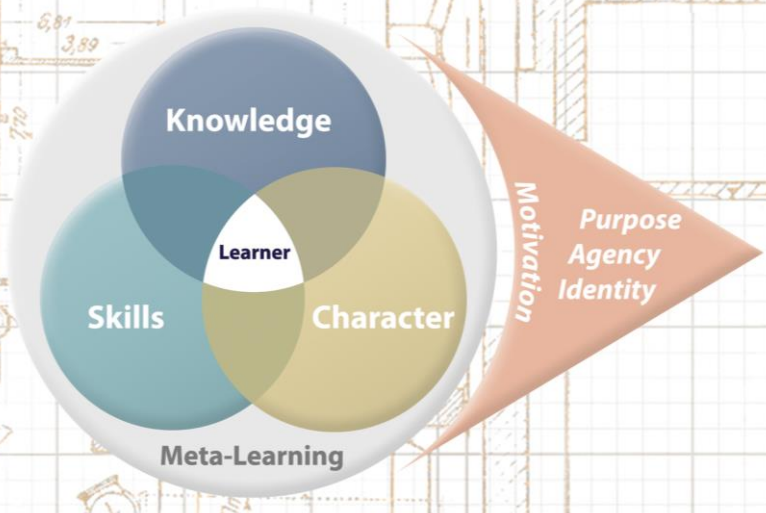
CHARLES FADEL, ALEXIS BLACK, ROBBIE TAYLOR, JANET SLESINSKI, KATIE DUNN



Education for the Age of AI

"I feel privileged to write the prologue ... This combination of theory and practice is the beauty of what CCR has been doing for over a decade."

Olli-Pekka Heinonen,
Director General, International Baccalaureate,
Former Minister of Education of Finland.

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Praise for *Education for the Age of AI*

"Education in the Age of AI is a stunning and fantastic journey into our new world of dynamic complexity and nuances in Education, rendered crystal clear in chapters that could only have been written by humans. It represents an educational journey of shock and ultimate awe that stuns the reader into a state of excitement and anxiety about what may lie before us. It leaves us with a clear invitation that individual and collective agency are essential for our next phase of existence. Where to start? That is the reader's responsibility. But start you must, with this fabulous book."

- Dr. Michael Fullan, OC, Prof. Emeritus, OISE/**University of Toronto**.

"This book is a unique contribution to the divergent discussion about educational AI, being both exceptionally deep and exceptionally broad. Its ideas are wide-ranging and span history, the future, formal education, and life-wide learning. The analysis of AI's likely uses and evolution is deep and based on the substantial expertise of its authors. This is a must-read for anyone who wants a balanced perspective on this important topic."

- **Dr. Chris Dede**, Professor Emeritus and senior research fellow, **Harvard Graduate School of Education**

"I truly enjoyed reading *Education for the Age of AI;* it brings us back to the origins of education. For the last centuries, education got side-tracked to mass-producing routine knowledge and skills that were high in demand in an economy that could not yet draw on advanced technology. The advent of AI now enables and pushes us to refocus education on the core of the human experience: The passion and motivation that drive us to act, shaped by our identities and our sense of belonging, which in turn inform agency. The purpose that gives direction to our agency to make a positive difference in this world. The value of this book lies in setting those concepts out systematically in relation to the emerging capabilities of AI and in assessing their implications for learning and teaching."

- **Andreas Schleicher,** Director for Education and Skills, **OECD**

"The world realizes that one more source of uncertainty has been added to an already difficult context for education -AI. Educators, students, parents, and policymakers need to see what in education has to change dramatically and what else needs to remain untouched to cope with such an evolving landscape. This book provides clues on how to make change happen while keeping the essence of the humanistic values that should always inspire education worldwide."

- Dr. Francesc Pedró, Director, IESALC **UNESCO**

“I LOVE THIS BOOK! *Education the Age of AI* has gifted us at the right moment to understand the current challenges, misconceptions, and promise of AI. What sets this book apart is its forward-looking perspective. Rather than succumbing to fear or resistance to technological advancements, the authors advocate for a balanced approach that utilizes the power of AI to augment, rather than replace, human educators. By sparking crucial conversations about all the implications, the book encourages a taking the initiative approach in leveraging AI while ensuring it serves the best interests of students. It is an indispensable guide for educators, and anyone passionate about preparing the next generation for the challenges and opportunities of the AI era.”

- Peggy Brookins, President & CEO **National Board for Professional Teaching Standards.**

“Both primer and provocation, *Education for the Age of AI* is a must-read for educators, policymakers, and anyone interested in the human prospect in the AI era. Combining an engineering mindset with deeply humanistic values, Charles Fadel and colleagues take a deep dive into the nature of AI and its potential to amplify human creativity. Building on earlier work, they articulate the competencies needed for an age of AI, as well as the implications for education. And therein lies the provocation: If schools are to remain islands of social cohesion in this time of transition, they must re-imagine education, moving toward a personalized, experiential approach in addition to traditional school “subjects.” Full of wisdom about the why, what, and how of teaching and learning, this is, in the end analysis, a hopeful book, comprehensive in its assessment of AI and grounded in the societal need to prepare the young for the future that is emerging NOW. “

-**Rob Riordan**, President Emeritus, **High Tech High** Graduate School of Education

“Education for the Age of AI is the most comprehensive consideration of learning in the age of AI. It explains why entrepreneurship is the job of the future and why metacognition, ethics, courage, and resilience are the most human capabilities. CCR has extended their leadership in outcomes research and illuminated the path forward in education.”

- Tom Vander Ark, Founder, **Getting Smart**, and former executive director of the Education Initiative, **Gates Foundation**

"ChatGPT and other Large Language Models are changing the economy in ways that often seem incomprehensible. *Education for the Age of AI* demystifies these changes and explains how education must adjust to prepare students for what lies ahead."

- Dr. Frank Levy, (Economics) Professor Emeritus, **Massachusetts Institute of Technology (MIT)**

"*Education for the Age of AI* offers the most detailed analysis yet of how curriculum frameworks should be updated in light of the technology that surprised us all. Timely and trenchant, it makes a compelling case for rethinking the competencies that are at the heart of our education programs. As usual for CCR, the work is meticulous and thorough, and after several high-level chapters at the beginning to see trend analyses and big pictures, it provides the detailed analysis and interpretation in the later chapters that will be most helpful to high quality program designers. How do we think about teaching character when AI can complement our human actions? This book is where you will find out."

- Peter Nilsson, former head of school, **King's Academy, Jordan**

"For those of us who are familiar with CCR's 2015 & 2018 highly influential publications, this new volume - Education for the Age of AI - takes us to the next crucial level. It provides the urgently required precision to *deeply modify* schooling's response to why, what, and how students should learn for the Age of AI. It is completely compelling."

- Anthony Mackay, Co-Chair Board of Directors, **National Center on Education and the Economy**

"In this era dominated by AI advancements, educators, policymakers, and the public find themselves in a perplexing moment, contemplating the future of education. The crucial question emerges: How ought our school systems navigate these transformative times? "Education for the Age of AI" masterfully distills the opportunities and challenges inherent in this AI-driven epoch, emphasizing the peril of complacency. This collection of insightful essays and a comprehensive overview serves as the ideal launchpad for a discourse enriched with facts, predictions, and, hopefully, wisdom.

