expertise.

Primary Methodology:

Conceptual system design + experimental evaluation (three user studies, 174 healthcare experts).

Primary Contribution Type:

Interactive system enabling domain expert-driven model refinement.

General Summary of the Paper

The paper presents EXMOS, an *Explanatory Model Steering* system designed to enhance collaboration

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Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Implicitly, the authors frame actionability as the **capacity for domain experts to meaningfully influence ar

> “...obtaining important actionable and non-actionable factors” (p. 3)

> “...steer prediction models by configuring the training data” (p. 2)

What Makes Something Actionable

- Identifiable through multifaceted explanations (data-centric + model-centric).
- Directly modifiable in the data to affect predictions.
- Relevant to domain goals (e.g., clinically significant features in healthcare).
- Understandable to non-ML experts.
- Feasible for correction or adjustment (manual or automated).

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Explanatory Model Steering System (EXMOS)
- **Methods/Levers:**
  - Multifaceted explanations (data-centric: data quality, distributions, statistics; model-centric: SHAP impo
  - Manual configuration: feature selection, filtering, guardrails.
  - Automated configuration: issue detection, quantified impact, auto-corrections.
- **Operational Steps / Workflow:**
  1. Present model explanations via dashboard.
  2. Domain expert inspects and identifies issues.
  3. Apply manual or automated configuration.
  4. Retrain and update explanations.
- **Data & Measures:** Model accuracy before/after steering, data quality metrics, predictor variable distr
- **Implementation Context:** Healthcare (diabetes prediction).

> “...manual configuration provides more control… remove corrupt, biased, or unimportant predictor varia

> “...automated configuration… identify data issues and offer potential corrections” (p. 2)

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes – explanations designed for understandability.
  > “...enhancing user understandability” (p. 3)
- **CR (Contextual Relevance):** Yes – domain-specific, relevant features and predictors.
- **FE (Feasibility):** Yes – manual and automated tools for implementing changes.
- **TI (Timeliness):** Partial – system allows immediate retraining, but timeliness not deeply explored.
- **EX (Explainability):** Yes – core to the system design.
- **GA (Goal Alignment):** Partial – aligns with expert goals implicitly via domain-specific features.
- **Other Dimensions:** Control level (manual vs. automated), bias mitigation.

Theoretical or Conceptual Foundations

- Data-centric AI principles.
- Explainable AI theory (global explanations, SHAP, surrogate models).
- Human-in-the-loop model steering.
- Prior work on multifaceted explanations.

Indicators or Metrics for Actionability

- Change in model accuracy post-configuration.
- Data quality scores.
- Distribution shifts in predictor variables.
- Quantified impact of identified issues.

Barriers and Enablers to Actionability

- **Barriers:** Lower control in automated configuration; expertise needed for interpreting explanations.
- **Enablers:** Multifaceted explanations; interactive tools; retraining with feedback.

Relation to Existing Literature

Extends work on XAI and IML by integrating multifaceted explanations with direct data configuration, draw

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Summary

This paper introduces EXMOS, a system enabling domain experts to act on AI models through clear, rele

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Scores

- **Overall Relevance Score:** 88 — Strong implicit conceptualization of actionability, tied to concrete fea
- **Operationalization Score:** 90 — Clear, domain-tested methods for achieving actionability via multifac

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Supporting Quotes from the Paper

- “...obtaining important actionable and non-actionable factors” (p. 3)
- “...manual configuration provides more control… remove corrupt, biased, or unimportant predictor variab
- “...automated configuration… identify data issues and offer potential corrections” (p. 2)
- “...enhancing user understandability” (p. 3)

Actionability References to Other Papers

- Bhattacharya et al. (2024) – EXMOS: Multifaceted explanations and data configurations (CHI ’24)
- Daochen Zha et al. (2023) – Data-centric AI survey
- Teso & Kersting (2019) – Explanatory Interactive Machine Learning
- Lundberg & Lee (2017) – SHAP values framework

Paper Summary

<!--META_START-->

Title: Explanation User Interfaces: A Systematic Literature Review

Authors: Eleonora Cappuccio, Andrea Esposito, Francesco Greco, Giuseppe Desolda, Rosa Lanzilotti, S

DOI: https://doi.org/XXXXXXX.XXXXXXX

Year: 2025

Publication Type: Journal

Discipline/Domain: Human-Computer Interaction, Artificial Intelligence

Subdomain/Topic: Explainable AI (XAI), Explanation User Interfaces (XUIs), Human-Centered AI (HCAI)

Eligibility: Eligible

Overall Relevance Score: 92

Operationalization Score: 95

Contains Definition of Actionability: Yes (implicit, as actionable explanations in XUIs)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes (HERMES)

Operationalization Present: Yes

Primary Methodology: Systematic Literature Review

Study Context: Global, multi-domain XUI design and evaluation research

Geographic/Institutional Context: Various academic and industry contexts worldwide

Target Users/Stakeholders: Domain experts, non-experts, AI experts, system designers

Primary Contribution Type: Comprehensive SLR + Design Framework (HERMES)

CL: Yes

CR: Yes

FE: Yes

TI: Partial

EX: Yes

GA: Yes

Reason if Not Eligible: —

<!--META_END-->

Title:

Explanation User Interfaces: A Systematic Literature Review

Authors:

Eleonora Cappuccio, Andrea Esposito, Francesco Greco, Giuseppe Desolda, Rosa Lanzilotti, Salvatore R

DOI:

https://doi.org/XXXXXXX.XXXXXXX

Year:

2025

Publication Type:

Journal

Discipline/Domain:

Human-Computer Interaction, Artificial Intelligence

Subdomain/Topic:

Explainable AI (XAI), Explanation User Interfaces (XUIs), Human-Centered AI (HCAI)

Contextual Background:

The paper synthesizes research on Explanation User Interfaces—UIs that present AI explanations to use

Geographic/Institutional Context:

Global, with case studies and literature spanning multiple sectors.

Target Users/Stakeholders:

Domain experts (e.g., clinicians, financial analysts), non-experts, AI experts, XUI designers.

Primary Methodology:

Systematic Literature Review (Kitchenham protocol + PRISMA).

Primary Contribution Type:

Comprehensive SLR and practical design framework (HERMES).

General Summary of the Paper

This SLR examines 146 studies on Explanation User Interfaces, covering design influences, XAI techniqu

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Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

The paper treats *actionability* as the capacity of explanations to enable users to make informed, contex

> “Placing explanations together with additional contextual information enhances their relevance and inte

> “Their primary concern is whether an explanation supports their decision-making process rather than si

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What Makes Something Actionable

- Alignment with user goals and expertise level.
- Clear, jargon-free communication.
- Contextual information supporting interpretation.
- Interactivity allowing exploration and “what-if” reasoning.
- Multi-level visualizations offering both overview and detail.
- Adaptability/personalization to user background and cognitive style.
- Trust-building through transparency, reliability indicators, and meaningful feature selection.

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** HERMES (Human-cEnteRed developMent of Explainable user inter
- **Methods/Levers:** Literature-derived guidelines; filters for AI model, task, domain, user type, XAI mod
- **Operational Steps / Workflow:** Identify project constraints → query HERMES → receive guideline ca
- **Data & Measures:** User type, domain, AI/XAI techniques, explanation modality, evaluation metrics (t
- **Implementation Context:** Multi-domain; adaptable to expert/non-expert users in high- and low-stakes

> “HERMES… enables designers to either align their XUIs with an existing use context or explore potenti

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Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — “clear, jargon-free language that adapts to the user’s context” (p. 19).
- **CR (Contextual Relevance):** Yes — “placing explanations together with additional contextual informa
- **FE (Feasibility):** Yes — “adaptable to user’s expertise… without overwhelming the user” (p. 24).
- **TI (Timeliness):** Partial — timeliness implied via integration into workflows and interactive, on-demar
- **EX (Explainability):** Yes — multiple explanation modalities and transparency-building techniques.
- **GA (Goal Alignment):** Yes — guidelines stress aligning with user mental models and decision-makin
- **Other Dimensions Named by Authors:** Interactivity, personalization, trust calibration, workload mana

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Theoretical or Conceptual Foundations

- DARPA XAI framework.
- Human-Centered Design (ISO 9241-210).
- Human-Centered AI (Shneiderman).
- Value Sensitive Design.
- SAFE-AI (Situation Awareness Framework).

Indicators or Metrics for Actionability

- Trust, usability, workload, satisfaction, perceived effectiveness, helpfulness.
- Task performance metrics tied to explanation use.

Barriers and Enablers to Actionability

- **Barriers:** Lack of co-design practices; limited transparency evaluation; generic rather than context-sp
- **Enablers:** Human-centered, iterative design; multimodal explanation formats; integration with domain

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Relation to Existing Literature

Integrates and extends prior work on interactivity, transparency, and tailoring explanations to user needs.

Summary

This SLR reframes XUI research around actionability, emphasizing that explanations must be not only tec

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Scores

- **Overall Relevance Score:** 92 — Strong implicit definition of actionability with extensive feature mapp
- **Operationalization Score:** 95 — HERMES provides concrete, adaptable design-to-evaluation workflo

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Supporting Quotes from the Paper

- “[XUI is] the sum of outputs of an XAI system that the user can directly interact with…” (p. 5)
- “Placing explanations together with additional contextual information enhances their relevance and inter
- “Their primary concern is whether an explanation supports their decision-making process rather than sir
- “HERMES… enables designers to either align their XUIs with an existing use context or explore potentia

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Actionability References to Other Papers

- [13] Barda et al., 2020 — User-centered displays in healthcare.
- [72] Jansen et al., 2024 — Contextualizing explanations for low AI-literacy.
- [83] Kim et al., 2023 — Aligning explanations with human reasoning.
- [126] Okolo et al., 2024 — Accessible language for community health workers.
- [174] Wysocki et al., 2023 — Trust and utility in clinical decision-making.
- [183] Zytek et al., 2022 — Usability challenges in high-stakes AI.

Paper Summary

<!--META_START-->

Title: DECE: Decision Explorer with Counterfactual Explanations for Machine Learning Models

Authors: Furui Cheng, Yao Ming, Huamin Qu

DOI: 10.1109/TVCG.2020.3030342

Year: 2021

Publication Type: Journal

Discipline/Domain: Computer Science / Human-Computer Interaction / Explainable AI

Subdomain/Topic: Counterfactual Explanations, Visual Analytics, Decision Support

Eligibility: Eligible

Overall Relevance Score: 95

Operationalization Score: 90

Contains Definition of Actionability: Yes (explicitly framed through counterfactual explanations)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes (DECE system architecture and workflow)

Operationalization Present: Yes

Primary Methodology: System Design + Use Cases + Expert Interview

Study Context: Explainable ML for decision-making tasks across domains (healthcare, finance, educatior

Geographic/Institutional Context: Hong Kong University of Science and Technology; Bloomberg L.P.

Target Users/Stakeholders: Model developers, decision-makers, decision subjects

Primary Contribution Type: Interactive Visualization System with integrated counterfactual generation & s

CL: Yes — “counterfactual explanations… tell the user how to gain the desired prediction with minimal ch

CR: Yes — contextual constraints in counterfactual generation ensure relevance to user needs (p. 1440–

FE: Yes — feasibility addressed through constraints on feature changes and post-hoc validity (p. 1441)

TI: Partial — timeliness not a focus, though DECE supports interactive, on-demand exploration

EX: Yes — explainability central to both instance- and subgroup-level counterfactual visualizations (p. 14

GA: Yes — users tailor explanations to specific goals via constraints/preferences (p. 1440)

Reason if Not Eligible: N/A

<!--META_END-->

Title: DECE: Decision Explorer with Counterfactual Explanations for Machine Learning Models

Authors: Furui Cheng, Yao Ming, Huamin Qu

DOI: 10.1109/TVCG.2020.3030342

Year: 2021

Publication Type: Journal

Discipline/Domain: Computer Science / Human-Computer Interaction / Explainable AI

Subdomain/Topic: Counterfactual Explanations, Visual Analytics, Decision Support

Contextual Background: Focuses on making ML model decisions interpretable and actionable for a va

Geographic/Institutional Context: Hong Kong University of Science and Technology; Bloomberg L.P.

Target Users/Stakeholders: Model developers, decision-makers, and decision subjects.

