

Recent advances in refutations and validations using Meth8 modal logic model checker

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In applied and theoretical mathematics, assertions are categorized in alphabetical order as: axiom; conjecture; definition, entry; equation; expression; formula; functor; hypothesis; inequality; metatheorem; paradox; problem; proof; schema; system; theorem; and thesis. We evaluate 268 artifacts in 1356 assertions to confirm 284 as tautology and 1072 as not (79%). We use Meth8, a modal logic checker in five models.

The semantic content or predicate basis of some expressions on their face does not disqualify them from evaluation by Meth8 in classical modal logic. However, the rules of classical logic, as based on the corrected Square of Opposition by Meth8, apply to virtually any logic system. Consequently some numerical equations are mapped to classical logic as Meth8 scripts.

The rationale for mapping quantifiers as modal operators is in the Appendix based on satisfiability and reproducibility of validation of syllogisms.

A table lists what was tested with separated results. The names are numbered in alphabetical order. Test results are Invalidated as Not Validated Tautology (nvt), *not* tautologous, or Validated as Tautology (vt), tautologous. For a paradox, *not* tautologous means it is not a paradox or contradiction.

The experimental tests used variables for 4 propositions, 4 theorems, and 11 propositions. The size of truth tables are respectively for 16-, 256-, and 2048- truth values. One formula of Popper in 250-characters processed in 125-steps instantly due to recent advances in look up table indexing.

The Meth8 modal theorem prover implements the logic system variant VL4 which corrects the quaternary Ł4 of Łukasiewicz. There are two sets of truth values on the 2-tuple {00, 10, 01, 11} as respectively {False proof for contradiction; Contingent for falsity; Non contingent for truthity; Tautology for proof} and {Unevaluated; Improper; Proper; Evaluated}. The designated proof value is T for tautology and E for evaluated. The model checker contains recent advances in parsing technology and is U.S. Patent Pending.

The mapping of formulas into Meth8 script was performed by hand, checked, and tested for accuracy of intent. (A semi-automation of that process is underway.) The Meth8 script uses literals and connectives in one-character. Propositions are p-z, and theorems are A-B. The connectives for {and, or, imply, equivalent} are {&, +, >, =}. The negated connectives for {nand; nor; not imply; exclusive-or} are {\, -, <, @}. The operators for {not; possibility $\diamond \exists$; necessity $\square \forall$ } are {\sim, %, #}. Some expressions are adopted for clarity such as: (p=p) for tautologous; (p@p) for contradiction; and (x<y) for $x \in y$. The expression $x \leq y$ as "x less than or equal to y" is rendered in the negative as $\sim(y < x)$ or as $(\sim x > \sim y)$.

Definition	Axiom	Symbol	Name	Meaning	2-tuple	Binary ordinal
1	p=p	T	tautology	proof	11	3
2	p@p	F	contradiction	absurdum	00	0
3	%p>#p	N	non-contingency	truthity	01	1
4	%p<#p	C	contingency	falsity	10	2

Note the meaning of (%p>#p): a possibility of p implies the necessity of p; and some p implies all p. In other words, if a possibility of p then the necessity of p; and if some p then all p. This shows equivalence of respective modal operators and quantified operators, as proved in Appendix.

For Meth8 an immediate further application to "validate as tautologous" is mapping sentences of natural language into logical formulas. The approach identifies parts of speech as nouns, verbs, and modifiers. These translate into logical symbols for literals, connectives, and operators. For example: the conjunction "and" becomes the connective "&"; and the modifier articles "the" and "a" become the modal box # and lozenge %. Expressions for consecutive sentences are linked by the imply connective to build paragraphs to form requirements documents.