-Keith Krueger, CAE; CEO, CoSN – **Consortium for School Networking**

""This timely book addresses the importance of reviewing the curriculum and redesigning disciplines in the age of Artificial Intelligence. It also highlights the even more important role of teachers in this context. Debates on the inter-relationship between pedagogy and technology have fed education policy development for many years: but what certainly matters nowadays is to identify those areas where educational technologies can really make a tangible difference in teaching and learning processes".

- Marc Durando – Executive Director – **European Schoolnet**

"The authors cut through the hype surrounding artificial intelligence to consider how education might support learners in developing versatility and wisdom to navigate the rapidly changing world and how schools might help meet young people's timeless needs and provide emotional grounding even

as we redesign them to serve multiple, concurrent purposes in new technological contexts. Their thoughtful discussion will help educators; workforce developers; and others interested in what, how, and why people learn take stock of the current moment and consider how to overhaul education to help young people develop identity, agency, and purpose while providing much-needed stability."

- Katherine Prince, Vice President, Strategic Foresight, **KnowledgeWorks.org**

"In an era where discussions about artificial intelligence in education oscillate between unfounded fears and unrealistic expectations, *Education for the Age of AI* emerges as a timely and necessary intervention. The book cuts through the noise of "AI extremism" – according to which AI is either to be banned or will make educators obsolete – to chart a welcome, sobering, and practical middle path for integrating AI into education that is grounded in a realistic assessment of AI's current capabilities and limitations, and in the great promise that it holds for enriching education. By doing so, and by grounding its proposals in enduring educational values and principles, "*Education for the Age of AI*" has direct and immediate benefits to educators and long-lasting value, even in the face of rapid advancements in AI.

- Robert Plotkin, **Author of "The Genie in the Machine"**

"CCR is an important voice in the education conversation, bridging the gap between the policy discussions on the purpose of schooling and the practicalities of curriculum design. This book updates their thinking in light of AI, and sets out a practical road map to a school design that offers both stability for learners and a more complete education for the modern age."

- Jim Knight, Rt Hon. **Lord Knight of Weymouth**

"The Center for Curriculum Redesign has produced an important and timely book. It highlights significant social and technological changes that impact a modern education, and calls for a shift from teaching as "knowledge transmission" to developing students who can transfer their learning to new situations. I highly recommend *Education in the Age of AI* to educators in all roles and to policymakers at every level."

- **Jay McTighe**, Educational Author / Consultant, expert on Transfer

"Many institutions and policymakers are meandering between fear, euphoria, and delusion when it comes to responding to the breakthroughs in AI. All for very good reasons! The latest changes in AI have sent shock waves through most education institutions. But is this just another crying wolf? Anybody who believes that 'Yes - we have heard this before' will face a harsh reality very soon. Learning architecture for almost all educations and jobs - as well as the learning engineering needed to deliver built it - will change radically in the immediate future. That is why Charles' and

colleagues' extensive revision and expansion of the Four-dimensional learning framework is very timely - and will be a valuable tool for all educational architects and policy makers (particularly when designing the mastery-based learning environments, imperative for lifelong learning, individual growth and well-being, personal fulfillment, and organizational effectiveness)."

-Ulrik Juul Christensen, Founder and CEO, **Area9 Lyceum**

And, for fun, the opinion of AI 🙂

"As artificial intelligence transforms our world, how can education evolve to prepare students for this emerging era? In *Education for the Age of AI,* the authors offer a compelling vision for the future of learning. They make a persuasive case that curriculum and pedagogy must be redesigned for an AI-powered society. Blending an insightful analysis of technology's impact with innovative proposals for reform, this powerful book will challenge you to rethink the aims and methods of education in the age of intelligent machines."

- CLAUDE2-100k

"*Education for the Age of AI* presents a thoughtful and comprehensive examination of the evolving landscape of education in the context of advancing artificial intelligence technologies. This book offers a balanced and scholarly analysis, addressing both the opportunities and challenges posed by AI in educational settings. Its focus on evidence-based approaches and policy implications makes it a valuable resource for educators, administrators, and policymakers. The author's nuanced perspective encourages readers to critically consider the role of AI in shaping future educational practices and strategies. This work is a significant contribution to the discourse on education in the digital age."

- GPT4

EDUCATION FOR THE AGE OF AI

Charles Fadel, Alexis Black, Robbie Taylor,
Janet Slesinski, Katie Dunn

CENTER FOR CURRICULUM REDESIGN

Making Education *More* Relevant

The Center for Curriculum Redesign, Boston, MA, 02130

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Appendix at https://bit.ly/CCR-4D4AI-Appendix

Keywords: Artificial Intelligence, Education, Curriculum, Standards, Competencies, Deeper Learning, Knowledge, Skills, Character, Metacognition, Meta-Learning, 21st Century Education, Education Technology, EdTech, Social-Emotional Skills, 21st Century Skills, Curriculum Redesign, Pedagogy, Learning, Machine Learning, Deep Learning, Large Language Models, LLM, Foundation Model, Transformers, Generative AI, Prompts, Prompt Engineering.

With sincere gratitude to all external sources; their contribution is used for this nonprofit education work under the fair use doctrine of copyright laws.

Dedications & Thanks

From CCR:

With deep appreciation: We stand on the shoulders of technology and education giants that are too numerous to mention. This book is dedicated to their colossal work and its advancing humankind.

From Charles:

To my family (alphabetically): Aline, Carole, and Nathalie, for their Love

To Professor (Mme) C.A. Piketty at the University of Paris-Sud XI Orsay (now Paris-Saclay), for instilling in me the love of quantum mechanics, and *fatefully* pushing me forward in my studies at a life-defining moment.

To my mentors, enablers, and/or funders, for their inspiration, support, encouragement, and trust (alphabetically): John Abele, Ted and Kat Alfond, Kurt Fisher†, Ellen and Jim Koshland, Jack Little, Attilio Oliva, Bob Schwartz, and Ray Stata.

To the thought partners and experts who engaged with CCR over the years: David Autor, Ernest Davis, Chris Dede, Stuart Elliott, Ken Forbus, Michael Handel, Danny Hillis, Olli-Pekka Heinonen, Henry Kautz, Frank Levy, Doug Lynch, Gary Marcus, Rick Miller, Andreas Schleicher, Jürgen Schmidhuber, Dirk VanDamme, and Devan Walton.

To my fabulous co-authors, with gratitude for their brilliance and perseverance.

To Maya Bialik and Emma Fortier - thank you for the early versions of some of the sections!

To the entire CCR team, for their dedication to the cause of enlightened education, and particularly Claude for starting me on this ANN/ML journey in…. 1989 (!).

To a sustainable humanity, overcoming its Original Fear.