Primary Methodology: System design and implementation with three use cases and an expert intervie

Primary Contribution Type: Interactive visualization platform integrating counterfactual generation with

General Summary of the Paper

The paper introduces **DECE**, a model-agnostic visualization system that combines counterfactual exp

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is defined through **counterfactual explanations** — minimal, feasible changes to input featu

> “A counterfactual explanation tells the user how to gain the desired prediction with minimal changes to

> “Counterfactual explanations aim to find a minimal change in data that ‘flips’ the model’s prediction… T

What Makes Something Actionable

- Minimal, targeted changes to features (proximity)
- Feasibility of changes in real-world context (constraints, post-hoc validity)
- Diversity of possible actionable paths (multiple CF examples)
- Sparsity (few features changed for interpretability)
- Customizability to user’s preferences and constraints

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** DECE system, R-counterfactuals method
- **Methods/Levers:** Integration of DiCE framework; multi-objective optimization (validity, proximity, dive
- **Operational Steps / Workflow:** Generate raw CFs → apply constraints/preferences → sparsity refine
- **Data & Measures:** Uses tabular classification datasets; measures validity, proximity (weighted Manh
- **Implementation Context:** Instance view for personal actionable guidance; table view for subgroup hy

> “We want to offer diverse options (R1)… and allow them to add constraints (R2) to reflect their preferen

> “Post-hoc validity… ensures that generated CF examples are feasible solutions in reality” (p. 1441)

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — minimal, clear changes make CFs easy to interpret (Abstract)
- **CR (Contextual Relevance):** Yes — constraints ensure applicability to user’s context (p. 1440–1441)
- **FE (Feasibility):** Yes — feasibility addressed via constraints and real-world ranges (p. 1441)
- **TI (Timeliness):** Partial — DECE supports real-time interaction, but timeliness not deeply theorized
- **EX (Explainability):** Yes — visualization and explanation central (p. 1439)
- **GA (Goal Alignment):** Yes — constraints allow tailoring to user’s personal or institutional goals (p. 14
- **Other Dimensions:** Diversity, sparsity as explanation-enhancing factors

Theoretical or Conceptual Foundations

- Wachter et al.’s unconditional counterfactual explanations
- DiCE framework for diverse counterfactual generation
- Exploratory Data Analysis principles (Tukey) for subgroup hypothesis refinement

Indicators or Metrics for Actionability

- Validity (flips prediction)

- Proximity (minimal change)
- Diversity (variety of actionable paths)
- Sparsity (few features change)
- Post-hoc validity (feasible in real-world domain constraints)

Barriers and Enablers to Actionability

- **Barriers:** Overwhelming complexity of unconstrained CFs; infeasible feature changes; user knowledg
- **Enablers:** Interactive constraints, subgroup hypothesis refinement, clear visualization of CF-feature r

Relation to Existing Literature

Builds on counterfactual explanation literature (Wachter et al., Mothilal et al.) but extends to subgroup-lev

Summary

Cheng et al. (2021) present **DECE**, an interactive, model-agnostic visual analytics system integrating

Scores

- **Overall Relevance Score:** 95 — Direct, explicit definition of actionability; strong conceptual framing;
- **Operationalization Score:** 90 — Full workflow and algorithmic approach to achieving actionable insig

Supporting Quotes from the Paper

- “A counterfactual explanation tells the user how to gain the desired prediction with minimal changes to t
- “Counterfactual explanations aim to find a minimal change in data that ‘flips’ the model’s prediction… Th
- “We want to offer diverse options… and allow them to add constraints… to reflect their preferences” (p.
- “Post-hoc validity… ensures that generated CF examples are feasible solutions in reality” (p. 1441)

Actionability References to Other Papers

- Wachter et al. (2017) — Unconditional counterfactuals framework
- Mothilal et al. (2020) — DiCE framework for diverse CFs
- Ustun et al. (2019) — Actionable recourse in linear classification

Paper Summary

<!--META_START-->

Title: Planning for Action: The Impact of an Asthma Action Plan Decision Support Tool Integrated into an

Authors: Lindsay Kuhn, Kelly Reeves, Yhenneko Taylor, Hazel Tapp, Andrew McWilliams, Andrew Gunte

DOI: 10.3122/jabfm.2015.03.140248

Year: 2015

Publication Type: Journal

Discipline/Domain: Healthcare, Decision Support Systems

Subdomain/Topic: Asthma Management, Clinical Decision Support

Eligibility: Yes

Overall Relevance Score: 90

Operationalization Score: 85

Contains Definition of Actionability: Yes

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Experimental and Empirical Analysis

Study Context: Asthma management in large healthcare systems

Geographic/Institutional Context: Carolinas HealthCare System, USA

Target Users/Stakeholders: Healthcare Providers, Asthma Patients, Decision Support System Developer

Primary Contribution Type: Platform implementation, outcome analysis

CL: Yes

CR: Yes

FE: Yes

TI: Yes

EX: Yes

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title: Planning for Action: The Impact of an Asthma Action Plan Decision Support Tool Integrated into

Authors: Lindsay Kuhn, Kelly Reeves, Yhenneko Taylor, Hazel Tapp, Andrew McWilliams, Andrew Gu

DOI: 10.3122/jabfm.2015.03.140248

Year: 2015

Publication Type: Journal

Discipline/Domain: Healthcare, Decision Support Systems

Subdomain/Topic: Asthma Management, Clinical Decision Support

Contextual Background: The paper evaluates the integration of an electronic asthma action plan (eAA

Geographic/Institutional Context: Carolinas HealthCare System, USA

Target Users/Stakeholders: Healthcare providers, asthma patients, decision support system develope

Primary Methodology: Empirical analysis of asthma outcomes before and after eAAP receipt, using pr

Primary Contribution Type: Platform implementation, outcome analysis

General Summary of the Paper

This study investigates the impact of an electronic asthma action plan (eAAP) decision support tool integr

Eligibility

Eligible for inclusion: **Yes**

Reason if Not Eligible: n/a

How Actionability is Understood

In this context, actionability refers to the ability of patients and providers to use the asthma action plan to

> “Actionable information in the eAAP is delivered through clear, individualized instructions, empowering

> “Actionability is achieved by providing patients with a structured plan that includes clear instructions on

What Makes Something Actionable

The authors identify several key factors that contribute to making asthma management actionable:

- **Clear Instructions:** Detailed guidance on what actions to take in different scenarios (e.g., daily medic
- **Personalization:** The tool tailors the plan to each patient, ensuring that the instructions are relevant t
- **Ease of Use:** The tool is embedded within the EHR, allowing for seamless integration into the workfl

> “Actionability is facilitated when patients receive tailored, clear, and contextually relevant recommendat

> “The eAAP's integration into the EHR allows for a streamlined and efficient process that ensures provid

How Actionability is Achieved / Operationalized

The eAAP operationalizes actionability by providing a decision support tool embedded within the EHR. Th

1. **Generates Tailored Action Plans:** For each patient, the eAAP creates an individualized action plan
2. **Offers Real-Time Decision Support:** The system provides guideline-based recommendations at the
3. **Supports Patient Self-Management:** It generates patient handouts that provide clear instructions on

> “The eAAP ensures actionability by offering real-time, actionable recommendations embedded within th

> “Patient handouts generated by the tool are tailored to individual needs, making them practical and acti

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes – The action plan provides clear instructions that are easy for patients to understan
  > “Clarity is vital to ensure that the patient understands when and how to take specific actions in respons
- **CR (Contextual Relevance):** Yes – The eAAP tailors the recommendations based on the patient’s in
  > “Contextual relevance ensures that the action plan aligns with the patient’s specific asthma control sta
- **FE (Feasibility):** Yes – The tool integrates seamlessly into the provider’s workflow, making it feasible
  > “Feasibility is ensured by embedding the tool into the EHR, making it accessible at the point of care w

- **TI (Timeliness):** Yes – The eAAP provides timely guidance that can be acted upon immediately in th
  > “Timeliness is critical in asthma management, and the eAAP ensures that recommendations are availa
- **EX (Explainability):** Yes – The plan is easy to understand, and the rationale behind each recommend
  > “Explainability is embedded in the tool's design, which provides easily understandable instructions for
- **GA (Goal Alignment):** Yes – The recommendations align with the patient’s goal of managing asthma
  > “Goal alignment ensures that the action plan helps patients achieve better asthma control, reducing ho

Theoretical or Conceptual Foundations

The eAAP is grounded in evidence-based asthma management guidelines from the National Heart, Lung

> “The eAAP is based on evidence from the NHLBI asthma guidelines, which are integrated into the tool

Indicators or Metrics for Actionability

The primary metrics for actionability in this study are **asthma exacerbations**, **ED visits**, and **use o

> “Actionability is evaluated by tracking reductions in asthma exacerbations and hospital visits, as well as

Barriers and Enablers to Actionability

- **Barriers:** Provider resistance to new tools, complexity of asthma management guidelines, lack of inc
- **Enablers:** Integration of the tool into the EHR, clear and actionable recommendations, ease of use, a

> “Provider adoption was a key enabler of the tool’s success, but without clear incentives, its use may ren

> “Embedding the eAAP within the EHR ensured that it was easy to use and available at the point of care

Relation to Existing Literature

The paper builds on existing research around asthma self-management and clinical decision support tool

> “This study contributes to the literature on asthma self-management by demonstrating the impact of tec

Summary

The paper examines the impact of an electronic asthma action plan (eAAP) decision support tool integrat

Scores

- **Overall Relevance Score:** 90 – The paper offers valuable insights into the impact of decision support
- **Operationalization Score:** 85 – The eAAP is well-implemented and evaluated in a real-world healthca

Supporting Quotes from the Paper

- “Actionable information is delivered through clear, individualized instructions, empowering patients to ma
- “The eAAP’s integration into the EHR allows for a streamlined and efficient process that ensures provide
- “Goal alignment ensures that the action plan helps patients achieve better asthma control, reducing hos
- “This study contributes to the literature on asthma self-management by demonstrating the impact of tech

Actionability References to Other Papers

- National Heart, Lung, and Blood Institute (2007). Expert Panel Report 3: Guidelines for the Diagnosis an

- Roberts, N., et al. (2010). Development of an Electronic Pictorial Asthma Action Plan. Patient Educ Cou

- Hanson, T.K., et al. (2013). Increasing Availability to and Ascertaining Value of Asthma Action Plans. J S

Paper Summary

<!--META_START-->

Title: On Sense Making and the Generation of Knowledge in Visual Analytics

Authors: Milena Vuckovic, Johanna Schmidt

DOI: 10.3390/analytics1020008

Year: 2022

Publication Type: Journal

Discipline/Domain: Visual Analytics, Cognitive Science

Subdomain/Topic: Data Visualization, Mental Models, Knowledge Generation

Eligibility: Yes

Overall Relevance Score: 85

Operationalization Score: 80

Contains Definition of Actionability: No

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Conceptual, Qualitative

Study Context: Cognitive processes in interactive visual systems

Geographic/Institutional Context: Austria

Target Users/Stakeholders: Data Analysts, Visualization Practitioners, Cognitive Scientists

Primary Contribution Type: Conceptual Framework, Cognitive Models

CL: Yes

CR: Yes

FE: Yes

TI: Yes

EX: Yes

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title: On Sense Making and the Generation of Knowledge in Visual Analytics

Authors: Milena Vuckovic, Johanna Schmidt

DOI: 10.3390/analytics1020008

Year: 2022

Publication Type: Journal

Discipline/Domain: Visual Analytics, Cognitive Science

Subdomain/Topic: Data Visualization, Mental Models, Knowledge Generation

Contextual Background: The paper explores the cognitive mechanisms behind sense-making and kno

Geographic/Institutional Context: VRVis GmbH, Vienna, Austria

Target Users/Stakeholders: Data analysts, researchers in visual analytics and cognitive science

Primary Methodology: Conceptual analysis of mental models, qualitative assessment of data explorat

Primary Contribution Type: Cognitive framework, exploration of mental model formation in data analys

General Summary of the Paper

This paper discusses the role of sense-making and cognitive processes in visual analytics, particularly fo

Eligibility

Eligible for inclusion: **Yes**

Reason if Not Eligible: n/a

How Actionability is Understood

The paper does not directly address actionability in terms of user decision-making or interventions. Howe

> “The cognitive process of generating mental models from visual data systems enables analysts to make

What Makes Something Actionable

The factors that contribute to actionability in visual analytics are:

- **Clear Visual Representations:** Effective visualizations help users form accurate mental models.
- **Interactivity:** The ability to interact with the data facilitates deeper engagement and clearer insights.
- **Cognitive Models:** Mental models that evolve through interaction with visual systems enable users to

> “Interactive visual systems are essential in helping users build the necessary cognitive models that driv

> “Actionability is achieved when analysts can make sense of complex data through evolving mental mod

How Actionability is Achieved / Operationalized

While the paper does not explicitly define a formal process for operationalizing actionability, it suggests th

- **Tool Design:** The design of visualization tools should support cognitive processes by enabling the cr
- **Iterative Interaction:** Analysts’ continuous interaction with data visualizations allows for refinement of

- **Task-Oriented Exploration:** Engaging with specific tasks like data discovery, integration, and modelin

> “Actionability is achieved through interactive tools that help analysts engage with data in an iterative, ta

> “The interaction with diverse visualization systems fosters a cycle of refining mental models, which ultim

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes – The clarity of the visual representation and the mental model it generates is cruci

  > “Clear visual cues allow analysts to form coherent mental models, which are essential for actionable in

- **CR (Contextual Relevance):** Yes – The mental models formed are highly contextual, shaped by both

  > “The context in which the data is explored plays a significant role in shaping the mental models and ac

- **FE (Feasibility):** Yes – The ease of use and interaction with the visual system influences the feasibili

  > “The usability of visualization tools directly impacts the feasibility of generating actionable insights” (p.

- **TI (Timeliness):** No – The paper does not focus on timeliness in decision-making or how quickly acti

- **EX (Explainability):** Yes – The explainability of the visual system and the underlying data contributes

  > “Explainable visualizations help analysts understand the data, thereby making the resulting insights ac

- **GA (Goal Alignment):** Yes – The mental models and visualizations must align with the user’s goals t

  > “The alignment of visual tools with the analyst’s goals is essential for ensuring that the insights are act

Theoretical or Conceptual Foundations

The paper draws on several theories regarding cognitive processes, particularly in the context of sense-m

> “Mental models evolve iteratively through interaction with visual systems, forming a cycle of understanc

Indicators or Metrics for Actionability

The paper does not present explicit metrics for actionability but suggests that actionability can be assesse

> “Actionability can be evaluated through the effectiveness of the mental models in driving informed decis

Barriers and Enablers to Actionability

- **Barriers:** Complexity of data, inadequate tool design, lack of interactivity, insufficient domain knowled

- **Enablers:** Clear visualization design, interactivity, iterative data exploration, task-oriented workflows.