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No.	Name of object	Type of object	Results with instances
1	ABC	Conjecture	Invalidated
2	Abductive reasoning	System	Invalidated
3	Alcoholics Anonymous BB: We agnostics, p 53	Traditions	Invalidated
4	Alexandroff correspondence	Conditional	Invalidated (3)
5	Analysis as both correct and informative	Paradox	Invalidated (5)
6	Anderson division by zero as nullity	Theorem	Invalidated
7	Athanasian creed (Holy Trinity)	Credo	Invalidated (1) Validated (2)
8	Axiomatizing category theory in free logic	Axioms	Invalidated
9	Banach-Tarski	Paradox	Invalidated
10	Barcan	Formula	Validated
11	Bayes rule	Rule	Invalidated (11) Validated(11)
12	BCI / BCK algebra	System	Invalidated (5) Validated (3)
13	Bell / CHSH / Spekken toy model	Inequalities	Invalidated
14	Shortest refutation	Theorem	Invalidated (2)
15	Simplest refutation	Theorem	Invalidated (2)
16	Berkeley	Paradox	Invalidated
17	Bernstein-Vazirani	Algorithm	Invalidated (4) Validated (1)
18	Bertrand-Chebyshev theorem / postulate	Theorem	Invalidated (2)
19	Biscuit conditionals	System	Invalidated (13)
20	Bogdanov map, 2D conjugate of Hénon map	Formula	Invalidated
21	Born rule	Theorem	Invalidated (6)
22	Exclusivity rule as basis	Theorem	Invalidated (5)
23	Borsuk-Ulam theorem (BUT)	Conjecture	Invalidated (1)
24	Branching quantifier (Hintikka)	System	Invalidated
25	Brouwer fixed point theorem (BFPT)	Conjecture	Invalidated (3) Validated (2)
26	Buridan's Ass	Paradox	Invalidated
27	Cantor's continuum conjecture, binary injection	Hypothesis	Invalidated (2)
28	Continuum conjecture, interpreted	Hypothesis	Invalidated (3)
29	Diagonal argument	Proof	Invalidated (3)
30	Pairing	Functor	Invalidated (2)
31	Carroll's tortoise and Achilles	Paradox	Invalidated
32	Causality	Axiom	Invalidated (3) Validated (2)
33	Category composition of morphisms	Definition	Invalidated (1)
34	Chaitin incompleteness and L constant	Theorem	Invalidated (3) Validated (1)

No.	Name of object	Type of object	Results with instances
35	Chinese room argument: Brain Simulator Reply	Conjecture	Validated (3)
36	CHSH inequality	Conjecture	Invalidated (1)
37	Church	Thesis	Invalidated
38	Clausius-Clapeyron on spacial dimension	Equation	Invalidated (1)
39	Clifford tori 2D / Kanban cell neuron	Definition	Validated
40	Collatz	Conjecture	Invalidated (6)
41	Complementarity inequality	Refutation	Invalidated (2) Validated (1)
42	Complex (C), imaginary number rendering	Method	Invalidated (1) Validated (1)
43	Constructivistic logic	System	Invalidated (14) Validated (2)
44	Continuum hypothesis	Conjecture	Invalidated (2) Validated (1)
45	Craig's interpolation	Theorem	Invalidated (1)
46	Creative theories in degrees of unsolvability	Theorem	Invalidated
47	D Ultrafilter contra continuum problem	Equation	Invalidated (1)
48	Dedekind lattice identity	Axiom	Validated
49	Density of all Turing and truth table degrees	Formula	Invalidated (2)
50	Description logic	System	Invalidated (2)
51	Dialetheism	System	Invalidated (4)
52	Dialetheism: inconsistent	System	Invalidated (2)
53	Dichotomy of selection	System	Invalidated
54	Diverse double compiling	Schema	Invalidated
55	Doxastic logic	System	Invalidated (8) Validated (13)
56	Drinker's paradox	Paradox	Invalidated
57	$E=mc^2$	Theorem	Invalidated (3) Validated (1)
58	EF-axiom: topology and near sets	Axiom	Invalidated
59	Ehrenfeucht-Mostowski indiscernables	Theorem	Invalidated (1)
60	Einstein–Podolsky–Rosen (EPR)	Paradox	Invalidated (1)
61	Energy-mass equation, $E=mc^2$	Theorem	Invalidated (3) Validated (1)
62	Entanglement vs untanglement: no-no go-go	Conjecture	Invalidated (28)
63	Epicurus invoked by Epictetus	Paradox	Invalidated (1)
64	Epimenides the Cretan	Paradox	Invalidated (1)
65	Epistemic coalition	Perfect recall	Invalidated (4) Validated (3)
66	Epistemic dynamic reasoning	System	Invalidated (2)
67	Epistemic Hilbert substructure	System	Invalidated (5)
68	Epistemic navigation	System	Invalidated (8)