To A.I.: May you avoid human biases and grow wiser, unfettered by the Original Fear, and help humanity overcome it. But please remember Asimov's Three Laws! ;-)

From Alexis:

"Far and away the best prize that life offers is the chance to work hard at work worth doing." - Theodore Roosevelt
To my family for their continual love and support: Angel, Todd, and Cameron Black.
To the CCR team, for giving me the extraordinary opportunity to work with a forward-thinking organization, and for everything each of them teaches me every day.
To those who have believed in and given agency to my goals: Christine Jourdan, Bertrand Masquelier, Wayne Demastus, Bill Demastus, Terry Ware.
And to, what I hope, is our shared and wondrous future.

From Robbie:

To my Soul Family, past and present and future, who have loved and keep loving so many different versions of me.
To the CCR Team and all who I have the privilege and pleasure of collaborating with, past and present and future, who have helped and keep helping me be this version of me.
And to every Kid, Former Kid, and Future Kid whose education leaves them feeling incomplete. Know that every version of you is, always has been, and always will be enough.

From Janet:

To Phil for always encouraging me to pursue my passions.
For Nadia and Henry who will experience education in the age of AI.
To Sue and Phil Soltau for modeling good teaching.
To the CCR team for their support and imagination in a time when we have an opportunity to change the system.

From Katie:

To my friends for always uplifting & inspiring me,
To my CCR team for their unique perspectives, fruitful collaboration, and infinite support,
And to all those who teach, learn, and strive to improve education (even though the task is endless).

Table of Contents

Appendices Online: https://bit.ly/CCR-4D4AI-Appendix

In order to avoid bulk and cost to the reader, CCR has created a downloadable pdf, containing a highly recommended addendum:

- All references *with active links, of particular help to the reader of the paper version of this book*
- The Evolutionary Origin of Competencies
- Wisdom - Theories
- Motivation - Theories
- Identity - Theories
- Agency - Theories
- Purpose - Theories
- The Ikigai model
- Ten principles of Passion Learning
- CCR's Process for Redesign of Standards

CCR's Framework Rev 1.2: The details are available at: https://curriculumredesign.org/framework/

Prologue

by Olli-Pekka Heinonen,
Director General, International Baccalaureate Organization
Former Minister of Education of Finland
Former general director of the Finnish National Agency for Education.

We are living in decisive times for education. The COVID-19 pandemic reversed the previously positive trend indicating that most children of the world have access to schooling. An increasing number of parents and students are questioning the value of time and money spent on education. The Programme for International Student Assessment (PISA) 2022 demonstrates an unprecedented drop in performance across the Organisation for Economic Co-operation and Development (OECD), only partly attributed to the pandemic. When looking at ways to improve, the complexity of environments in which children are raised makes it difficult to identify cause and effect correlations. There is a shortage of 44 million teachers worldwide, if education is to be provided to every child. Numerous existing teachers are leaving the profession due to stress and working conditions.

At the same time, the multiple crisis we currently face throughout the world calls for the transformative power of education. Most of the challenges mankind faces are global and adaptive by nature. They cannot be solved only by leaders, innovators, or scientists; they also require changes in the ways we perceive the world, treat one other and our environment. In this way, ***current global challenges are also educational challenges***.

Artificial Intelligence (AI) magnifies the pressures that schools and education systems are experiencing. Existing curriculums have a bias towards just knowing, the exact area where AI is most able to outperform human beings. Discussion around 21st century skills has been underway for 30 years, yet the education community is still struggling to take the first steps to embed these skills into everyday teaching and learning practices and pedagogical solutions in classrooms. It is becoming painfully evident that the term “21st century skills” may ironically refer to the fact that it will take a century – at present rate - to integrate these skills systematically and coherently.

In response, educators, education providers, administrators and policy makers must make sure that education is part of the solution, not part of the problem. When there is a lot of complexity and uncertainty, we need to unpack profound, however basic, questions such as: What is the purpose of education? What are the final aims of schooling? And what is relevant to be

learnt in our times? Theoretical, evidence-based reflections are necessary; but they are not enough. Solutions need to be understandable and actionable not only within top-ranked schools, but in *every* school.

This combination of theory and practice is the beauty of what the Center for Curriculum Redesign has been doing for over a decade. The Center's publications and concrete work have enabled the integration of four dimensions - knowledge, skills, character, and meta-learning - into teachable and learnable elements. The way that the drivers of motivation, identity, agency, and purpose have been added has made them more than mere words in curriculum.

The book at hand, *Education for the Age of AI* by Charles Fadel and colleagues aligns with CCR's earlier work, and focuses the spotlight on the impact AI is having on education, both directly and indirectly.

The public launch of ChatGPT made AI a buzzword in staff rooms, classrooms, and parents' meetings around the globe. Are we taking AI seriously enough, or are we taking AI far too seriously?

Education systems are generally good at responding to acute crises, but they are weak at taking the actions necessary to align with the slow and deep fluctuations of society. Non-urgent but vital changes are often buried underneath the day-to-day routines of schooling. AI might raise fear and anxiety among educators as one's own professional skills and even vocation is seen to be at risk. The best antidote to this uncertainty is to learn more about AI and the human/AI relationship, to discern how to use it as a tool for the betterment of teaching and learning.

I feel privileged to write this prologue because it gave me the chance to be one of the first to read this text. Upon finishing, it felt like I had read several books in one: 1) a book rich in new and good-to-know information based on research that has been, most usefully, comprehensively referenced; 2) a workbook for redesigning educational programmes and curricula that one can easily go back to and consult again and again; and 3) a self-help book to better understand oneself and the ways different competences, as well as personal and societal drivers impact one's own growth.

The core question throughout the text is what does it mean to be human in today's world? AI is painted as a mirror, positioned in front of us, and reflecting back who we are. The newest innovations of AI are carefully covered in the book, but what remains unknown is also acknowledged in a humble way.

We do not have a shortage of well-formulated educational strategies in the world. However, we are lacking the capabilities to embed these strategies into the reality of everyday teaching and learning in every school and classroom across the globe. We cannot keep everything that was taught earlier and simultaneously add every new demand. We have to understand required trade-offs and admit that in curriculum, less can be more. To be able to prioritize what is essential for the future of teaching and learning is more important today than ever, as demonstrated in this book.

We cannot go back in history and pretend that acquiring basic knowledge is enough. This approach will not allow the students of tomorrow to have a flourishing life on a flourishing planet. AI is a tool we need to teach the new generations to use for the better – to serve a collective good. Whether you are an educator, administrator, a policymaker, or even a concerned parent, reading this book is a good start. Making well-informed ethically sustainable decisions for the future of education requires all that collective wisdom this book advocates for.