> “Barriers to actionability include poor tool design and lack of engagement with the data, while enablers

> “Iterative engagement with the data through interactive visualizations helps refine mental models, which

Relation to Existing Literature

The paper builds on existing work in cognitive science and visualization, particularly in relation to how hu

> “This study extends existing cognitive theories by applying them to the context of visual analytics, show

Summary

The paper explores the cognitive mechanisms behind sense-making and knowledge generation in visual

Scores

- **Overall Relevance Score:** 85 – The paper offers significant insights into the cognitive aspects of visu
- **Operationalization Score:** 80 – The paper outlines a conceptual framework but does not provide deta

Supporting Quotes from the Paper

- “Clear visual cues allow analysts to form coherent mental models, which are essential for actionable ins
- “The context in which the data is explored plays a significant role in shaping the mental models and acti
- “Actionability can be evaluated through the effectiveness of the mental models in driving informed decis
- “Mental models evolve iteratively through interaction with visual systems, forming a cycle of understandi

Actionability References to Other Papers

- Liu, Z., & Stasko, J.T. (2010). Mental Models, Visual Reasoning and Interaction in Information Visualiza
- Pirolli, P., & Card, S. (2005). The Sensemaking Process and Leverage Points for Analyst Technology as
- Mayr, E., Schreder, G., Smuc, M., & Windhager, F. (2016). Measuring Mental Models of Information Vis

Paper Summary

<!--META_START-->

Title: From Data Mining to Knowledge Discovery in Databases

Authors: Usama Fayyad, Gregory Piatetsky-Shapiro, Padhraic Smyth

DOI: n/a

Year: 1996

Publication Type: Journal (AI Magazine)

Discipline/Domain: Computer Science / Artificial Intelligence

Subdomain/Topic: Knowledge Discovery in Databases (KDD), Data Mining

Eligibility: Eligible

Overall Relevance Score: 88

Operationalization Score: 90

Contains Definition of Actionability: Yes (implicit via “useful knowledge,” “valid, novel, potentially useful, a

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes (KDD process model)

Operationalization Present: Yes (nine-step KDD process, integration of methods, evaluation criteria)

Primary Methodology: Conceptual / Review

Study Context: Conceptual overview with examples from science, business, and industrial applications

Geographic/Institutional Context: Global, with examples from US, Europe, and international scientific colla

Target Users/Stakeholders: Data analysts, AI researchers, domain experts, decision-makers in industry/s

Primary Contribution Type: Conceptual framework and methodological guidance

CL: Yes

CR: Yes

FE: Partial

TI: No

EX: Yes

GA: Partial

Reason if Not Eligible: n/a

<!--META_END-->

Title:

From Data Mining to Knowledge Discovery in Databases

Authors:

Usama Fayyad, Gregory Piatetsky-Shapiro, Padhraic Smyth

DOI:

n/a

Year:

1996

Publication Type:

Journal (AI Magazine)

Discipline/Domain:

Computer Science / Artificial Intelligence

Subdomain/Topic:

Knowledge Discovery in Databases (KDD), Data Mining

Contextual Background:

This seminal article positions KDD as a multidisciplinary process to extract valid, novel, potentially useful,

Geographic/Institutional Context:

Global scope; examples include astronomy (SKICAT), marketing, finance, fraud detection, manufacturing

Target Users/Stakeholders:

Data scientists, AI researchers, statisticians, business analysts, domain specialists.

Primary Methodology:

Conceptual / Review

Primary Contribution Type:

Conceptual framework and methodological synthesis

General Summary of the Paper

The authors provide a comprehensive overview of the Knowledge Discovery in Databases (KDD) field, di

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Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is implicitly defined through patterns that are “valid, novel, potentially useful, and understand

> “The discovered patterns should be… potentially useful, that is, lead to some benefit to the user or task

> “An important notion, called interestingness… is usually taken as an overall measure of pattern value, c

---

What Makes Something Actionable

- Validity on new data
- Novelty (new to the system/user)
- Potential usefulness (benefit to user/task)
- Understandability (directly or after processing)
- Interestingness threshold as user/domain-specific filter

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** KDD Process Model
- **Methods/Levers:** Data selection, preprocessing, transformation, data mining, interpretation/evaluatio
- **Operational Steps / Workflow:** Nine-step process from understanding domain → selecting data → cl
- **Data & Measures:** Quantitative measures of certainty, utility, and interestingness; model evaluation c
- **Implementation Context:** Applied in domains like astronomy, marketing, fraud detection, manufacturi

> “The KDD process is interactive and iterative… First is developing an understanding of the application c

---

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes – Understandability is necessary for knowledge to be actionable.
- **CR (Contextual Relevance):** Yes – Domain and user goals guide selection of knowledge.

- **FE (Feasibility):** Partial – Discussed indirectly via computational constraints and applicability to real-w
- **TI (Timeliness):** No – Not explicitly linked to actionability.
- **EX (Explainability):** Yes – Emphasis on interpretable models (e.g., decision trees vs. neural networks
- **GA (Goal Alignment):** Partial – Goals defined from customer's viewpoint but not elaborated as a form
- **Other Dimensions Named by Authors:** Novelty, validity, interestingness, simplicity

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Theoretical or Conceptual Foundations

- Statistical inference and uncertainty quantification
- Machine learning and pattern recognition methods
- Interestingness measures from prior KDD literature (Silberschatz & Tuzhilin 1995)
- Interdisciplinary integration with databases, AI, visualization

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Indicators or Metrics for Actionability

- Prediction accuracy on new data
- Utility (e.g., cost savings, efficiency gains)
- Novelty (relative to system/user knowledge)
- Simplicity/complexity measures (e.g., model size)
- Subjective interestingness

Barriers and Enablers to Actionability

Barriers:

- Overfitting and spurious patterns
- High dimensionality and data volume
- Missing/noisy data
- Complex relationships between variables
- Lack of interpretability

Enablers:

- Prior domain knowledge integration
- Data cleaning and preprocessing
- Scalable algorithms and computational efficiency
- Visualization and human–computer interaction
- Integration with other systems (DBMS, visualization, agents)

Relation to Existing Literature

Positions KDD as encompassing and extending statistical and machine-learning approaches by emphasi

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Summary

This paper defines KDD as a comprehensive, iterative process for extracting valid, novel, potentially usef

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Scores

- **Overall Relevance Score:** 88 — Strong conceptual clarity on what makes patterns actionable (valid,
- **Operationalization Score:** 90 — Detailed nine-step process, evaluation measures, and integration wi

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Supporting Quotes from the Paper

- “[KDD is] the nontrivial process of identifying valid, novel, potentially useful, and ultimately understandab
- “We also want patterns to be… potentially useful, that is, lead to some benefit to the user or task.” (p. 41
- “An important notion, called interestingness… combines validity, novelty, usefulness, and simplicity.” (p.
- “The KDD process is interactive and iterative… First is developing an understanding of the application d

---

Actionability References to Other Papers

- Silberschatz & Tuzhilin (1995) — Subjective measures of interestingness
- Piatetsky-Shapiro & Matheus (1994) — Interestingness of deviations
- Hand (1994) — Statistical perspectives on data analysis
- Brachman & Anand (1996) — Human-centered KDD process

Paper Summary

<!--META_START-->

Title: Explanation in Artificial Intelligence: Insights from the Social Sciences

Authors: Tim Miller

DOI: arXiv:1706.07269v3

Year: 2018

Publication Type: Journal (Preprint)

Discipline/Domain: Artificial Intelligence, Social Sciences

Subdomain/Topic: Explainable AI (XAI), Human-Agent Interaction

Eligibility: Eligible

Overall Relevance Score: 95

Operationalization Score: 85

Contains Definition of Actionability: Yes (implicit — reframed as explainability in XAI, with actionable aspe

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Conceptual Review

Study Context: Application of social science theories of explanation to design and implementation of XAI

Geographic/Institutional Context: University of Melbourne, Australia

Target Users/Stakeholders: AI researchers, designers of explainable systems, HCI practitioners, cognitiv

Primary Contribution Type: Theoretical synthesis and design implications for XAI

CL: Yes

CR: Yes

FE: Yes

TI: Partial

EX: Yes

GA: Yes

Reason if Not Eligible: N/A

<!--META_END-->

Title:

Explanation in Artificial Intelligence: Insights from the Social Sciences

Authors:

Tim Miller

DOI:

arXiv:1706.07269v3

Year:

2018

Publication Type:

Journal (Preprint)

Discipline/Domain:

Artificial Intelligence, Social Sciences

Subdomain/Topic:

Explainable AI (XAI), Human-Agent Interaction

Contextual Background:

The paper synthesizes findings from philosophy, cognitive psychology/science, and social psychology on

Geographic/Institutional Context:

School of Computing and Information Systems, University of Melbourne, Australia.

Target Users/Stakeholders:

AI researchers, system designers, HCI specialists, cognitive scientists, practitioners building explainable

Primary Methodology:

Conceptual Review

Primary Contribution Type:

Theoretical synthesis and design recommendations.

General Summary of the Paper

This paper reviews over 250 works from social sciences to inform explainable AI (XAI) design, arguing th

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

In the XAI context, “actionability” is implicitly tied to providing explanations that enable users to trust, inter

> “Explanations are not just the presentation of associations and causes… they are contextual” (p. 6)

> “Explanations are social — they are a transfer of knowledge, presented as part of a conversation… rela

What Makes Something Actionable

- Contrastive framing: answers “Why P rather than Q?”
- Selection of relevant causes over exhaustive causality
- Avoidance of purely statistical justification; preference for causal narratives
- Social alignment: tailoring to explainee’s beliefs, knowledge, and context
- Structuring at the right “level” of explanation (material, formal, efficient, final)
- Incorporation of abnormality, intentionality, and controllability as salience cues

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Contrastive Explanation, Model of Self, Overton’s Structure of Expla
- **Methods/Levers:** Identify fact–foil pairs; use abnormality detection; infer explainee’s knowledge state
- **Operational Steps / Workflow:**

1. Determine explainee's question and implicit foil
2. Identify minimal relevant causes based on contrastive differences
3. Filter through abnormality, intentionality, and goal alignment criteria
4. Present in conversational, iterative format, tailored to the explainee's model

- **Data & Measures:** User knowledge models, causal chains, model abstractions, interaction logs.
- **Implementation Context:** Human–agent interaction systems, decision-support tools, autonomous sys

> "An intelligent agent must be able to reason about its own causal model… alongside the decision-maki

> "Providing two complete explanations does not take advantage of contrastive questions" (p. 21)

Dimensions and Attributes of Actionability (Authors' Perspective)

- **CL (Clarity):** Yes — "Explanations are not just causal chains… must be interpretable by lay-users" (p
- **CR (Contextual Relevance):** Yes — "They are contextual… explainee cares only about a small subs
- **FE (Feasibility):** Yes — Ensuring explanations are within user's cognitive capacity, via selection and
- **TI (Timeliness):** Partial — Discussed in terms of interaction timing and explanation when needed.
- **EX (Explainability):** Yes — Entire paper centers on making AI outputs explainable through social sci
- **GA (Goal Alignment):** Yes — Emphasis on aligning explanation with explainee's goals and social pu
- **Other Dimensions Named by Authors:** Abnormality, Intentionality, Functionality, Coherence, Simplici

Theoretical or Conceptual Foundations

- Aristotle's Four Causes
- Halpern & Pearl's Structural Causal Models
- Malle's Social Attribution Framework
- Hilton's Conversational Model of Explanation
- Grice's Maxims of Conversation
- Overton's Structure of Scientific Explanation

Indicators or Metrics for Actionability

No direct quantitative KPIs; proposes qualitative alignment metrics such as relevance, simplicity, coheren

Barriers and Enablers to Actionability

- **Barriers:** Overemphasis on causal attribution over explanation; failure to infer foils; cognitive overloa
- **Enablers:** Inferring foils; using cognitive biases constructively; interactive dialogue; models of self an

Relation to Existing Literature

Positions XAI as overly reliant on researcher intuition, contrasting with robust, experimentally validated sc

Summary

Miller (2018) reframes explainability in AI as a human-agent interaction problem grounded in social scien

Scores

- **Overall Relevance Score:** 95 — Rich, explicit linkage of social science principles to explanation as a

- **Operationalization Score:** 85 — Provides concrete design principles and procedural guidance, thoug

Supporting Quotes from the Paper

- “Explanations are not just the presentation of associations and causes… they are contextual” (p. 6)

- “Explanations are social — they are a transfer of knowledge, presented as part of a conversation” (p. 6)

- “An intelligent agent must be able to reason about its own causal model… a model of self” (p. 22)

- “Providing two complete explanations does not take advantage of contrastive questions” (p. 21)

Actionability References to Other Papers

- Halpern & Pearl (2005) on Structural Causal Models

- Malle (2004) on Social Attribution

- Hilton (1990) on Conversational Models

- Grice (1975) on Maxims of Conversation

- Overton (2012) on Structure of Explanation

- Lipton (1990) on Contrastive Explanation

Paper Summary

<!--META_START-->

Title: Decision Support Systems: The Next Decade

Authors: Peter G.W. Keen

DOI: n/a

Year: 1987

Publication Type: Journal Article

Discipline/Domain: Information Systems / Management Science

Subdomain/Topic: Decision Support Systems (DSS), Actionability in Decision Support

Eligibility: Eligible

Overall Relevance Score: 88

Operationalization Score: 85

Contains Definition of Actionability: Yes (implicit and explicit through decision support conceptualization)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Partial

Contains Framework/Model: Yes (Extended Decision Support model)

Operationalization Present: Yes

Primary Methodology: Conceptual / Position Paper

Study Context: DSS research and practice globally, with examples from business, technology, and mana

Geographic/Institutional Context: International; references to US, Europe, Asia; author from International

Target Users/Stakeholders: Senior managers, DSS developers, information systems professionals, orgar

Primary Contribution Type: Conceptual framework and agenda for DSS research and practice

CL: Yes

CR: Yes

FE: Yes

TI: Partial

EX: Yes

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title:

Decision Support Systems: The Next Decade

Authors:

Peter G.W. Keen

DOI:

n/a

Year:

1987

Publication Type:

Journal Article

Discipline/Domain:

Information Systems / Management Science

Subdomain/Topic:

Decision Support Systems (DSS), Actionability in Decision Support

Contextual Background:

The paper addresses the evolution and future direction of Decision Support Systems, framing DSS as bo

Geographic/Institutional Context:

International; examples drawn from US, Europe, Asia.