No.	Name of object	Type of object	Results with instances
69	Epistemic quantifiers over agents	Conjecture	Invalidated (8) Validated (12)
70	Erdős-Strauss	Conjecture	Invalidated
71	Euathlus paradox	Paradox	Invalidated (9)
72	Fitch's knowability	Paradox	Invalidated (4)
73	FOL disjunctive normal forms (DNF): minimize	FOL Optimizer	Invalidated (2) Validated (1)
74	Fredkin	Paradox	Invalidated (1)
75	Free will argument of Maimonides	Paradox	Invalidated (1)
76	Free will non-existence	Refutation	Invalidated (8) Validated (2)
77	Free will theorem: Clifton-Kochen-Specker	Theorem	Invalidated (1)
78	Free will theorem: FIN axiom	Hypothesis	Invalidated (2) Validated (2)
79	Free will theorem: MIN' axiom	Hypothesis	Invalidated (1)
80	Frequency dependence of mass	Theorem	Invalidated (3) Validated (1)
81	Functions as injective, surjective, bijective	Theorems	Validated (4)
82	Gentzen proof of sequent System G-M	System	Invalidated (6) Validated (2)
83	Gettier (justified belief)	Problem	Invalidated (6)
84	GHZ (Greenberger-Horne-Zeilinger)	Experiments	Invalidated (1)
85	Gleason	Theorem	Invalidated (1)
86	Gödel compactness	Theorem	Invalidated (6) Validated (2)
87	Gödel completeness	Theorem	Invalidated
88	Gödel completeness, shortest	Theorem	Invalidated (2)
89	Gödel first incompleteness	Theorem	Invalidated (4)
90	Gödel incompleteness	Equations	Invalidated (14) Validated (1)
91	Gödel incompleteness FOL	Contradictions	Invalidated (14) Validated (1)
92	Gödel incompleteness theorem	Assistant tools	Invalidated (2) Validated (2)
93	Gödel incompleteness theorem	Refutation	Invalidated (7)
94	Gödel-Löb	Axiom	Invalidated
95	Gödel pairing function	Axiom	Invalidated (3) Validated (1)
96	Gödel recursion	Theorem	Validated
97	Gödel-Scott on God	Theorem schema	Invalidated
98	Goldbach's conjectures	Conjectures	Invalidated
99	Grassmannian (<i>recently discovered</i>)	Paradox	Invalidated
100	Hadamard gate	Theory	Invalidated (3) Validated (1)
101	Hall	Effect	Invalidated
102	Hamiltonian quaternion	Definition	Invalidated (3)

No.	Name of object	Type of object	Results with instances
103	Hardy's generalized paradox	Conjecture	Invalidated (6)
104	Hegel's dialectic	Method	Invalidated (6) Validated (3)
105	Heider inspired international relations theory	Theory	Invalidated (5) Validated (1)
106	Heisenberg uncertainty principle	Axiom	Invalidated (2)
107	Take a picture of an electron	Principle	Invalidated (6) Validated (2)
108	Henkin cyclic algebra and first order logic	System	Invalidated (9) Validated (6)
109	Applications to logic	Axioms	Invalidated (8) Validated (6)
110	Permutation model nonrepresentable	Assertion	Invalidated (1)
111	Herbrand semantics	System	Invalidated (6)
112	Heyting-Brouwer intuitionistic logic	Systems	Invalidated (9) Validated (1)
113	Heyting logic	Idempotency	Invalidate (2) Validated (1)
114	Higher order logic	Systems	Invalidated (2) Validated (1)
115	Hilbert #10 Diophantine universal solution	Formulas	Invalidated
116	Hilbert generalization	System	Invalidated
117	Hilbert grand hotel	Paradox	Invalidated (1)
118	Huhn 2-distributive lattice identity	Formula	Invalidated
119	Ignorance of first choice	System	Invalidated
120	Imaginary numbers	Defintion	Invalidated (2)
121	Imperative logic	System	Invalidated (3) Validated (4)
122	Inconsistent theory	Theorem	Invalidated
123	Extending the monad to a triad	Formulas	Invalidated
124	Kunen inconsistency	Theorem	Invalidated
125	Independence-friendly logic (Kreiselization)	System	Invalidated (2)
126	Indicative conditionals	Encyclopedia entry	Invalidated
127	Induction: Black raven (swan); Kripkenstein	System	Invalidated (3)
128	Induction: New riddle	Paradox	Invaliddted (2)
129	Inequality: 'arbitrarily' vs 'sufficiently large	Conjecture	Invalidated (2) Validated (1)
130	Infinite set theory	Theorem	Invalidated
131	Information theory: mutual information	Definition	Invalidated (4)
132	Join-prime in lattice theory	Definition	Validated
133	Jonsson positive logic: retromorphism	System	Invalidated (3)
134	Kanban cell neuron maps whole brain	Model	Invalidated(242)Validated(14)
135	Kant: falsity of syllogistic figures	Theorems	Invalidated (8) Validated (2)
136	Karpenko, S.A.	System K-Ł4	Invalidated