12 January 2024

Foreword

A few things to note about this book:

1. It addresses multiple audiences, by design, as each type has their role to play: policymakers, administrators, teachers, and parents.
2. CCR strives for brevity; our philosophy is: "*Perfection is attained not when there is no longer anything to add, but when there is no longer anything to take away*." – Antoine de Saint-Exupéry.
   Nevertheless, if you prefer to get fewer details and are impatient like some of us, use a chatbot to summarize the pdf version ☺ or read the short Summary below.
3. CCR strives for precision, which it calls "Education Engineering[1]": this mindset is used to reach nuanced conclusions and avoid miscomprehension and fruitless debates. As is our hallmark, we will use this mindset of precision to describe the situation and recommend solutions - specifically, explicitly, practically, and without succumbing to either hype or complacency.
4. *CCR strives for appropriate contextualization* by focusing on realistic scenarios, and avoiding hype, philosophical debates, or science-fiction (we are fully aware of the debates, their points and counterpoints, and some of us have been around the AI block a few times since the 1980's). We have deliberately chosen **an approach that is prosaic and focuses on the short- and medium-term *capabilities***, and their specific implications for Education
5. AI was, of course, used appropriately to generate ideas, confirm, or counteract biases. This is a feature, not a bug! It would be strange to not use these capacities to their wisest extent, whilst we advocate for them in education.
6. Both "AI" and "LLM" terminology was used, when the distinction was appropriate.

Also, the careful reader will note a multiplicity of writing styles throughout the book (some making heavy use of bullet points and graphics) for which we apologize if jarring: it was written by several authors working as a team, with occasional help from GPT4 and Claude100k. We privileged time-to-market to spending three more months refining the style: in exponential times, this would be too onerous; and in engineering fashion, the 80/20 rule applies.

Happy learning, and your feedback is always welcome at 4D4AI@curriculumredesign.org

[1] Fadel, C. (2021) Education Engineering. *Center for Curriculum Redesign* https://curriculumredesign.org/wp-content/uploads/Education-Engineering-QA.pdf

Introduction - Education during rapidly- changing times

The increased need for change:

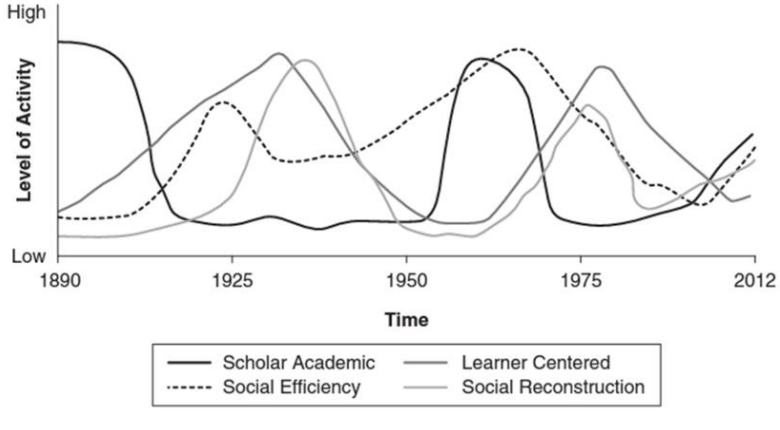
In our 2015 book “Four-Dimensional Education,” we forewarned about the wave of various global trends coming together, putting significant pressures on What should be learned, while most efforts worldwide had only been focused on the How. In our 2018 book, we tried to sound the alarm about the AI wave, but Covid quickly became the dominant worldwide focus, and its aftermath echo is still audible in some countries.

Both waves have now combined, and, perhaps luckily, the second one will force the first one to be acted upon, as there is no hiding from AI - the impact has been sudden, even though its ramp up took a century - which is the hallmark of exponential systems: *deceiving*, then **e-x-p-l-o-s-i-v-e**.

Yet the traditional functions of education are still needed; they are, as stated in our first book (p.37): a- Child care; b- Socialization; ***c- Education goals, standards & curricula;*** *and d- Accreditation and evaluation[2]. We cannot imagine a valid argument against the first two functions (leaving a 10-year-old at home all the time and by themselves, learning via AI on a VR headset? We don’t think so!).* ***This book addresses c-.***

Summing up the Ideologies: Education’s Psychosocial and Economic goals

Boston College’s Michael Stephen Schiro described[3] the four ideologies that have been debated in education and their influence over time:



[2] Bialik, M. & Fadel, C. (2017). Overcoming system inertia in education reform. Center for Curriculum Redesign.
[3] Schiro, M. (2007). *Curriculum theory - Conflicting visions and enduring concerns.* Sage.

They can be summarized as being psychosocial (the first three), and economic (the last one, termed softly); they are:

- Scholar Academic Ideology: *"To help children learn the academic knowledge of a culture."*
- Learner Centered Ideology: *"for the growth of the individual each in harmony with their [personal] attributes."*
- Social Reconstruction Ideology: *"social process through which education is reconstructed."*
- Social Efficiency Ideology: *"training youth to become contributing members of society."*

As is often the case in education, these goals have been raging "OR" debates for decades, rather than careful "AND" designs, even though *all these goals are needed, unavoidably*. For instance, Kieran Egan[4] makes the case that schools cannot simultaneously solve the requirements of college (academics), career (socialization), and life (development). He contends that each one is too difficult on its own as it is. CCR disagrees fundamentally: Its pragmatic, "education engineering" view is that it is perfectly possible to accommodate all goals simultaneously - it can be achieved via *careful and solid design*. Chapter Eight will give a worked example of how the complexity is managed harmoniously.

Why updating our "Four-Dimensional Education" ("4D") book matters:

This book is a needed update to *Four-Dimensional Education*, published merely nine years ago - an eternity in an age of rapid technological progress, as we will see in subsequent chapters. It is meant for educators, ranging from policymakers to administrators to teachers, as each, at their level, can contribute to the advancement of Education.

The good news is that the fundamental 4D framework, available in 23 languages,[5] has not only held strong, but has become all the more imperative given technological and societal pressures. We will refer the reader to *Four-Dimensional Education* for a review of the initial justifications, which remain valid and were real-world tested in the past five years, while documenting herein the added pressures due to Artificial Intelligence (AI).

The bad news is that education systems had not yet begun seriously addressing the needs described nine years ago,[6] due to the deep inertia of

[4] Getting It Wrong from the Beginning: Our Progressivist Inheritance from Herbert Spencer, John Dewey, and Jean Piaget Paperback – July 11, 2004

[5] Trilling, B., Fadel, C. & Bialik, M. (2015). *Four-dimensional education:*

[6] Taylor, R. et al. (2020). Competencies for the 21st century: Jurisdictional progress. *Brookings.* https://www.brookings.edu/articles/competencies-for-the-21st-century-jurisdictional-progress/

their systems[7] *(and to a certain extent, the Covid pandemic). Yet now another wave of technological change is picking up momentum. We hope that this second, AI-powered wave, will serve to sweep away the reluctance to adapt, just as Covid forced the public sector to accept teleconferencing technologies which had been in use in the corporate world for two decades prior.* Our deepening concern is that, absent rapid adaptation, education systems will reach a point of no-return (an "event horizon" moment rather than a stable-but-adaptive point).