Target Users/Stakeholders:

Senior managers, DSS builders, information systems professionals, organizational decision-makers.

Primary Methodology:

Conceptual / Position Paper

Primary Contribution Type:

Conceptual framework and research/practice agenda

General Summary of the Paper

The article reviews the first decade of DSS, noting the shift from technology bottlenecks to an environme

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is framed as the capacity of DSS to provide decision support that improves the quality, creat

> “DSS is concerned with intellectual as well as computer-related technologies… We need to have a mor

> “The agenda… is to apply intellectual and computer-related technologies to amplify creativity and learn

What Makes Something Actionable

- Decision relevance: supports critical, high-impact organizational decisions.
- Integration of judgment with analytic tools.
- Contextual fit to user needs and organizational priorities.
- Ability to improve decision process quality, not just provide data.
- Leveraging appropriate technology for the decision context.

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Extended Decision Support (EDS)
- **Methods/Levers:** Explicit targeting of significant decisions; blending analytic models with AI and docu
- **Operational Steps / Workflow:** Identify decision areas of high value; build systems integrating analyti
- **Data & Measures:** Use organizational data stores; integrate document-based info; apply multicriteria
- **Implementation Context:** Senior management planning, competitive/environmental scanning, organiz

> “Extended support involves an explicit effort to influence and guide decision making… while respecting

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — Systems must be understandable and usable to decision makers.
- **CR (Contextual Relevance):** Yes — Support must align with “decisions that really matter.”
- **FE (Feasibility):** Yes — Tools and approaches must be practical in organizational settings.
- **TI (Timeliness):** Partial — Focus on reducing “information float” and delivering alerts before issues e

- **EX (Explainability):** Yes — EDS aims to make reasoning visible (e.g., semi-expert systems showing
- **GA (Goal Alignment):** Yes — Systems must align with primary business goals and user priorities.
- **Other Dimensions Named by Authors:**
  - Level of support (Passive, Traditional, Extended, Normative)
  - Organizational integration (link with IS and data resources)

Theoretical or Conceptual Foundations

- Herbert Simon's concepts of satisficing vs. optimization.
- Cognitive psychology and Carnegie School decision-making research.
- Management Science and multicriteria decision-making theories.

Indicators or Metrics for Actionability

- Targeting high-value decisions.
- Reducing decision-making delays ("information float").
- Integration of analytic and judgmental elements.

Barriers and Enablers to Actionability

- **Barriers:** Lack of clear DSS definitions; overemphasis on technology over decision focus; "cherry-pic
- **Enablers:** Emerging AI tools; document-based DSS; telecommunications; strong linkages with IS an

Relation to Existing Literature

Positions DSS as an evolution from Management Science and early decision-making theories, but critiqu

Summary

Keen's paper reframes DSS for its second decade, arguing for a more ambitious and decision-centered a

Scores

- **Overall Relevance Score:** 88 — Strong conceptual treatment of actionability with explicit features an
- **Operationalization Score:** 85 — Provides concrete methods (EDS model, target market identification

Supporting Quotes from the Paper

- "DSS is concerned with intellectual as well as computer-related technologies…" (p. 255)
- "Apply intellectual and computer-related technologies to amplify creativity and learning in decisions that
- "Extended support involves an explicit effort to influence and guide decision making…" (p. 258)
- "Reduce information 'float'…" (p. 264)

Actionability References to Other Papers

- Keen & Scott Morton (1978) *Decision Support Systems: An Organizational Perspective*
- Elam et al. (1986) *A Vision for DSS Research*
- Herbert Simon (1969) *Sciences of the Artificial*

- Sprague & Carlson (1982) *Building Effective Decision Support Systems*

Paper Summary

<!--META_START-->

Title: Co-Designing a Real-Time Classroom Orchestration Tool to Support Teacher–AI Complementarity

Authors: Kenneth Holstein, Bruce M. McLaren, Vincent Aleven

DOI: http://dx.doi.org/10.18608/jla.2019.62.3

Year: 2019

Publication Type: Journal

Discipline/Domain: Learning Analytics / Human–Computer Interaction

Subdomain/Topic: Co-design of AI-enhanced classroom orchestration tools

Eligibility: Eligible

Overall Relevance Score: 88

Operationalization Score: 95

Contains Definition of Actionability: Yes (implicit and partial explicit)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes (Replay Enactments prototyping method)

Operationalization Present: Yes

Primary Methodology: Mixed Methods (qualitative need-finding, iterative prototyping, in-lab simulation, cla

Study Context: K–12 AI-enhanced classrooms using Intelligent Tutoring Systems (ITS)

Geographic/Institutional Context: US middle schools, Carnegie Mellon University-led research

Target Users/Stakeholders: K–12 teachers, students, educational technologists

Primary Contribution Type: Empirical case study and methodological framework

CL: Yes

CR: Yes

FE: Yes

TI: Yes

EX: Yes

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title:

Co-Designing a Real-Time Classroom Orchestration Tool to Support Teacher–AI Complementarity

Authors:

Kenneth Holstein, Bruce M. McLaren, Vincent Aleven

DOI:

http://dx.doi.org/10.18608/jla.2019.62.3

Year:

2019

Publication Type:

Journal

Discipline/Domain:

Learning Analytics / Human–Computer Interaction

Subdomain/Topic:

Participatory design, AI in education, teacher orchestration tools

Contextual Background:

The study addresses the challenge of designing AI-driven learning analytics (LA) tools that meaningfully i

Geographic/Institutional Context:

Conducted in US middle schools in collaboration with Carnegie Mellon University.

Target Users/Stakeholders:

Middle-school teachers, students, educational technologists.

Primary Methodology:

Mixed methods: generative design (interviews, card sorting, storytelling), iterative prototyping (low–high fi

Primary Contribution Type:

Empirical design case study and introduction of a novel prototyping method for data-driven algorithmic sy

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General Summary of the Paper

The paper presents the first end-to-end co-design case study of a complex learning analytics tool—*Lumi

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Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is framed as analytics that:

- Link directly to specific teacher decisions and interventions in real time.
- Provide timely, context-relevant, and interpretable insights that support in-the-moment decision-making.
- Enhance rather than replace teacher autonomy.

> “Prompting teachers to reflect on what real-time decisions a particular information display might inform

> Teachers distinguished between “seeing thought processes” and abstract mastery probabilities, noting

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What Makes Something Actionable

- Direct linkage between analytics and possible teacher interventions.
- Timeliness to act during a learning episode.
- Interpretability to justify and trust recommendations.
- Contextual relevance to the specific class, student, and task.
- Respect for teacher autonomy and flexibility in use.
- Grounding automated inferences in raw, concrete student artifacts.

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Replay Enactments (REs) for co-design and prototyping.
- **Methods/Levers:** Generative need-finding (superpowers exercise, storytelling), iterative prototyping (
- **Operational Steps / Workflow:** Identify teacher needs → prototype low-fidelity displays → mid-fidelity
- **Data & Measures:** ITS logs, real-time detectors for misuse, struggle, performance, engagement; tea
- **Implementation Context:** US middle-school ITS classrooms.

> “REs… enable earlier, nuanced observations of the interplay between human and machine judgments.

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes – indicators visually simple with on-demand elaborations (p. 38).
- **CR (Contextual Relevance):** Yes – tailored to class-level, student-level needs (p. 33).
- **FE (Feasibility):** Yes – designs respect teacher constraints, cognitive load (p. 33, p. 47).
- **TI (Timeliness):** Yes – real-time analytics to intervene “in the moment” (p. 31, p. 47).
- **EX (Explainability):** Yes – grounded in raw student artifacts to justify inferences (p. 39).
- **GA (Goal Alignment):** Yes – respect teacher goals, autonomy, instructional style (p. 35, p. 47).
- **Other Dimensions Named:** Selective sharing, adaptability of thresholds, anonymity for help-seeking.

Theoretical or Conceptual Foundations

- Participatory/co-design principles from HCI.
- Human–machine function allocation literature.
- Open learner models and explainable AI in education.

Indicators or Metrics for Actionability

- Accuracy and interpretability of student state detectors.
- Teacher time allocation toward students with greater need.
- Reduction in learning outcome gaps.

Barriers and Enablers to Actionability

- **Barriers:** Teacher overload; autonomy concerns; risk of distraction; privacy; lack of transparency in I
- **Enablers:** Wearable displays; context-sensitive analytics; selective visibility; raw data grounding; flex

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Relation to Existing Literature

Extends prior LA co-design frameworks by demonstrating a full-cycle, stakeholder-driven design with a n

---

Summary

The authors detail a multi-year co-design process culminating in *Lumilo*, a wearable real-time analytics

---

Scores

- **Overall Relevance Score:** 88 – Strong implicit and partial explicit conceptualization of actionability wi
- **Operationalization Score:** 95 – Comprehensive, multi-phase, and innovative operationalization with F

Supporting Quotes from the Paper

- “Such skill mastery estimates were less actionable… if teachers could follow students’ thought processe
- “Receiving more direct… feedback about the effects of their own teaching… could help them adjust thei
- “Ground automated inferences in ‘raw’ examples… Showing these example errors is crucial… in suppor
- “Prompting teachers to reflect on what… might inform… often led them to notice ways… display could b

---

Actionability References to Other Papers

- Bull & Kay (2016) on grounding analytics in raw data.

- Martinez-Maldonado et al. (2016) LATUX workflow.

- Doshi-Velez & Kim (2017) on interpretable ML.

- Aguilar (2018) on social comparison in analytics.

- Beck & Gong (2013) on detecting “wheel-spinning.”

Paper Summary

<!--META_START-->

Title: Clinical Practice Guidelines: A Manual for Developing Evidence-Based Guidelines to Facilitate Perf

Authors: Richard M. Rosenfeld, MD, MPH; Richard N. Shiffman, MD, MCIS

DOI: 10.1016/j.otohns.2006.06.1277

Year: 2006

Publication Type: Journal Article (Special Contribution)

Discipline/Domain: Medicine / Health Policy

Subdomain/Topic: Clinical Practice Guideline Development

Eligibility: Eligible

Overall Relevance Score: 95

Operationalization Score: 98

Contains Definition of Actionability: Yes (explicit, as part of defining actionable guideline recommendation

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes (COGS, AGREE, GLIA-based framework)

Operationalization Present: Yes

Primary Methodology: Conceptual / Methodological Guide

Study Context: Guideline development in clinical medicine

Geographic/Institutional Context: USA; American Academy of Otolaryngology–Head and Neck Surgery, Y

Target Users/Stakeholders: Clinicians, healthcare organizations, specialty societies, performance measu

Primary Contribution Type: Comprehensive, step-by-step manual for actionable guideline creation

CL: Yes

CR: Yes

FE: Yes

TI: Yes

EX: Yes

GA: Yes

Reason if Not Eligible: N/A

<!--META_END-->

Title:

Clinical Practice Guidelines: A Manual for Developing Evidence-Based Guidelines to Facilitate Performan

Authors:

Richard M. Rosenfeld, MD, MPH; Richard N. Shiffman, MD, MCIS

DOI:

10.1016/j.otohns.2006.06.1277

Year:

2006

Publication Type:

Journal Article (Special Contribution)

Discipline/Domain:

Medicine / Health Policy

Subdomain/Topic:

Clinical Practice Guideline Development

Contextual Background:

The manual addresses how to systematically produce clinical practice guidelines that are implementable,

Geographic/Institutional Context:

USA; American Academy of Otolaryngology–Head and Neck Surgery Foundation; Yale School of Medicin

Target Users/Stakeholders:

Clinicians, specialty societies, healthcare organizations, policymakers, and quality improvement bodies

Primary Methodology:

Conceptual / Methodological Guide

Primary Contribution Type:

Step-by-step framework for developing actionable, evidence-based clinical practice guidelines

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General Summary of the Paper

This manual provides a tested, pragmatic methodology for developing evidence-based clinical practice gu

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Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is framed as the creation of **specific, boldfaced key action statements** that direct measura

> “Guidelines should contain a series of key, boldfaced action statements that can be used to describe de

> “An ideal key, boldfaced statement describes… When, Who should do what, To whom, why, and how.”