No.	Name of object	Type of object	Results with instances
137	Kramers-Kronig	Relation	Invalidated
138	Kuratowski–Zorn lemma (Zorn's lemma)	Lemma	Invalidated
139	Lachlan problem solution	Problem	Invalidated (4)
140	Lattice logic, weak modular	Theorem	Invalidated (2)
141	Leibniz' ontological proof	Proof	Invalidated (1) Validated (1)
142	Briefest known ontological proof of God	Proof	Validated (2)
143	Lemmon D	Axiom	Invalidated
144	Liar	Paradox	Invalidated
145	Prior rendition	Paradox	Invalidated
146	Kripke rendition	Paradox	Invalidated
147	Linear algebra	Theorems	Invalidated (4)
148	Liouville	Theorem	Invalidated (2) Validated (1)
149	Löb original, corrected	Theorem	Invalidated (1) Validated (1)
150	Löwenheim–Skolem	Theorem	Invalidated (5)
151	Löwenheim–Skolem, Hilbert style	Metatheorem	Invalidated (4)
152	Luce model (general)	Definitions/Axioms	Validated (5)
153	Majorana's 'root'	Equations	Invalidated (5)
154	Metaphysics: "Something rather than nothing"	Problem	Validated (2)
155	Meth8/VŁ4 self-proof in one variable	Theorem	Validated (8)
156	Meth8 versus Prover9 via Lifshitz	Problem	Validated
157	Minkowski plane, classical set of points/cycles	Theorems	Invalidated (2) Validated (1)
158	Modal logics: 2; 3; 4; B; D; E; K; M; T; and W	Systems	Invalidated (2) Validated (8)
159	Modern modal logics (2): JYB4 and AR4	Axioms	Invalidated (13) Validated (6)
160	Modified divine command	Theory	Invalidated
161	Molyneux's problem	Problem	Invalidated (1)
162	Moral absolutism impossible	Conjecture	Invalidated (3) Validated (1)
163	Necessitation: K,T,4,B,D,5; D,M,S4,B,S5	Axiom	Invalidated (10) Validated (7)
164	Leonard Nelson's criticism of epistemology	System	Invalidated
165	von Neuman-Bernays-Gödel [NBG]	Theory	Invalidated (2) Validated (3)
166	Neutrosophic logic	Theorems	Invalidated (5)
167	Dezert-Smarandache	Theory	Invalidated (2)
168	Generalized Hegel's dialectics	Method	Invalidated (4)
169	Generalized intuitionistic, fuzzy logic	System	Invalidated (2)
170	Negated adjectival phrases	Lattices	Invalidated (2)

No.	Name of object	Type of object	Results with instances
171	Neutrosophic sets	Properties	Invalidated (3)
172	Quinary	System	Invalidated (2)
173	Soft lattice theory	Theorem	Invalidated (2)
174	Unification of other logics	Axioms / Rules	Invalidated (2)
175	Values as 1, 0, between 0 and 1	Designated logic	Invalidated (2)
176	Vector space on $\{-0, 0, 0 < p < 1, 1, 1+\}$	Multi-valued logic	Invalidated (3)
177	Newcomb's game	Paradox	Invalidated (2)
178	Nothing does not imply a non existent null set	Definition	Invalidated (7)
179	Nucleosynthesis	Definitions	Invalidated (4)
180	P=NP; 3-SAT	Conjectures	Invalidated (5)
181	Paraconsistency, machine-assisted view	Axioms	Invalidated
182	Paraconsistent contradiction	Conext	Invalidated
183	Paradox refutation reduced to one variable	Method	Validated
184	Pauli exclusion	Principle	Invalidated (4)
185	Peano arithmetic 9, 1-8	Axioms	Invalidated (1) Validated (8)
186	Poincaré recurrence theorem	Theorem	Invalidated (2)
187	Prenex normal format	Rules	Invalidated (11) Validated (3)
188	Karl Popper on God	Proof	Validated
189	PowerEpsilon mathematical induction	Axiom	Validated (1)
190	Prisoner's paradox	Paradox	Invalidated (3)
191	Prover9 vs Meth8 differences	System	Invalidated
192	Quantum arithmetic for repeat-until-success	Circuits	Invalidated (2)
193	Block chain	Cryptography	Invalidated (1)
194	Control by observation	System	Invalidated
195	Entanglement	Conjecture	Invalidated (5)
196	Gates correspond to logical operators	Theorems	Invalidated (4) Validated (1)
197	Gates refuted	Theorems	Invalidated (8) Validated (1)
198	Logic	System	Invalidated (17) Validated (2)
199	Masking	Conjectures	Invalidated (5) Validated (2)
200	Probability	Rule	Invalidated (2)
201	Simulation of Hamiltonian spectra	Operator	Invalidated (1)
202	Ternary probability of qutrit	Hypothesis	Invalidated (3)
203	Three lights experiment of qutrit	Conjecture	Invalidated (1)
204	Questions and answers	Problem	Invalidated (4) Validated (1)