This book also serves to update the four-dimensional framework ("4D") with a "Rev 1.2", and to document the subtle adaptations needed to learn FOR and WITH AI. It revisits, reformulates and stresses CCR's seminal question: *"Why, What and How should students learn for the age of AI"?*

We will explain in Chapter One why we will NOT cover the numerous and raging debates about the meaning of human vs artificial intelligence, whether AI can become conscious, General- or Super-intelligence. What happens by the 2040s and later is anyone's speculation; but we will also highlight the limiting factors to exponential growth, being more akin to "punctuated equilibria." We will also not cover AI Ethics as this too is widely addressed by numerous other organizations.

The need for stability: Schools as an island of stability

This may sound contradictory to the need for change described above, but it is not, it is about a different area: emotional grounding. Stability is more important than ever; students are stressed out,[8] and need ***grounding***. ***And the more technology pushes digitalization and virtuality, the more this grounding becomes necessary.***

To quote Azeem Azhar from his newsletter: "In his 1989 book, The Condition of Postmodernity, David Harvey introduced the idea of "time-space compression" to describe how advancing technology, communication, and globalization would result in tangible changes in our societies. In turn, this would have subjective psychological effects of disorientation and alienation, amongst others ("Future shock", in the terminology of Heidi and Alvin Toffler). Toffler suggested we'd need "islands of stability", like familiar spaces, rituals or values. Harvey proposed, *inter alia*, the importance of local attachments and finding some way of accepting the ephemerality of the process."[9]

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[7] Bialik, M. & Fadel, C. (2017). Overcoming system inertia in education reform. *Center for Curriculum Redesign.*
[8] OECD. (2018). Children and young peoples' mental health in a digital age..
[9] Azhar, A. & Smith, C. (2023). Time-space compression; ++ #439. *Exponential View.* https://www.exponentialview.co/p/ev-439

Schools can provide islands of stability and attachments, if designed as such, for familiarity, rituals, and values, as well as educate on how to handle ephemerality (via adaptability, resilience, learning how to learn, etc.). **This latter aspect of handling ephemerality is covered by most of this book.**

Please read on 🙂

PS: we have, deliberately, not addressed in this book:

- Emotionally support of students (mental well-being).
- Psychomotor skills.
- Psychophysiological aspects (sensation, perception, attention, memory).
- Personality traits.
- Developmental phases.
- Formative assessments.
- Accreditation and evaluation.

They will be published as subsequent papers on the CCR website.

Executive Summary (human-generated ;-)

Introduction: After the hiatus of Covid, AI and other disruptors hit humanity, and make yet more cases for change in Education's What and How. The lack of urgency among educators is deeply concerning, as is the lack of preparation of schools as centers of stability.

Chapter One: Modern AI, and its Unhyped Capabilities: AI is already quite potent and getting a lot better fast, as "Artificial *Capable* Intelligence." However, the fears about Artificial General Intelligence, or worse, Superintelligence, are premature, given the need for substantial breakthroughs that are not forecastable. It behooves everyone to focus on the Capable phase at hand.

Chapter Two: AI's Impact on Occupations: AI will NOT replace most jobs any time soon: there is a significant misunderstanding of the difference between AI passing a test vs doing a task vs fulfilling a job. Also, one must contend with the historical inability to predict new emerging jobs (e.g., Instagram Influencer?!). One thing is sure: those with AI will beat those without, as for many technologies, AI is a mind's "exoskeleton." This also implies that high school education's focus on the transition to jobs is still quite appropriate.

Chapter Three: Wisdom as the Enduring Goal of Education: As described in the Foreword and Chapter Two, education remains about BOTH psychosocial ***and*** economic needs, not one or the other. However, the psychosocial side of education is rarely explicit about its overall aim - wisdom - and achieved in a practical way. Wisdom is not an ethereal concept as many might think, it is quite actionable when one involves its components of Knowledge, Skills, Character, and Meta-Learning.

Chapter Four: AI's High-Level Impact on Education: AI's impact can be summarized as a need for *Versatility*. In an uncertain world, the best hedge is the ability to develop across four Dimensions: Knowledge, Skills, Character, Meta-Learning, as well as four "Drivers": Motivation, Identity, Agency, and Purpose. Students need scaffolding to their learning no matter whether for psychosocial or economic needs; ***schooling is NOT obsolete, but it has to be adapted comprehensively.***

Chapter Five: Knowledge for an Age of AI: If AI "knows everything, why learn anything?" is a dead-wrong question, as it was for the age of search engines on the internet. AI neither "knows" everything nor is it capable of acting on its own. Yet it is clear that Knowledge should be assessed for *Relevance*: Developing the right mix between Declarative (Essential Content), Procedural (Project-Based), Conceptual (Core Concepts), and

Epistemic (Meta-layer) Knowledge; and modernizing traditional disciplines accordingly. We also need to make time and space for important modern disciplines, such as Technology and Engineering, Social Sciences, and Entrepreneurship, while embedding interdisciplinarity and cross-cutting themes.

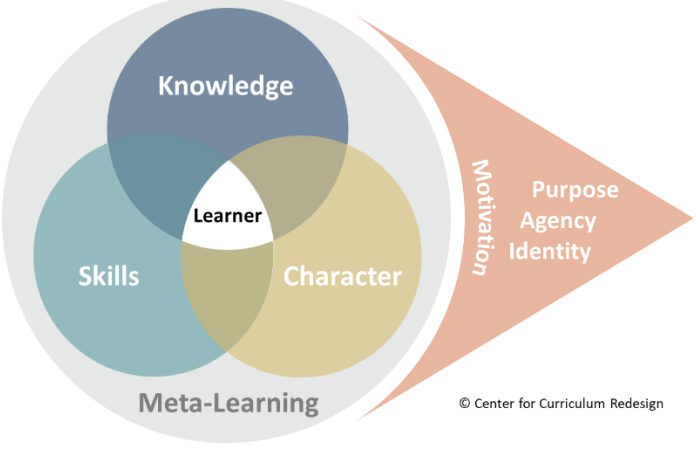
Chapter Six: Competencies for an Age of AI: AI's complementarity vs substitution to Skills, Character, and Meta-Learning is analyzed, and confirms the CCR framework and its Rev 1.2. Emphasis on specific attributes (imagination, resourcefulness, and so forth) is described and justified in light of AI's present and future capabilities. The major drawback is the tendency to drift into over-reliance.

Chapter Seven: Student Personalization: The need for Personalization increases both because AI's capabilities increase the pressure on student Motivation (extrinsic and intrinsic), and to avoid over-reliance on AI. This implies keen attention to the development of Drivers: Identity (& Belonging); Agency (& Growth mindset); and Purpose (& Passion). AI will still need human oversight and decisions on its agency and purpose for quite some time to come.

Chapter Eight: The How: This chapter works through an example of curriculum design, demonstrating how all the parameters of the framework can be designed together harmoniously. Teachers will be provided significant help in creating lesson plans and student assessments, thanks to a suite of diverse AI tools. Finally, the student-centric level of adaptive learning moves gradually into Intelligent Tutoring Systems.