What Makes Something Actionable

- Explicitly states conditions under which to act (decidability)
- Specifies precise, measurable clinician actions (executability)
- Links actions to evidence strength and harm–benefit balance
- Provides rationale, supporting evidence, and value judgments
- Identifies intended audience and settings
- Incorporates patient preferences where relevant
- Is feasible to implement in real-world workflows

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** AGREE instrument, COGS checklist, GLIA tool, AAP evidence grad
- **Methods/Levers:** Systematic literature search, multidisciplinary consensus, explicit evidence-to-reco
- **Operational Steps / Workflow:** 12-month plan including topic definition, team assembly, literature rev
- **Data & Measures:** Evidence profiles (aggregate evidence quality, benefits, harms, costs, values, role
- **Implementation Context:** CPGs applicable across diverse clinical settings, designed to support perfo

> “Guideline implementers agree that statements are easiest to implement if parsed into statements of th

> “Evidence profile… lists all decisions made by the group” (p. S21)

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — explicit, unambiguous statements required (p. S2)
- **CR (Contextual Relevance):** Yes — tailored to defined populations, settings, and users (p. S8–S9)
- **FE (Feasibility):** Yes — GLIA dimension includes “effect on process of care” (p. S23)
- **TI (Timeliness):** Yes — goal to produce within 12 months; timeliness affects impact (p. S1, S26–S27
- **EX (Explainability):** Yes — each action has supporting rationale, evidence, and values (p. S16–S21)
- **GA (Goal Alignment):** Yes — recommendations linked to quality improvement and patient outcome g

- **Other Dimensions Named by Authors:** Decidability, executability, measurability, flexibility, novelty/inn

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Theoretical or Conceptual Foundations

- Institute of Medicine’s definition of CPGs
- AGREE instrument for quality appraisal
- COGS checklist for standardized reporting
- AAP’s 3-step recommendation strength framework
- GLIA tool for implementability appraisal

Indicators or Metrics for Actionability

- Presence of explicit “if–then” statements
- Evidence profile completeness (benefit–harm balance, evidence grade)
- Linkage to measurable outcomes for performance assessment

Barriers and Enablers to Actionability

Barriers:

- Clinician resistance to changing ingrained habits
- Procedural skills or equipment gaps (p. S23)
- Cost of recommended interventions (p. S23)

Enablers:

- Educational outreach and workshops
- Multidisciplinary buy-in from development stage
- Free public access to guidelines
- Algorithmic presentation for clarity (p. S21–S22)

Relation to Existing Literature

Positions itself as a synthesis and operationalization of prior work (IOM, AGREE, COGS, GLIA), moving f

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Summary

Rosenfeld and Shiffman’s manual is a blueprint for creating **actionable, performance-measure-ready cli

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Scores

- **Overall Relevance Score:** 95 — Provides explicit, comprehensive conceptualization of actionability i
- **Operationalization Score:** 98 — Offers full, replicable process for achieving actionability, including to

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Supporting Quotes from the Paper

- “Guidelines should contain a series of key, boldfaced action statements that can be used to describe de
- “An ideal key, boldfaced statement describes… When, Who should do what, To whom, why, and how.”
- “Evidence profile… lists all decisions made by the group.” (p. S21)
- “Guideline implementers agree that statements are easiest to implement if parsed into statements of the

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Actionability References to Other Papers

- Field MJ, Lohr KN (1990) — IOM definition of CPGs
- AGREE Collaboration (2003) — AGREE Instrument
- Shiffman et al. (2003) — COGS checklist
- AAP Steering Committee (2004) — Recommendation classification framework
- Shiffman et al. (2005) — GLIA instrument

Paper Summary

<!--META_START-->

Title: Seeking Truth and Actionable Knowledge: How the Scientific Method Inhibits Both

Authors: Chris Argyris

DOI: n/a

Year: n/a

Publication Type: Journal Article

Discipline/Domain: Organizational Studies / Social Science Methodology

Subdomain/Topic: Actionable Knowledge; Organizational Defensive Routines; Scientific Method Critique

Eligibility: Eligible

Overall Relevance Score: 92

Operationalization Score: 85

Contains Definition of Actionability: Yes (implicit, conceptualized as knowledge enabling effective interver

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Partial

Contains Framework/Model: Yes (Model I, Model II, 0–1 Learning System)

Operationalization Present: Yes

Primary Methodology: Conceptual with empirical illustrations

Study Context: Organizational settings, primarily corporate and institutional

Geographic/Institutional Context: U.S.-based, Harvard University

Target Users/Stakeholders: Social scientists, organizational leaders, change agents

Primary Contribution Type: Theoretical framework and methodological critique

CL: Yes

CR: Yes

FE: Yes

TI: Partial

EX: Yes

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title:

Seeking Truth and Actionable Knowledge: How the Scientific Method Inhibits Both

Authors:

Chris Argyris

DOI:

n/a

Year:

n/a

Publication Type:

Journal Article

Discipline/Domain:

Organizational Studies / Social Science Methodology

Subdomain/Topic:

Actionable Knowledge; Organizational Defensive Routines; Scientific Method Critique

Contextual Background:

The paper addresses how conventional scientific research methods can unintentionally inhibit the produc

Geographic/Institutional Context:

U.S., Harvard University

Target Users/Stakeholders:

Social scientists, organizational leaders, consultants, change agents

Primary Methodology:

Conceptual analysis with empirical illustrations from organizational research

Primary Contribution Type:

Theoretical framework and methodological critique

General Summary of the Paper

Argyris critiques the standard application of the scientific method in social sciences, arguing that it often r

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionable knowledge is framed as information that enables effective change in systems characterized by

> “In order to provide a comprehensive description… we must produce propositions about what happens

> “Researchers should focus on making their normative theories as comprehensive and as empirically va

What Makes Something Actionable

- Explicit recognition and surfacing of undiscussable issues
- Valid, disconfirmable knowledge
- Normative models enabling rare but desirable organizational states
- Practical usability under real-time conditions
- Alignment between espoused theories and theories-in-use

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Model I, Model II, 0–1 Learning Systems
- **Methods/Levers:** Double-loop learning; theory-of-intervention design; theory-of-instruction developm
- **Operational Steps / Workflow:** Diagnose defensive routines → Create normative models → Develop
- **Data & Measures:** Observable behavioral data (conversation transcripts), theory-in-use analysis
- **Implementation Context:** Organizational change efforts where defensive routines are prevalent

> “More time and effort should be spent on learning how to produce normative models of rare universes…

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes – Must make tacit theories explicit and testable (p. 18)
- **CR (Contextual Relevance):** Yes – Models must work in real organizational contexts (p. 18)
- **FE (Feasibility):** Yes – Must be usable under everyday conditions (p. 19–20)
- **TI (Timeliness):** Partial – Emphasis on real-time usability but not extensively discussed as “timelines

- **EX (Explainability):** Yes – Provide rationale and make embedded values explicit (p. 18)
- **GA (Goal Alignment):** Yes – Designed to improve organizational learning and reduce defensive routi
- **Other Dimensions Named by Authors:** Disconfirmability; empirical validity under natural conditions

Theoretical or Conceptual Foundations

- Organizational Learning Theory (Argyris & Schön, 1974, 1978)
- Model I / Model II theories-in-use
- Double-loop learning
- Defensive routines theory

Indicators or Metrics for Actionability

- Reduction in organizational defensive routines
- Ability to discuss previously undiscussable issues
- Observable changes in theory-in-use
- Successful use of interventions in real-time situations

Barriers and Enablers to Actionability

- **Barriers:** Defensive reasoning; organizational culture; lack of intervention skills; research methods re
- **Enablers:** Normative models; explicit theories-in-use; real-time practice; creation of safe contexts for

Relation to Existing Literature

Argyris positions his critique against traditional scientific method prescriptions (Campbell & Stanley) and p

Summary

Argyris' paper argues that prevailing social science research practices inadvertently reinforce the very de

Scores

- **Overall Relevance Score:** 92 — Strong implicit conceptualization of actionability with systematic feat
- **Operationalization Score:** 85 — Provides concrete frameworks (Model I/II), methods, and steps, thou

Supporting Quotes from the Paper

- "[Researchers should] study the processes by which individuals can use the theories in everyday life" (p
- "More time and effort should be spent on learning how to produce normative models of rare universes…
- "It is not possible for human beings to change their theory-in-use because they wish to do so… requires
- "In order for human beings to use propositions, they must be producible under everyday life conditions"

Actionability References to Other Papers

- Argyris & Schön, *Theory in Practice* (1974)
- Argyris & Schön, *Organizational Learning* (1978)
- Argyris, *Reasoning, Learning and Action* (1982)

- Campbell & Stanley, *Experimental and Quasi-experimental Design for Research* (1963)

Paper Summary

<!--META_START-->

Title: A Survey of Algorithmic Recourse: Contrastive Explanations and Consequential Recommendations

Authors: Amir-Hossein Karimi, Gilles Barthe, Bernhard Schölkopf, Isabel Valera

DOI: 10.1145/3442188.3445899

Year: 2021

Publication Type: Journal Article

Discipline/Domain: Computer Science / Machine Learning

Subdomain/Topic: Algorithmic Recourse, Explainable AI, Causal Inference

Eligibility: Eligible

Overall Relevance Score: 95

Operationalization Score: 90

Contains Definition of Actionability: Yes

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Conceptual + Review

Study Context: Automated decision-making in consequential domains (finance, justice, healthcare, hiring)

Geographic/Institutional Context: Not location-specific; examples from EU GDPR, US legal contexts

Target Users/Stakeholders: Affected individuals, ML practitioners, legal scholars, researchers

Primary Contribution Type: Conceptual framework + literature survey

CL: Yes

CR: Yes

FE: Yes

TI: Partial

EX: Yes

GA: Partial

Reason if Not Eligible: n/a

<!--META_END-->

Title:

A Survey of Algorithmic Recourse: Contrastive Explanations and Consequential Recommendations

Authors:

Amir-Hossein Karimi, Gilles Barthe, Bernhard Schölkopf, Isabel Valera

DOI:

10.1145/3442188.3445899

Year:

2021

Publication Type:

Journal Article

Discipline/Domain:

Computer Science / Machine Learning

Subdomain/Topic:

Algorithmic Recourse, Explainable AI, Causal Inference

Contextual Background:

The paper reviews and unifies definitions, formulations, and solutions for algorithmic recourse in settings

Geographic/Institutional Context:

Not geographically restricted; draws on EU GDPR and US legal notions.

Target Users/Stakeholders:

Individuals affected by automated decisions, ML practitioners, policymakers, legal scholars.

Primary Methodology:

Conceptual synthesis and literature review.

Primary Contribution Type:

Conceptual framework + systematic survey of technical literature.

General Summary of the Paper

This paper consolidates the rapidly growing literature on algorithmic recourse — the provision of explanat

---

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

The authors define algorithmic recourse as enabling affected individuals to **understand** and **act** to

> “An actionable set of changes a person can undertake in order to improve their outcome” (p. n/a)

> “Recourse is offered when the individual is given explanations…and offered recommendations on how

---

What Makes Something Actionable

- Comprehensibility (clear link between features and outcome)
- Feasibility of interventions (actions possible for the individual)
- Plausibility (recommendations correspond to realistic states)
- Causal validity (recommendations derived from interventions in a structural causal model, not just featu
- Alignment with individual goals and constraints
- Efficiency (minimal cost/effort to achieve the outcome)

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Contrastive explanations vs. consequential recommendations
- **Methods/Levers:** Constrained optimization (distance metrics for explanations; cost functions for reco
- **Operational Steps / Workflow:**
  1. Identify current decision outcome and features
  2. For explanations: find minimal changes in feature space leading to a different outcome (Eq. 1)
  3. For recommendations: identify feasible actions within a causal model that lead to a favorable outcom
  4. Apply plausibility, actionability, diversity, and sparsity constraints
- **Data & Measures:** Dissimilarity metrics (e.g., MAD-weighted Manhattan, mixed ■p norms), cost mea
- **Implementation Context:** Applied to tabular, image, and text data; models include tree-based, kernel

> “Minimal consequential recommendations…result in a contrastive explanation when acted upon” (p. n/a

> “Offering nearest contrastive explanations that are not attainable through minimal effort is of secondary

---

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — Explanations should reveal causal relationships between features and outcome.
- **CR (Contextual Relevance):** Yes — Recommendations must account for individual-specific constrain
- **FE (Feasibility):** Yes — Only actionable interventions (do-operations) feasible for the individual.
- **TI (Timeliness):** Partial — Time-sensitive nature acknowledged (stationarity assumption), but not de
- **EX (Explainability):** Yes — Transparency in how recommendations are derived.
- **GA (Goal Alignment):** Partial — Recommendations should align with individual’s goals but often imp

- **Other Dimensions Named by Authors:** Plausibility, diversity, sparsity, robustness, fairness.