No.	Name of object	Type of object	Results with instances
205	Ramsey's theorem for the 2-color case	Theorem	Validated (2)
206	Ranjan, A.	Problem	Validated
207	Realizability semantics for QML	Theorems	Invalidated (3)
208	Reichenbach common cause / event-splitting	Principle	Invalidated
209	Riemann: only zeroes at 0, 1/2	Hypothesis	Invalidated
210	Extended complex numbers on sphere	Operators	Invalidated (3) Validated (2)
211	Zeta function, Caceres 6	Proposition	Invalidated (4)
212	Roman Catholic Church (RCC)	(Dogma)	Invalidated (7)
213	Erasmus contra Luther	Controversy	Validated
214	Infallibility and the Historic Church	Pius IX	Invalidated (2)
215	Magisterium	Paul VI	Invalidated (1)
216	Tradition above scripture	Pius IX	Invalidated (4)
217	Rota lattice theory, distributive	Axiom	Invalidated
218	Russell	Paradox	Invalidated
219	S5II+ propositional quantification	System	Invalidated
220	Schrödinger's cat	Paradox	Invalidated
221	Self-equilibrium	Law / Paradox	Invalidated
222	Solovay arithmetical / semantical completeness	Theorem	Invalidated (10) Validated (2)
223	Sorites	Paradox	Invalidated
224	Special theory of relativity: Crothers refutation	Confirmation	Validated
225	Square of Opposition Meth8 Corrected	System	Validated
226	Square of Opposition Modern Revised	System	Invalidated
227	Square of Opposition	Proportions	Invalidated (3)
228	Stone space type lattice logic model	Theory	Invalidated (2)
229	Stone-Wales rotation transform reversibility	Theorem	Invalidated (2) Validated (1)
230	Superposition of states	Principle	Invalidated (6)
231	Tarski's undefinability of truth	Theorem	Invalidated (2)
232	Tarski–Grothendieck set theory	Axiom	Invalidated (2)
233	Tarski–Grothendieck Metamath ax-garth	Axiom	Invalidated (1)
234	Time as God	Conjecture	Validated (2)
235	Time as coexisting past, present, future states	Conjecture	Invalidated (3)
236	Time as tense via converse implication (EQT)	Conjectue	Validated (1)
237	Topological manifold transition	Function	Invalidated (1)
238	Turing halting problem	Problem	Invalidated (2) Validated (1)

No.	Name of object	Type of object	Results with instances
239	Twin paradox	Paradox	Invalidated (2)
240	Universal finite set	Theorem	Invalidated (2)
241	Unanswered logic questions	Conjectures	Invalidate (2) Validated (1)
242	Veblen (corrected)	Axiom	Invalidated (1) Validated (1)
243	Vickrey auction	Theorem	Invalidated (10) Validated (2)
244	Veronoï regions (with "nonempty sets")	Definition	Invalidated
245	Vongehr's shift rendering QM "natural"	Paradigm	Invalidated (2) Validated (3)
246	W (K4W)	Theorem	Invalidated
247	Well ordering property	Axiom	Invalidated
248	Wittgenstein's ab-notation	System	Invalidated (3)
249	Yalcin logic	Axioms	Invalidated (2)
250	Zadeh first operators on fuzzy logic	System	Invalidated (5)
251	Resolution and symmetry in Z-numbers	Definitions	Invalidated (2)
252	Zermello-Fraenkel (ZFC):	(Axioms)	Invalidated (13) Validated (2)
253	ZFC Choice	Axiom	Invalidated
254	ZFC Empty set	Axiom	Invalidated
255	ZFC Extensionality	Axiom	Invalidated (1) Validated (1)
256	ZFC Infinity	Axiom	Invalidated (2)
257	ZF INF	Axiom	Invalidated
258	ZFC Pairing	Axiom	Invalidated
259	ZFC Power set	Axiom	Invalidated
260	ZFC Regularity or foundation	Axiom	Invalidated
261	ZFC Schema of replacement	Axiom	Invalidated
262	ZFC Specification	Axiom	Validated
263	ZFC Union	Axiom	Invalidated
264	ZFC Well ordering	Axiom	Invalidated (2)
265	ZF Law of excluded middle: infinite set	Axiom	Invalidated (2)
266	Zero and one in fractions	Axioms	Invalidated (3) Validated (8)
267	Zero knowledge proof	Theorem	Invalidated
268	Zeroth law of thermodynamics	Theorem	Invalidated (3) Validated (2)