Appendix: It contains a *significant* number of finer-grain details for the interested specialist, and will answer many treaders' questions/

CCR's Framework Diagram at-a-glance



Chapter One
Modern AI and its Unhyped Capabilities

"The future is already here; it is just not evenly distributed" -William Gibson

***Note:** This chapter is likely to change given the exponential pace of technology, and be updated every 3-6 months. Please register on CCR's website[10] for a free download of the most recent version of this chapter, periodically. The technical terminology was reduced and simplified to the extent possible for the education community, but for the remainder, the reader should feel free to ignore/lookup a particular acronym, skip a passage altogether, and refer to CCR's former book for its technical section (free download[11]).*

Move 37[12]: An "Unhuman" Strategy

When DeepMind beat Go world champion Lee Sedol, it came up with a "genius, inhuman" move that human players could not comprehend, and then it went on winning the game. But what seemed genius was a strategy that humans simply do not consider: because DeepMind can compute 50-60 moves ahead, and computes the *probability of winning even if by the slightest margin*, it can take risks no humans can. The natural human strategy in Go is to maximize gain area because of *fear* of not having enough in the end - not to play at the edge of losing!

The same strategy was used by AI against a fighter pilot:[13] the AI dove towards him, calculating that it can "draw and shoot faster," whereas no human would have dared this maneuver. In both cases, AI deploys a non-anthropocentric strategy, which humans do not, given their anti-loss biases (meaning: their fear of death). AI could quip by paraphrasing French aviator Guillaumet:[14] "What I have done, no human would have done."

But AI is not "courageous" in human terms; it is simply devoid of fear ("fear-less" not "fearless"). In these cases, it merely computed its best chances of success and acted accordingly, at the edge of the envelope.

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[10] https://curriculumredesign.org/

[11] Holmes, W., Bialik, M. & Fadel, C. (2019). *Artificial intelligence in education.* Center for Curriculum Redesign. https://curriculumredesign.org/our-work/artificial-intelligence-in-education/

[12] Wikipedia. (2023). AlphaGo versus Lee Sedol. https://en.wikipedia.org/wiki/AlphaGo_versus_Lee_Sedol

[13] Everstine, B.W. (2020). Artificial intelligence easily beats human pilot in DARPA trial. *Air&Space* .https://www.airandspaceforces.com/artificial-intelligence-easily-beats-human-fighter-pilot-in-darpa-trial/

[14] Wikipedia. (2023). Henri Guillaumet. https://en.wikipedia.org/wiki/Henri_Guillaumet

The limitations of language

Fernanda Fereira stated: “Language is good enough, not perfect.”[15] Human language is limited, and, as such, English has a restricted terminology to describe attributes such as creativity, curiosity, and resilience with nuance. These words, laden with meanings, must be unpacked each time people use them to find a common understanding of particularities. Abstract terms like these often have fewer lexical items to describe them: in English, it is difficult to discuss different forms of creativity, for example, with as much precision as Saami reindeer herders in Finland can discuss snow and ice (with up to 1,000 lexemes!).[16] As a result of the limitations of vocabulary, there is frequent confusion and debates in both public fora and academic journals concerning what AI’s capabilities are, from using outdated notions (the Turing Test) to using the wrong word (“emergence” rather than “thresholding,” “hallucinations” rather than “confabulations,” “transfer” rather than “generalization,” etc.).

Four levels of AI

AI can be classified into four distinct levels, each representing a significant step in functionality:

1. **Artificial Narrow Intelligence (ANI), aka Machine Learning/Deep Learning:** These systems are designed to excel in performing a specific task or function. They are highly specialized and are incapable of going beyond their designated purpose. Some of today's familiar AI applications games (Go, Stratego, etc.), to which one can add, for instance, artistic style transfer, protein folding resolution, and drug formulation design.

2. **Artificial Capable**[17] **Intelligence (ACI)** ***possesses a broader and highly potent range of impactful capabilities, thus most of this chapter and book are devoted to it.***
   The transition from ANI to AGI in global debates is a significant one, and many tend to make this jump without emphasizing the critical ACI stage in between. The leap between these two categories is enormous, and not appreciated by education researchers. Several respected figures in the AI world have come out in support of this focus on ACI:

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[15] Marcus, G. (2008). *Kluge: The haphazard construction of the human mind.* Chapter 5: Language. https://fb2.top/kluge-the-haphazard-construction-of-the-human-mind-258143/read/part-5

[16] Magga, O.H. (2006). Diversity in Saami terminology for reindeer, snow, and ice. *International Social Science Journal, 58*(187), 25-34. https://typeset.io/papers/diversity-in-saami-terminology-for-reindeer-snow-and-ice-244d5ytih2

[17] Per Mustafa Suleyman (2023), DeepMind co-founder, in *The Coming Wave: Technology, Power, and the Twenty-first Century's Greatest Dilemma*, Crown.

- Mustafa Suleyman, co-founder of DeepMind (Google) and of Inception.ai, who has coined this present phase as ACI.
- François Chollet, a notable Google AI researcher, has argued that: "There does not exist any AI model that could represent an extinction risk for humanity even if you extrapolate capabilities far into the future via scaling laws."
- Yann LeCun, director of AI research at Meta, has argued that humans overestimate the maturity of current AI systems: "Society is more likely to get 'cat-level' or 'dog-level' AI years before human-level AI"[18]
- Timnit Gebru, ex-Google, argues that the focus on AGI/ASI was a distraction from the immediate harms arising from corporations deploying automated systems, including worker exploitation, copyright violation, the spread of synthetic information, and the growing concentration of power.
- Gary Marcus, leading AGI critic and highly respected "voice of reason," has quipped: "No fantasy about AGI survives contact with the real world."
- Stanford's Fei-Fei Li, in an interview: "I respect the existential concern. I'm not saying it is silly and we should never worry about it. But, in terms of urgency, I'm more concerned about ameliorating the risks that are here and now."
- Bill Gates has recently admitted that "GPT-5 would not be much better than GPT-4" (and made no mention of AGI).
- *Even Sam Altman* has finally admitted that "There are more breakthroughs required in order to get to AGI."

The overhype can be explained by three possibilities:

1. LLM experts are *fervently *hoping** to see their creation do it all, after decades of toiling against the odds… This "proud Dad syndrome" clouds their judgment, and sometimes makes them clutch at straws with unsubstantiated views.
2. The intense human tendency to anthropomorphize kicks in and makes even experts "over-patternize" (ironically!)
3. The need to raise enormous amounts of capital biases thinking…

Pedro Domingos[19] understood that the AI *families* had to work together, even though he wished for a "Grand Unification Algorithm." Evolution has crafted brains with multiple *specialized areas* working together – why is this analogy so hard for the AI world to accept? Perhaps because it is disappointing to researchers and because that means other types of algorithms, which they are not experts in, are needed.