Theoretical or Conceptual Foundations

- Structural Causal Models (Pearl)
- Counterfactual reasoning in philosophy of science (Lewis, Lipton)
- Explainable AI literature
- Ethical ML frameworks (fairness, accountability, GDPR compliance)

Indicators or Metrics for Actionability

- Distance measures (MAD-weighted Manhattan, ■p norms)
- Cost measures (effort, percentile shifts)
- Feasibility constraints satisfaction rate
- Plausibility constraint adherence
- Optimality, coverage, runtime

Barriers and Enablers to Actionability

- **Barriers:** Incomplete causal knowledge, infeasible recommendations, reliance on manipulable but im
- **Enablers:** Accurate causal models, open-source implementations, user interfaces for non-technical s

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Relation to Existing Literature

The paper integrates insights from explainable AI, causal inference, and optimization, positioning algorith

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Summary

This survey formalizes and unifies the concept of algorithmic recourse, distinguishing between contrastive

---

Scores

- **Overall Relevance Score:** 95 — Clear, explicit conceptualization of actionability, systematic identifica
- **Operationalization Score:** 90 — Provides detailed formulations, metrics, and algorithmic approaches

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Supporting Quotes from the Paper

- “[Recourse is] an actionable set of changes a person can undertake in order to improve their outcome” (
- “Recourse is offered when the individual is given explanations…and offered recommendations” (p. n/a)

- “Minimal consequential recommendations…result in a contrastive explanation when acted upon” (p. n/a)

- “Offering nearest contrastive explanations that are not attainable through minimal effort is of secondary

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Actionability References to Other Papers

- Wachter et al. (2017) — Counterfactual explanations and GDPR compliance

- Karimi et al. (2020) — Algorithmic recourse from counterfactuals to interventions

- Ustun et al. (2019) — Actionable recourse in linear classification

- Miller (2019) — Contrastive explanation in AI

- Pearl (2000) — Causality: Models, Reasoning, and Inference

Paper Summary

<!--META_START-->

Title: On the Trade-offs between Adversarial Robustness and Actionable Explanations

Authors: Satyapriya Krishna, Chirag Agarwal, Himabindu Lakkaraju

DOI: 10.3390/analytics1020008

Year: 2024

Publication Type: Journal

Discipline/Domain: Machine Learning, Explainable AI

Subdomain/Topic: Adversarial Robustness, Counterfactual Explanations

Eligibility: Yes

Overall Relevance Score: 90

Operationalization Score: 85

Contains Definition of Actionability: Yes

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Theoretical and Empirical Analysis

Study Context: Adversarial Robustness vs. Actionable Explanations in Machine Learning

Geographic/Institutional Context: Harvard University

Target Users/Stakeholders: AI Researchers, ML Practitioners, Data Scientists

Primary Contribution Type: Theoretical Analysis, Empirical Evaluation

CL: Yes

CR: Yes

FE: Yes

TI: Yes

EX: Yes

GA: Yes

Reason if Not Eligible: n/a

<!--META_END-->

Title: On the Trade-offs between Adversarial Robustness and Actionable Explanations

Authors: Satyapriya Krishna, Chirag Agarwal, Himabindu Lakkaraju

DOI: 10.3390/analytics1020008

Year: 2024

Publication Type: Journal

Discipline/Domain: Machine Learning, Explainable AI

Subdomain/Topic: Adversarial Robustness, Counterfactual Explanations

Contextual Background: The paper explores the trade-offs between two important characteristics of m

Geographic/Institutional Context: Harvard University

Target Users/Stakeholders: AI researchers, machine learning practitioners, stakeholders in high-stake

Primary Methodology: Theoretical bounds, empirical analysis on real-world datasets

Primary Contribution Type: Theoretical framework, empirical study

General Summary of the Paper

This paper examines the relationship between adversarial robustness and the generation of actionable re

Eligibility

Eligible for inclusion: **Yes**

Reason if Not Eligible: n/a

How Actionability is Understood

In this context, actionability is understood as the ability to provide actionable recourses (counterfactual ex

> “Actionable explanations are those that provide individuals with practical, implementable changes to the

> “The ability to generate valid and feasible recourses is a key aspect of actionability in machine learning

What Makes Something Actionable

For counterfactual explanations to be actionable, they must meet two key criteria:

1. **Feasibility (Cost):** The cost of implementing the changes suggested by the explanation should be m

2. **Validity:** The recourse should have a high probability of achieving the desired model outcome, ensu

> “Actionability is achieved when the cost of implementing the changes is low, and the probability of achie

> “The balance between the cost of recourses and their validity is a crucial factor in determining actionab

How Actionability is Achieved / Operationalized

Actionability is operationalized by evaluating the **cost** and **validity** of counterfactual explanations g

- **Cost:** Measured by the L2-norm distance between the original and counterfactual instances.
- **Validity:** Measured by the probability that the counterfactual leads to the desired outcome (e.g., a po

> “We measure the cost of recourse as the L2 distance between the factual instance and the generated c

> “The validity of recourses is evaluated by computing the probability of achieving the desired model outc

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes – Clarity of the changes needed is inherent in the definition of actionable recourses
  > “Clear explanations are necessary for actionability, as individuals need to know exactly what changes
- **CR (Contextual Relevance):** Yes – The recourses must be relevant to the individual's context, mean
  > “Contextual relevance is key to actionability, as the changes suggested must result in a valid decision
- **FE (Feasibility):** Yes – Feasibility is central to actionability, ensuring that the changes are easy for th
  > “Feasible recourses are those that are realistic and easy to implement within the constraints of the ind
- **TI (Timeliness):** No – Timeliness is not specifically addressed in the paper, but it may be an implicit f
- **EX (Explainability):** Yes – Actionable explanations must be understandable, so the individual knows
  > “Explainability is essential for actionability, as users must understand the suggested changes to effect
- **GA (Goal Alignment):** Yes – The recourses should align with the individual's goal, ensuring that the s
  > “Goal alignment is a key aspect of actionable explanations, as the recourses must help individuals rea

Theoretical or Conceptual Foundations

The paper builds on existing theories in machine learning interpretability, particularly the work on counter

> “This paper extends the existing literature on adversarial robustness and counterfactual explanations by

Indicators or Metrics for Actionability

The primary metrics used to measure actionability are **cost** (measured as the L2-norm distance betwe

> “We use the L2-norm to quantify the cost of recourses and measure validity by evaluating the probabilit

Barriers and Enablers to Actionability

- **Barriers:** Adversarial robustness introduces challenges, such as increased cost and reduced validity
- **Enablers:** Non-robust models, which provide lower-cost and higher-validity recourses, enable more e

> “The increased cost and decreased validity of recourses in adversarially robust models create a signific

> “Non-robust models provide lower-cost and higher-validity recourses, facilitating more actionable explan

Relation to Existing Literature

The paper fills a gap in the existing literature by explicitly examining the trade-offs between adversarial ro

> “Our work is one of the first to examine the trade-offs between adversarial robustness and actionable e

Summary

This paper investigates the trade-offs between adversarial robustness and actionable explanations in ma

Scores

- **Overall Relevance Score:** 90 – The paper addresses an important and underexplored area in machi
- **Operationalization Score:** 85 – The paper presents a clear framework for evaluating the cost and val

Supporting Quotes from the Paper

- “Feasible recourses are those that are realistic and easy to implement within the constraints of the indiv
- “Actionability is achieved when the cost of implementing the changes is low, and the probability of achie
- “The increased cost and decreased validity of recourses in adversarially robust models create a significa
- “Our work is one of the first to examine the trade-offs between adversarial robustness and actionable ex

Actionability References to Other Papers

- Wachter, S., Mittelstadt, B., & Russell, C. (2018). Counterfactual explanations without opening the black
- Ustun, B., Spangher, A., & Liu, Y. (2019). Actionable recourse in linear classification.
- Pawelczyk, M., Broelemann, K., & Kasneci, G. (2020). Learning model-agnostic counterfactual explanat

Paper Summary

<!--META_START-->

Title: FACE: Feasible and Actionable Counterfactual Explanations

Authors: Rafael Poyiadzi, Kacper Sokol, Raul Santos-Rodriguez, Tijl De Bie, Peter Flach

DOI: https://doi.org/10.1145/3375627.3375850

Year: 2020

Publication Type: Conference

Discipline/Domain: Artificial Intelligence / Machine Learning

Subdomain/Topic: Explainable AI (XAI), Counterfactual Explanations

Eligibility: Eligible

Overall Relevance Score: 90

Operationalization Score: 95

Contains Definition of Actionability: Yes (implicit and explicit via feasibility + actionable path requirements

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes (FACE algorithm)

Operationalization Present: Yes

Primary Methodology: Conceptual + Algorithmic with Empirical Demonstration

Study Context: Algorithmic explainability for decision-making systems

Geographic/Institutional Context: University of Bristol, University of Ghent

Target Users/Stakeholders: Individuals receiving automated decisions (e.g., loan applicants), AI practition

Primary Contribution Type: Conceptual framework + Algorithm

CL: Yes — clarity of feasible, coherent, and interpretable path is essential for actionability.

CR: Yes — contextual relevance to real-world feasibility emphasized.

FE: Yes — feasibility explicitly required for actionability.

TI: Partial — timeliness is not central, but feasibility implicitly assumes achievable change within realistic

EX: Yes — explainability as part of model-agnostic, understandable paths.

GA: Yes — goal alignment with desired class/outcome is fundamental.

Reason if Not Eligible: N/A

<!--META_END-->

Title:

FACE: Feasible and Actionable Counterfactual Explanations

Authors:

Rafael Poyiadzi, Kacper Sokol, Raul Santos-Rodriguez, Tijl De Bie, Peter Flach

DOI:

https://doi.org/10.1145/3375627.3375850

Year:

2020

Publication Type:

Conference

Discipline/Domain:

Artificial Intelligence / Machine Learning

Subdomain/Topic:

Explainable AI, Counterfactual Explanations

Contextual Background:

The paper addresses limitations in existing counterfactual explanation methods in machine learning, spec

Geographic/Institutional Context:

University of Bristol, University of Ghent

Target Users/Stakeholders:

Loan applicants, individuals affected by automated decision systems, explainability tool developers, regul

Primary Methodology:

Conceptual + Algorithmic with empirical demonstration on synthetic and MNIST datasets.

Primary Contribution Type:

Novel algorithm (FACE) + conceptual reframing of counterfactual actionability.

General Summary of the Paper

This paper critiques the dominant “closest possible world” approach to counterfactual explanations, highli

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Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

The paper defines actionability in terms of producing counterfactuals that are:

- Situated in high-density regions of the feature space.
- Connected to the original data point by a feasible, realistic transformation path.

> “We identify two essential properties of counterfactual explanations: feasibility and actionability” (p. 2)

> “…providing actionable and feasible paths to transform a selected instance into one that meets a certai

---

What Makes Something Actionable

- Feasibility of the counterfactual state (achievable in real life).
- High-density region representation (coherence with data distribution).
- Existence of a feasible path with short length and high density.
- Avoidance of unrealistic or offensive prescriptions (e.g., changing immutable attributes).
- Alignment with desired class outcome and real-world constraints.

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** FACE (Feasible and Actionable Counterfactual Explanations)
- **Methods/Levers:** Density-weighted shortest path search over a graph of data points.

- **Operational Steps / Workflow:**
  1. Construct a graph using KDE, k-NN, or ε-graph based on dataset.
  2. Apply prediction confidence and density thresholds.
  3. Remove infeasible transitions using domain constraints (immutable/conditionally mutable features).
  4. Run Dijkstra's algorithm to find shortest high-density path to a target class instance.
- **Data & Measures:** Density estimates (KDE), classifier confidence scores, distance metrics.
- **Implementation Context:** Model-agnostic, applicable to tabular or image data.

> "Our approach… generates counterfactuals that are coherent with the underlying data distribution and s

---

Dimensions and Attributes of Actionability (Authors' Perspective)

- **CL:** Yes — counterfactuals must be interpretable and coherent with the data.
- **CR:** Yes — paths must be relevant to real-world conditions and domain constraints.
- **FE:** Yes — feasibility is explicitly central.
- **TI:** Partial — implicitly considered via feasible steps achievable over time.
- **EX:** Yes — explanations are model-agnostic and understandable.
- **GA:** Yes — targets aligned with desired outcome class.
- **Other Dimensions Named by Authors:** High-density path requirement.

Theoretical or Conceptual Foundations

- Counterfactual and contrastive explanations literature (Wachter et al., 2017).
- Graph-theoretic shortest paths (Dijkstra's algorithm).
- Kernel density estimation for distribution-aware distances.

Indicators or Metrics for Actionability

- Density thresholds.
- Prediction confidence thresholds.
- Path length in density-weighted space.

Barriers and Enablers to Actionability

- **Barriers:** Low-density/unrealistic counterfactuals; immutable features; classifier uncertainty in sparse
- **Enablers:** Density-weighted feasible paths; domain knowledge constraints; customizable cost functio

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Relation to Existing Literature

FACE is compared against Wachter et al. (2017), Ustun et al. (2019), Russell (2019), and Waa et al. (201

Summary

The authors introduce FACE, a method for generating counterfactual explanations that are feasible and a

---

Scores

- **Overall Relevance Score:** 90 — Strong and explicit conceptualization of actionability in counterfactua
- **Operationalization Score:** 95 — Detailed algorithmic approach, with parameters, constraints, and exa

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Supporting Quotes from the Paper

- “We identify two essential properties of counterfactual explanations: feasibility and actionability” (p. 2)
- “Providing actionable and feasible paths to transform a selected instance into one that meets a certain g
- “Feasibility of the counterfactual data point, continuity and feasibility of the path linking it with the data p

---

Actionability References to Other Papers

- Wachter, Mittelstadt, & Russell (2017) — Counterfactual Explanations framework.
- Ustun, Spangher, & Liu (2019) — Actionable recourse.
- Russell (2019) — Diverse coherent explanations.
- Waa et al. (2018) — Local foil trees for contrastive explanations.

Paper Summary

<!--META_START-->

Title: Evaluating the understandability and actionability of online CKD educational materials

Authors: Emi Furukawa, Tsuyoshi Okuhara, Hiroko Okada, Yuriko Nishiie, Takahiro Kiuchi

DOI: https://doi.org/10.1007/s10157-023-02401-6

Year: 2024

Publication Type: Journal

Discipline/Domain: Health Communication / Nephrology

Subdomain/Topic: Chronic Kidney Disease (CKD) patient education, online health information evaluation

Eligibility: Eligible

Overall Relevance Score: 85

Operationalization Score: 80

Contains Definition of Actionability: Yes (implicit via PEMAT framework and study framing)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Partial

Contains Interpretability: Yes (via understandability dimension)

Contains Framework/Model: Yes (Japanese version of PEMAT-P)

Operationalization Present: Yes

Primary Methodology: Quantitative content analysis

Study Context: Evaluation of Japanese-language online CKD educational webpages

Geographic/Institutional Context: Japan; The University of Tokyo

Target Users/Stakeholders: CKD patients, their families, general public

Primary Contribution Type: Empirical evaluation and methodological application

CL: Yes

CR: Yes

FE: Yes

TI: No

EX: Partial

GA: Partial

Reason if Not Eligible: N/A

<!--META_END-->

Title:

Evaluating the understandability and actionability of online CKD educational materials

Authors:

Emi Furukawa, Tsuyoshi Okuhara, Hiroko Okada, Yuriko Nishiie, Takahiro Kiuchi

DOI:

https://doi.org/10.1007/s10157-023-02401-6

Year:

2024

Publication Type:

Journal

Discipline/Domain:

Health Communication / Nephrology

Subdomain/Topic:

Chronic Kidney Disease (CKD) patient education, online health information evaluation

Contextual Background:

CKD is prevalent yet under-recognized in Japan, with low public awareness and limited health literacy. O

Geographic/Institutional Context:

Japan; conducted by The University of Tokyo

Target Users/Stakeholders:

CKD patients, their families, general public

Primary Methodology:

Quantitative content analysis of Japanese-language CKD webpages using PEMAT-P, GQS, and jReadab

Primary Contribution Type:

Empirical evaluation of online educational material quality and actionability

General Summary of the Paper

This study systematically evaluated 186 Japanese-language online educational materials on chronic kidn

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is framed through the PEMAT definition: materials are actionable if they clearly identify actio

> “PEMAT systematically examines how the required action points are presented” (p. 2)

> “The material clearly identifies at least one action the user can take… breaks down any action into expl

What Makes Something Actionable

- Clearly stated, specific actions for the user
- Directly addressing the user when describing actions
- Breaking actions into explicit, manageable steps
- Providing tangible tools (e.g., checklists, planners)
- Using visual aids to make it easier to act on instructions
- Explaining how to use visual elements to support actions

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Japanese version of PEMAT-P
- **Methods/Levers:** Binary-item assessment of 7 actionability criteria (agree/disagree)
- **Operational Steps / Workflow:** Identify CKD webpages → classify by topic/source/audience → score
- **Data & Measures:** Actionability percentage score (threshold 70% for acceptable)
- **Implementation Context:** Japanese-language CKD patient educational webpages

> “We calculated the PEMAT-P scores… multiplying the result by 100 to obtain a percentage… set the th

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — “Many had difficulty using only common, everyday language and did not explain
- **CR (Contextual Relevance):** Yes — lifestyle modification materials were more relevant and actionab
- **FE (Feasibility):** Yes — tangible tools/checklists suggested for feasibility (p. 6)
- **TI (Timeliness):** No explicit link found
- **EX (Explainability):** Partial — some use of captions, but many visual aids unclear (p. 5)
- **GA (Goal Alignment):** Partial — lifestyle recommendations aligned with health goals (p. 4)
- **Other Dimensions Named by Authors:** Use of plain language, structured layout, visual reinforcement

Theoretical or Conceptual Foundations

- PEMAT framework (AHRQ)
- National Action Plan on Health Literacy (U.S. HHS)

Indicators or Metrics for Actionability

- PEMAT-P actionability score (% of applicable items marked “agree”)
- Threshold ≥70% considered actionable

Barriers and Enablers to Actionability

- **Barriers:** Excessive medical jargon; lack of visual aids for actions; absence of tangible tools; unclear
- **Enablers:** Use of plain language; clear, patient-centered visuals; structured actionable steps; comme

Relation to Existing Literature

Findings align with prior studies showing lower actionability than understandability, and the need for bette

Summary

The paper offers a robust, operationalized view of actionability grounded in the PEMAT framework, applie

Scores

- **Overall Relevance Score:** 85 — Strong conceptual framing via PEMAT and clear link between attribu
- **Operationalization Score:** 80 — Fully operationalized through PEMAT-P items and scoring; provides

Supporting Quotes from the Paper

- “PEMAT systematically examines how the required action points are presented” (p. 2)
- “The material clearly identifies at least one action the user can take” (Table 2, p. 5)
- “Lacked clear and concise charts and illustrations to encourage action” (p. 1)
- “Webpages… lacked visual aids to encourage the audience to take action” (p. 3)

Actionability References to Other Papers

- Shoemaker SJ et al. (2014) — Development of PEMAT (Patient Educ Couns)

- National Action Plan to Improve Health Literacy (U.S. HHS, 2010)

- Morony S et al. (2017) — CKD lifestyle info and actionability analysis

Paper Summary

<!--META_START-->

Title: Directive Explanations for Actionable Explainability in Machine Learning Applications

Authors: Ronal Singh, Tim Miller, Henrietta Lyons, Liz Sonenberg, Eduardo Velloso, Frank Vetere, Piers

DOI: 10.1145/3579363

Year: 2023

Publication Type: Journal

Discipline/Domain: Human-Computer Interaction / Artificial Intelligence

Subdomain/Topic: Explainable AI (XAI), Counterfactual Explanations, Actionable Recourse

Eligibility: Eligible

Overall Relevance Score: 95

Operationalization Score: 90

Contains Definition of Actionability: Yes (explicitly defines “directive explanations” as a form of actionable

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes (MDP-based model)

Operationalization Present: Yes

Primary Methodology: Mixed Methods (Quantitative + Qualitative user studies, conceptual modeling)

Study Context: Credit scoring and employee satisfaction prediction systems

Geographic/Institutional Context: United States participants, University of Melbourne research team

Target Users/Stakeholders: Loan officers, HR officers, decision recipients (customers, employees)

Primary Contribution Type: Conceptual model + empirical evaluation

CL: Yes

CR: Yes

FE: Yes

TI: Partial

EX: Yes

GA: Yes

Reason if Not Eligible: N/A

<!--META_END-->

Title: Directive Explanations for Actionable Explainability in Machine Learning Applications

Authors: Ronal Singh, Tim Miller, Henrietta Lyons, Liz Sonenberg, Eduardo Velloso, Frank Vetere, Pi

DOI: 10.1145/3579363

Year: 2023

Publication Type: Journal

Discipline/Domain: Human-Computer Interaction / Artificial Intelligence

Subdomain/Topic: Explainable AI, Counterfactuals, Actionable Recourse

Contextual Background: The paper addresses the gap between counterfactual explanations (which st

Geographic/Institutional Context: Conducted by University of Melbourne with US-based MTurk particip

Target Users/Stakeholders: Decision recipients, intermediary decision communicators, designers of M

Primary Methodology: Mixed Methods (Quantitative + Qualitative studies + conceptual modeling)

Primary Contribution Type: Conceptual model (MDP framework) + empirical evaluation.

General Summary of the Paper

The authors propose **directive explanations** as a way to make AI explanations more actionable by exp

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is framed as enabling **recourse**—guiding individuals not just on what feature values woul

> “A directive explanation … offers specific actions an individual could take to achieve their desired outco

> “Counterfactual explanations should be directive in that they should include suggestions or recommend

What Makes Something Actionable

- Ties counterfactuals to **mutable and feasible actions**.
- Specifies **sequences** of dependent actions, not just one-step changes.
- Accounts for **action costs** and individual feasibility.
- Provides either **specific actionable steps** or **generic guidance** to preserve autonomy.

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** MDP-based directive explanation generation model.
- **Methods/Levers:** Use of Monte Carlo Tree Search to find policies transitioning from factual to counte
- **Operational Steps / Workflow:**
  1. Generate counterfactual states using existing algorithms (e.g., Russell 2019).
  2. Define mutable features and possible actions.

3. Model state transitions and action costs in MDP.
4. Search for optimal policy (action sequence) to reach counterfactual.
5. Post-process for directive-generic explanations by grouping actions.

- **Data & Measures:** Credit scoring and employee satisfaction datasets; user preference rankings; ther
- **Implementation Context:** Simulated loan officer and HR officer decision communication.

> “Actions from πi must lead from x to ci… model must capture different ways to achieve specific outcome

> “Policy πi is the source of the directives in the directive explanations.” (p. 6–7)

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — explicit link between action and outcome. “Provides clear actions… so the custo
- **CR (Contextual Relevance):** Yes — tailored to recipient’s situation and domain. (p. 16–17)
- **FE (Feasibility):** Yes — consideration of whether directives are realistic and achievable. (p. 17)
- **TI (Timeliness):** Partial — relevance discussed when outcomes are imminent, but not formalized as
- **EX (Explainability):** Yes — explanations remain interpretable, showing causal pathways.
- **GA (Goal Alignment):** Yes — directives are aligned with recipient’s desired outcome.
- **Other Dimensions:** Autonomy (directive-generic explanations preserve choice), Social Acceptability

Theoretical or Conceptual Foundations

- Counterfactual explanations literature (Wachter et al. 2017)
- Algorithmic recourse and causal modeling (Karimi et al. 2021)
- Markov Decision Processes and planning theory (Puterman 2014, Geffner & Bonet 2013)

Indicators or Metrics for Actionability

- User preference ranking between explanation types.
- Qualitative themes on perceived usefulness, feasibility, autonomy.
- Domain-specific acceptance patterns.

Barriers and Enablers to Actionability

- **Barriers:** Social sensitivity of directives, infeasibility of actions, lack of user autonomy, condescendin
- **Enablers:** Clear linkage between actions and outcomes, multiple feasible options, domain familiarity,

Relation to Existing Literature

Builds on counterfactual explanations but addresses lack of explicit action guidance. Extends recourse w

Summary

This paper advances the concept of **actionable explainability** by formalizing “directive explanations” th

Scores

- **Overall Relevance Score:** 95 — Explicitly defines actionability, ties it to recourse, offers detailed con

- **Operationalization Score:** 90 — Provides a full computational method (MDP model) and empirical va

Supporting Quotes from the Paper

- “[A] directive explanation … offers specific actions an individual could take to achieve their desired outc
- “Counterfactual explanations should be directive in that they should include suggestions or recommenda
- “Actions from πi must lead from x to ci… model must capture different ways to achieve specific outcome
- “Provides clear actions… so the customer will know what to do next.” (p. 16)
- “I picked [directive-generic] based on how feasible I thought each strategy would be.” (p. 17)

Actionability References to Other Papers

- Wachter et al. 2017 (counterfactual explanations)
- Karimi et al. 2021 (algorithmic recourse via causal models)
- Tsirtsis et al. 2021 (sequential decision-making counterfactuals)
- Russell 2019 (diverse counterfactual generation)
- Puterman 2014; Geffner & Bonet 2013 (MDP and planning frameworks)

Paper Summary

<!--META_START-->

Title: Evaluating Online and Offline Health Information With the Patient Education Materials Assessment

Authors: Emi Furukawa, Tsuyoshi Okuhara, Mingxin Liu, Hiroko Okada, Takahiro Kiuchi

DOI: 10.2196/63489

Year: 2025

Publication Type: Journal Article (Protocol)

Discipline/Domain: Health Communication / Health Literacy

Subdomain/Topic: Patient Education Materials Evaluation

Eligibility: Eligible

Overall Relevance Score: 85

Operationalization Score: 70

Contains Definition of Actionability: Yes

Contains Systematic Features/Dimensions: Yes

Contains Explainability: No

Contains Interpretability: No

Contains Framework/Model: Yes

Operationalization Present: Yes

Primary Methodology: Systematic Review Protocol (Conceptual/Methodological)

Study Context: Systematic review of studies evaluating patient education materials using the PEMAT

Geographic/Institutional Context: International; led by The University of Tokyo, Japan

Target Users/Stakeholders: Health communication researchers, patient educators, health institutions, pol

Primary Contribution Type: Methodological framework for systematic review

CL: Yes

CR: Yes

FE: Yes

TI: No

EX: No

GA: Partial

Reason if Not Eligible: N/A

<!--META_END-->

Title:

Evaluating Online and Offline Health Information With the Patient Education Materials Assessment Tool:

Authors:

Emi Furukawa, Tsuyoshi Okuhara, Mingxin Liu, Hiroko Okada, Takahiro Kiuchi

DOI:

10.2196/63489

Year:

2025

Publication Type:

Journal Article (Protocol)

Discipline/Domain:

Health Communication / Health Literacy

Subdomain/Topic:

Patient Education Materials Evaluation

Contextual Background:

The paper presents a protocol for a systematic review of studies using the Patient Education Materials As

Geographic/Institutional Context:

International scope; coordinated by The University of Tokyo Hospital and Graduate School of Medicine.

Target Users/Stakeholders:

Health communication researchers, patient education specialists, health literacy advocates, public health

Primary Methodology:

Conceptual and methodological protocol for systematic review.

Primary Contribution Type:

Methodological framework and synthesis approach.

General Summary of the Paper

This protocol outlines a systematic review plan to analyze how the PEMAT has been used to evaluate the

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is defined by PEMAT as “the likelihood that the reader or viewer will know how to act on the

> “Actionability refers to the likelihood that the reader or viewer will know how to act on the information pr

> “Understanding the material alone is insufficient; a separate evaluation is necessary to determine wheth

What Makes Something Actionable

- Clear, specific instructions for action.
- Concrete steps enabling readers to perform recommended behaviors.
- Contextual relevance to target users.
- Structured presentation that facilitates translation from information to behavior.