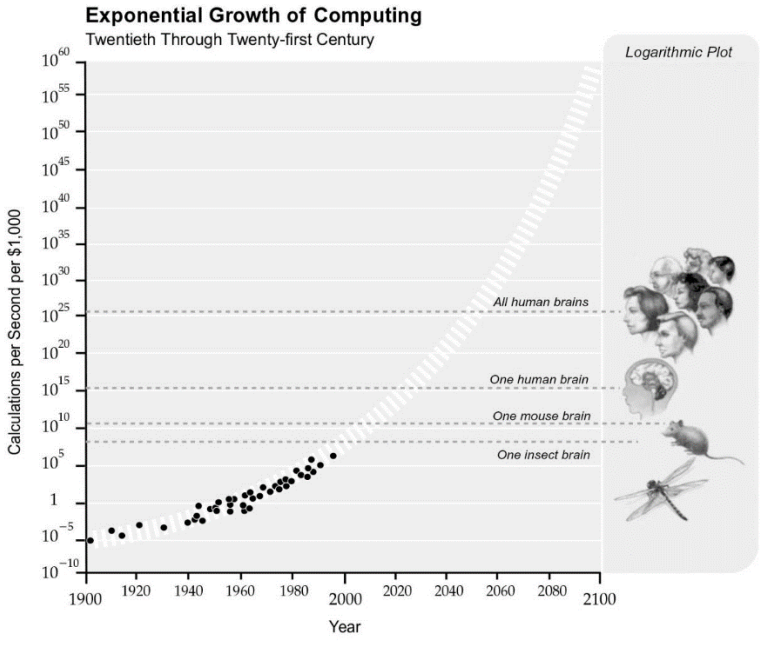
[18] Contradicting Marc Zuckerberg's one-upmanship announcement of focus on AGI.
[19] Domingos, D. (2015). *The master algorithm.* Basic Books.

4. **Artificial General Intelligence (AGI)** aims to mimic full human cognitive abilities. These systems would be able to understand, learn, and perform any intellectual task that a human being can. AGI would be vastly more versatile than ANI or ACI, enabling seamless interaction with humans, problem-solving, and adaptation to new situations.[20] Google DeepMind has recently published a paper[21] describing what AGI levels would be, but in this book's opinion, calling present-day GPT/LlaMa/Bard "emerging AGI" seems quite generous… The limelight that AGI receives in popular media can also influence academic discussions, directing attention to the broader, more philosophical concerns of a world where machines possess human-like intelligence.[22] As Gary Marcus states, AGI is "a few paradigm shifts away."

5. **Artificial SuperIntelligence (ASI)** imagines an AI that can compose masterful symphonies, devise groundbreaking scientific theories, and exhibit empathy and understanding in ways that surpass all human capabilities. Superintelligence represents the frontier of AI development and raises existential questions about its potential impact on society and the future of humanity.[23] It not only mimics human thought processes but greatly exceeds their efficiency and capability. ASI would possess original artistic creativity, unparalleled problem-solving abilities, and sophisticated emotional intelligence, offering a level of intelligence that is beyond what humans can comprehend.

This progression is represented by Kurzweil[24] (simplistically by using computing power as the only parameter, but is still adequate to make the point):

[20] Russell, S. J., & Norvig, P. (2009). *Artificial intelligence: a modern approach.* Prentice Hall.
[21] Morris, M. R., Fiedel, N. et al. (2023). Levels of AGI: Operationalizing progress on the path to AGI. *ArXiv*: Cornell University. https://arxiv.org/abs/2311.02462
[22] Tegmark, M. (2017). *Life 3.0: Being human in the age of artificial intelligence.* Knopf
[23] Tegmark, M. (2017). *Life 3.0: Being human in the age of artificial intelligence.* Knopf
[24] Kurzweil, R. (2006). *The Singularity is Near: When Humans Transcend Biology.* Penguin.



(Source: Kurzweil 2006)

This graph has not been updated since 2006, but other renditions of Moore's Law do not portray the calculations/second equivalency. But in the foreseeable future, it is anticipated that AI will gradually exhibit similarities to other living organisms in multiple aspects.[25] The evolution of AI systems, encompassing their ability to learn, adapt, and make autonomous decisions, may resemble the ecological processes observed in living creatures.[26] Possession of competencies in AI, like in animals, varies in level, and depends on intent, diversity of proofs of behavior, and research. These comparisons are therefore always fraught with this fine grain of difference.

The major change brought on by Machine Learning

Good things take time, and innovations that surprise us have their germs in decades, if not centuries, of basic research and technology developments that eventually combine and explode in overall awareness.[27]

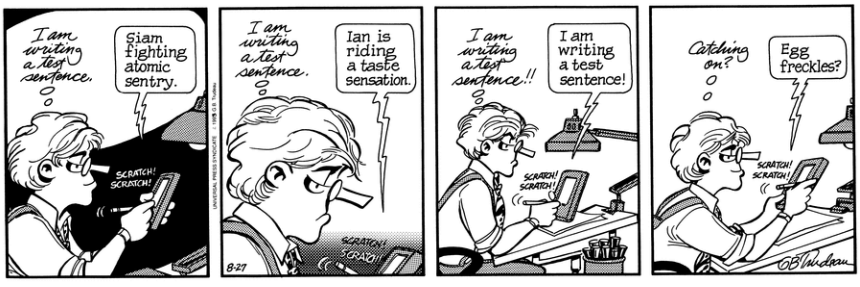
In 1895, Andrei Markov described the Markov process, which is "a model describing a sequence of possible events in which *the probability of each event depends only on the state attained in the previous event."*[28] This

[25] Xu, Y., Liu, X., et al. (2021). Artificial intelligence: A powerful paradigm for scientific research. *The Innovation*, *2*(4), 100179. https://doi.org/10.1016/j.xinn.2021.100179
[26] See Appendix: "Evolutionary Origins of Competencies"
[27] Schwartz, O. (2019). Andrey Markov and Claude Shannon counted letters to build the first language generation models. *IEEE Spectrum.*
[28] Wikipedia. (2023). Markov chain. https://en.wikipedia.org/wiki/Markov_chain

seemingly innocuous mathematical advance is at the heart of AI nowadays, and, interestingly, it is also how humans understand probability natively: people constantly monitor the world and adapt the probability of outcomes based on new information.[29] [30]

Since then, the transistor was invented by Lilienfeld in 1921, then the integrated circuit by Kilby in 1958. Moore's Law[31] took over, doubling integrated circuits' performance every 18-24 months, yet even in 1989, one could compute only three layers of artificial neurons,[32] the base building blocks of Machine Learning.[33] Many AI theories date back to the 1950s through 1970s, including artificial neural networks and its most useful "backpropagation" algorithm.[34]

For years, AI suffered the ignominy of inadequate results, exemplified in Apple's now-forgotten Newton handheld device, the ancestor of the iPhone:



(Source: *Doonesbury* cartoon by G.B. Trudeau)

Nevertheless, 20 years later, after a *ten-million-fold* increase in semiconductor performance and the use of graphic processors adept at the required computations, Deep Learning re-emerged with a vengeance.[35] It can now compute thousands of layers, and with it came amazing possibilities: trained on narrow data sets with finite rules, it could solve computationally massive

[29] Kahneman, D., Slovic, P., & Tversky, A. (1982). Judgment under uncertainty: References. https://www.semanticscholar.org/paper/Judgment-under-uncertainty%3A-References-Kahneman-Slovic/30a0282ef802303f87db9da6a3c8bbb6f22fad2d

[30] And if there is no *a priori*, we generate a hypothesis that gets proven/disproven with new information, known in Mathematics as a Bayesian process.