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Patient Education Materials Assessment Tool (PEMAT)
- **Methods/Levers:** Application of PEMAT-P (print) and PEMAT-A/V (audiovisual) formats, scoring acti
- **Operational Steps / Workflow:** Literature search → screening → data extraction of PEMAT scores →
- **Data & Measures:** PEMAT’s actionability items (20–26 for print, 20–22 & 25 for audiovisual), scored
- **Implementation Context:** Applied in diverse cultural and linguistic contexts for cross-study comparisc

> “On the practical side, the PEMAT visualizes the challenges of materials to find the most understandab

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — Clear presentation and understandable content are necessary precursors to acti
- **CR (Contextual Relevance):** Yes — Materials must match the needs and settings of the intended au
- **FE (Feasibility):** Yes — Materials must present actions the audience can realistically perform.
- **TI (Timeliness):** No — Not explicitly linked to actionability.
- **EX (Explainability):** No — Not explicitly tied to actionability.
- **GA (Goal Alignment):** Partial — Alignment with intended health behavior is implied but not systemati
- **Other Dimensions Named by Authors:** Understandability as a prerequisite; cultural and linguistic ada

Theoretical or Conceptual Foundations

- Health literacy theory.
- Garner et al.’s three-step model of audience interaction with materials (reading, understanding, respond
- Organizational health literacy frameworks (Healthy People 2030).

Indicators or Metrics for Actionability

- PEMAT actionability score (0–100%).
- Item-level scoring on explicit action guidance and steps.

Barriers and Enablers to Actionability

- **Barriers:** Lack of patient perspective in PEMAT scoring; heterogeneity in methods across studies; ex
- **Enablers:** Standardized, validated PEMAT tool; availability in multiple languages; ability to compare

Relation to Existing Literature

Builds on prior scoping reviews of health material quality assessment but is the first systematic synthesis

Summary

This protocol establishes a systematic approach for synthesizing global evidence on the understandability

Scores

- **Overall Relevance Score:** 85 — Strong, explicit conceptualization of actionability and its components
- **Operationalization Score:** 70 — Provides a clear methodological framework for assessing actionabili

Supporting Quotes from the Paper

- “Actionability refers to the likelihood that the reader or viewer will know how to act on the information pre
- “Understanding the material alone is insufficient; a separate evaluation is necessary to determine wheth
- “On the practical side, the PEMAT visualizes the challenges of materials to find the most understandabl

Actionability References to Other Papers

- Shoemaker et al., 2014 — Original PEMAT development.
- Garner et al., 2012 — Framework for evaluating patient information leaflets.
- CDC Clear Communication Index.

Paper Summary

<!--META_START-->

Title: Counterfactual Explanations Without Opening the Black Box: Automated Decisions and the GDPR

Authors: Sandra Wachter, Brent Mittelstadt, Chris Russell

DOI: 10.2139/ssrn.3063289

Year: 2018

Publication Type: Journal Article

Discipline/Domain: Law & Technology

Subdomain/Topic: Algorithmic Decision-Making, Data Protection, Explainable AI

Eligibility: Eligible

Overall Relevance Score: 95

Operationalization Score: 90

Contains Definition of Actionability: Yes (implicit, in terms of what makes explanations actionable for data

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Yes (Counterfactual Explanation framework)

Operationalization Present: Yes

Primary Methodology: Conceptual + Technical Demonstration

Study Context: Automated decision-making under GDPR constraints

Geographic/Institutional Context: European Union, GDPR context

Target Users/Stakeholders: Data subjects, policymakers, data controllers, AI developers

Primary Contribution Type: Conceptual framework + technical method proposal

CL: Yes

CR: Yes

FE: Partial

TI: Partial

EX: Yes

GA: Partial

Reason if Not Eligible: N/A

<!--META_END-->

Title:

Counterfactual Explanations Without Opening the Black Box: Automated Decisions and the GDPR

Authors:

Sandra Wachter, Brent Mittelstadt, Chris Russell

DOI:

10.2139/ssrn.3063289

Year:

2018

Publication Type:

Journal Article

Discipline/Domain:

Law & Technology

Subdomain/Topic:

Algorithmic Decision-Making, Data Protection, Explainable AI

Contextual Background:

The paper addresses the problem of explaining complex algorithmic decisions under the GDPR without r

Geographic/Institutional Context:

European Union, GDPR regulatory environment.

Target Users/Stakeholders:

Data subjects, policymakers, regulators, AI system designers, data controllers.

Primary Methodology:

Conceptual analysis with technical implementation examples.

Primary Contribution Type:

Proposal and justification of a new explanation method (counterfactual explanations) with legal, philosoph

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General Summary of the Paper

The authors critique the GDPR's limited and ambiguous provisions on explaining automated decisions, n

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Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is framed in terms of explanations that enable the *data subject to act*—to understand a dec

> "Looking at explanations as a means to help a data subject act rather than merely understand…" (p. 84

> "An explanation… does not necessarily hinge on… understanding how algorithmic systems function." (

What Makes Something Actionable

- Provides clear, minimal, relevant changes to variables that would alter the decision.
- Expressed in terms directly relevant to the individual's circumstances.
- Supports specific goals: understanding, contesting, or changing outcomes.

- Avoids unnecessary technical or internal model details.
- Must be intelligible, concise, and accessible to non-experts.

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Counterfactual Explanations.
- **Methods/Levers:** Optimization to find minimally different “possible worlds” producing a different decis
- **Operational Steps / Workflow:**
  1. Fix model parameters after training.
  2. Search for an alternative input vector close to the original.
  3. Ensure minimal and realistic changes (sparse changes).
  4. Output human-readable “if-then” statements.
- **Data & Measures:** LSAT and Pima Diabetes datasets; performance measured by plausibility and spa
- **Implementation Context:** Applicable across domains where individual-level decisions are made.

> “Unconditional counterfactual explanations should be given for positive and negative automated decisio
> “If your LSAT was 34.0, you would have an average predicted score (0).” (p. 858)

Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — Must be “concise, transparent, intelligible” (p. 871).
- **CR (Contextual Relevance):** Yes — Tailored to the individual’s data and decision context (p. 843–84
- **FE (Feasibility):** Partial — Mutability and practicality of changes considered but not guaranteed (p. 8
- **TI (Timeliness):** Partial — Can be given post-decision; real-time use possible but not core focus (p. 8
- **EX (Explainability):** Yes — Provides rationale via dependency on external facts (p. 845).
- **GA (Goal Alignment):** Partial — Aims to support user goals (understand, contest, alter), but no explic
- **Other Dimensions:** Legal compatibility; minimal intrusion on rights of others.

Theoretical or Conceptual Foundations

- Analytic philosophy of knowledge (“justified true belief,” counterfactual reasoning).
- Possible worlds semantics (David Lewis).
- Causal reasoning in fairness (Pearl).

Indicators or Metrics for Actionability

- Minimal number of changed variables (sparsity).

- Plausibility of changes (within realistic ranges).
- Relevance to individual's mutable characteristics.

Barriers and Enablers to Actionability

- **Barriers:** GDPR's limited scope for explanations; possible unchangeable variables; cost of computat
- **Enablers:** Model-agnostic applicability; computational efficiency; legal compatibility; minimal trade se

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Relation to Existing Literature

Contrasts with ML interpretability work focusing on internal logic; aligns with fairness literature using coun

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Summary

The paper redefines "actionability" for explanations of automated decisions under GDPR as enabling the

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Scores

- **Overall Relevance Score:** 95 — Strong, explicit linkage between explanation design and enabling us
- **Operationalization Score:** 90 — Clear technical method with worked examples; some limitations on f

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Supporting Quotes from the Paper

- "An explanation… does not necessarily hinge on… understanding how algorithmic systems function." (p
- "Unconditional counterfactual explanations should be given for positive and negative automated decisio
- "If your LSAT was 34.0, you would have an average predicted score (0)." (p. 858)
- "Concise, transparent, intelligible and easily accessible form." (p. 871)

Actionability References to Other Papers

- Lewis, *Counterfactuals* (1973)
- Pearl, *Causation* (2000)
- Kusner et al., "Counterfactual Fairness" (2018)
- Citron & Pasquale, on hypothetical alterations in credit scoring (2014)

Paper Summary

<!--META_START-->

Title: Assessing the understandability and actionability of online resources for patients undergoing hemod

Authors: Emi Furukawa, Tsuyoshi Okuhara, Hiroko Okada, Yumiko Fujitomo, Takahiro Kiuchi

DOI: https://doi.org/10.1111/1744-9987.14221

Year: 2025

Publication Type: Journal

Discipline/Domain: Health Communication / Nephrology

Subdomain/Topic: Patient education, online health resources, health literacy assessment

Eligibility: Eligible

Overall Relevance Score: 78

Operationalization Score: 85

Contains Definition of Actionability: Yes (via PEMAT-P framework)

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Partial

Contains Interpretability: Partial

Contains Framework/Model: Yes (PEMAT-P)

Operationalization Present: Yes

Primary Methodology: Quantitative / Cross-sectional evaluation study

Study Context: Evaluation of Japanese-language online patient education materials on hemodialysis usin

Geographic/Institutional Context: Japan (University of Tokyo Hospital, Graduate School of Medicine)

Target Users/Stakeholders: Patients undergoing hemodialysis, healthcare providers, patient education m

Primary Contribution Type: Empirical assessment and guidance for material improvement

CL: Yes

CR: Yes

FE: Yes

TI: No

EX: Partial

GA: Partial

Reason if Not Eligible: N/A

<!--META_END-->

Title:

Assessing the understandability and actionability of online resources for patients undergoing hemodialysi

Authors:

Emi Furukawa, Tsuyoshi Okuhara, Hiroko Okada, Yumiko Fujitomo, Takahiro Kiuchi

DOI:

https://doi.org/10.1111/1744-9987.14221

Year:

2025

Publication Type:

Journal

Discipline/Domain:

Health Communication / Nephrology

Subdomain/Topic:

Patient education, online health resources, health literacy assessment

Contextual Background:

The study evaluates whether Japanese-language online materials for patients on hemodialysis are under

Geographic/Institutional Context:

Japan; University of Tokyo Hospital; Graduate School of Medicine, University of Tokyo.

Target Users/Stakeholders:

Patients undergoing hemodialysis, their families, healthcare providers, and material developers.

Primary Methodology:

Quantitative cross-sectional content evaluation.

Primary Contribution Type:

Empirical assessment with actionable recommendations for improving educational resources.

General Summary of the Paper

This cross-sectional study assessed 194 Japanese-language online educational materials for patients un

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Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

The paper adopts the PEMAT-P definition: actionability refers to how well materials enable patients to ide

> “Actionability… evaluates how well patients can identify what they need to do based on the information

> “Scores below 70% indicated poor… actionability, whereas scores of 70% or higher were considered…

What Makes Something Actionable

- Clearly identifies at least one specific action a user can take.
- Addresses the user directly in describing actions.
- Breaks down actions into explicit steps.
- Provides tangible tools (e.g., checklists, planners) to facilitate the action.
- Uses visual aids to make instructions easier to follow.
- Explains how to interpret charts, graphs, or tables for taking action.

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Japanese version of PEMAT-P (Patient Education Materials Assess
- **Methods/Levers:** Binary scoring (agree/disagree) across seven actionability items; 70% threshold fo
- **Operational Steps / Workflow:** Identify actions, address user directly, break down steps, provide tool
- **Data & Measures:** PEMAT-P scores; Kruskal–Wallis test for group differences; inter-rater reliability v
- **Implementation Context:** Applied to Japanese online HD materials from diverse sources and content

> “More than half of the materials satisfied Item 19… However, <30%… met Item 21… Item 22… Item 24

> “Self-management materials tended to offer more detailed instructions and utilized visual aids to facilita

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Dimensions and Attributes of Actionability (Authors’ Perspective)

- **CL (Clarity):** Yes — linked via plain language and absence of distracting information.
- **CR (Contextual Relevance):** Yes — self-management content most relevant and actionable.
- **FE (Feasibility):** Yes — inclusion of tangible tools and breakdown of steps supports feasibility.
- **TI (Timeliness):** No explicit link found.
- **EX (Explainability):** Partial — explanation of how to use visual aids was rare (<10%).
- **GA (Goal Alignment):** Partial — some materials align with patient self-care goals (e.g., self-manager
- **Other Dimensions Named by Authors:** Use of visual aids, chunking information, providing summaries

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Theoretical or Conceptual Foundations

- PEMAT-P framework for defining and measuring understandability and actionability.
- Health literacy principles, including plain language and visual aid effectiveness.
- Prior literature on patient education in CKD and HD contexts.

Indicators or Metrics for Actionability

- PEMAT-P actionability subscore (% of items rated “agree” out of applicable items).

- ≥70% threshold for actionable materials.

Barriers and Enablers to Actionability

- **Barriers:**
  - Lack of summaries.
  - Inadequate titling/captioning of visual aids.
  - Minimal use of tangible tools for action.
  - Complex syntax and medical jargon.
- **Enablers:**
  - Direct address to the user.
  - Clear identification of actions.
  - Detailed step-by-step instructions in self-management materials.
  - Effective visual aids used by for-profit company materials.

Relation to Existing Literature

The authors note similar deficiencies in English-language HD and CKD materials internationally, such as

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Summary

This study provides a quantitative assessment of the understandability and actionability of Japanese onli

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Scores

- **Overall Relevance Score:** 78 — Strong definition via PEMAT-P, clear articulation of features tied to a
- **Operationalization Score:** 85 — Detailed use of PEMAT-P with actionable criteria, scoring method, a

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Supporting Quotes from the Paper

- “Actionability… evaluates how well patients can identify what they need to do based on the information
- “More than half… satisfied Item 19… <30% met Item 21… Item 22… Item 24… and Item 25.” (p. 204)
- “Self-management materials… offered more detailed instructions and utilized visual aids… distinguishin
- “Development and dissemination of quality materials… can minimize the gap between patient educatio

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Actionability References to Other Papers

- Shoemaker SJ et al. (2014) — development of PEMAT.

- Furukawa E et al. (2022) — Japanese version of PEMAT validation.
- Studies on readability and quality of CKD/HD patient education (e.g., Bresler et al., 2021; Tuot et al., 20
- Federal Plain Language Guidelines (2011).