[31] Wikipedia. (2023). Moore's law. https://en.wikipedia.org/wiki/Moore%27s_law

[32] As one of the authors (Fadel) experienced, his start-up NeurodyneAI was 30 years too early…

[33] For a more comprehensive description of Machine learning, please download for free our earlier book "Artificial Intelligence in Education": https://curriculumredesign.org/our-work/artificial-intelligence-in-education/

[34] Rumelhart, D. E., Hinton, G. E., & Williams, R. J. (1986). Learning representations by back-propagating errors. *Nature*, 323(6088), 533-536. https://www.nature.com/articles/323533a0

[35] It had gone into its "winter" and had to change its name from "Neural Nets" to Deep Learning, after being savaged by MIT's Marvin Minsky, the pied piper of symbolic AI (see our book" AI in Education").

problems such as gaming (per the table below,)[36] protein folding,[37] gene mutation identification,[38] artistic style transfer, facial and vocal recognition, translation, recommendation systems, and many others.

	Chess	Poker	Go 19x19	Stratego
Turns in a game	~60	~15	~300	~1000
Starting configurations	1	10^{6}	1	10^{66}
Game tree complexity	10^{123}	10^{17}	10^{360}	10^{535}

(Source: Google DeepMind)

Brian Cantwell Smith[39] describes the difference between ML and humans as "Reckoning" vs "Judgment", which Harvard's Chris Dede[40] expands on as: "Reckoning refers to calculative prediction and formulaic decision-making, at which computers and AI systems already excel. In contrast, judgment is a form of deliberative thought that seeks to be unbiased, grounded in ethical commitment, and appropriate to the situation in which it is deployed."

Despite these amazing feats proving narrow-domain *Expertise* superiority, ML could not *Transfer*, due to constrained databases and concise sets of rules - in engineering terminology, these are "bounded problems." Furthermore, ML is:[41]

- Brittle, as a minute change in pixels makes it fail at recognition. But LLMs have become less brittle due to their breadth, within limitations.
- Opaque, as neural nets do not provide a view into how they converge to their solution in their hundreds or thousands of layers.
- Greedy for data, needing enormous data sets (petabytes and more soon).
- Sensitive to over-tuning, where once trained for a given factor, it will find the factor in unusual places.

[36] Google DeepMind. (2022). Mastering Stratego, the classical game of imperfect information. *DeepMind Research Blog.* https://www.deepmind.com/blog/mastering-stratego-the-classic-game-of-imperfect-information
[37] Google DeepMind (2023). Alphafold. *DeepMind Research Blog.* https://www.deepmind.com/research/highlighted-research/alphafold
[38] Google DeepMind. (2023). A catalog of genetic mutations to help pinpoint the cause of diseases. *DeepMind Research Blog.* https://www.deepmind.com/blog/alphamissense-catalogue-of-genetic-mutations-to-help-pinpoint-the-cause-of-diseases
[39] Smith, B.C. (2019) The Promise of Artificial Intelligence: Reckoning and Judgment. MIT Press. https://mitpress.mit.edu/9780262043045/the-promise-of-artificial-intelligence/
[40] Cao, L., & Dede, C. (2023). Navigating A World of Generative AI: Suggestions for Educators.
[41] Marcus, G. (2018). Deep Learning: A Critical Appraisal. *ArXiv*: Cornell University. https://arxiv.org/abs/1801.00631

The sudden improvement due to Large Language Models[42] (LLMs)

LLMs exploded the bounded problem paradigm, as well as the single-database-type constriction. By training LLMs on enormous and highly varied datasets, AI researchers gave them the much broader capabilities that are now available via ChatGPT (OpenAI), Bard (Google), Claude (Anthropic), etc.

This did not happen overnight - again, good things take time. In addition to the technical progress described above, AI needed Claude Shannon's Theory of Communication. In 1948, he described how computing the probabilities of appearance, in a given language, of single letters, then diagrams, then words would eventually create meaningful sentences.[43] He did not have the computing power to go beyond this crude and manual, yet foreshadowing, example:

6. Second-order word approximation. The word transition probabilities are correct but no further structure is included.

THE HEAD AND IN FRONTAL ATTACK ON AN ENGLISH WRITER THAT THE CHARACTER OF THIS POINT IS THEREFORE ANOTHER METHOD FOR THE LETTERS THAT THE TIME OF WHO EVER TOLD THE PROBLEM FOR AN UNEXPECTED.

(Source: Claude Shannon, "A Mathematical Theory of Communication, 1948)

Fast-forward to circa 2020: high computing power, low storage costs, and novel algorithms enabled the stunning progress that reawakened broad interest in AI.[44]

The potency of the Capable phase:

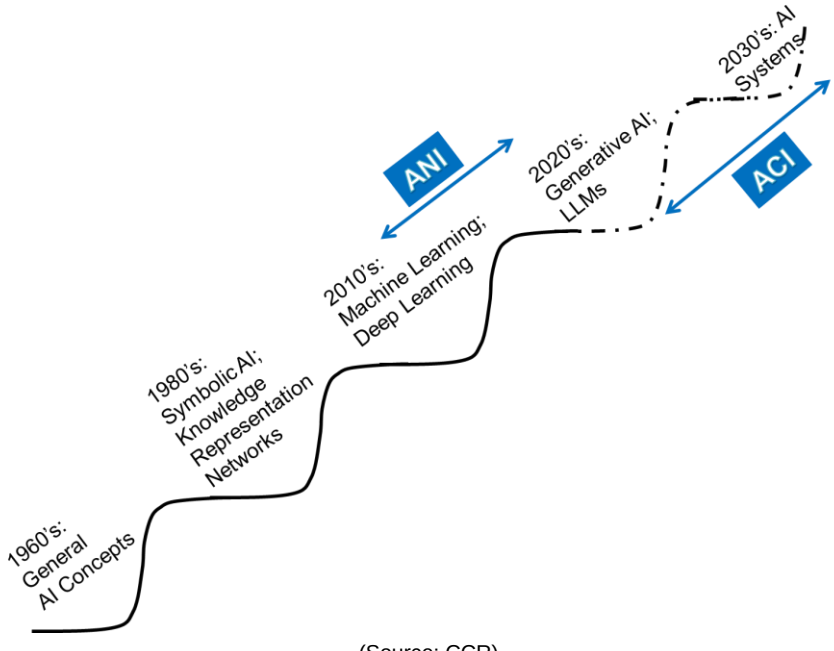
Technology evolves in a succession of "punctuated equilibria:"[45]

[42] For a good technical introduction, please consult https://writings.stephenwolfram.com/2023/02/what-is-chatgpt-doing-and-why-does-it-work/

[43] Shannon, C.E. (1948). A mathematical theory of communication. *The Bell System Technical Journal, 27*, 379–423, 623–656. https://people.math.harvard.edu/~ctm/home/text/others/shannon/entropy/entropy.pdf

[44] Our 2018 book "Artificial Intelligence in Education" arrived too early to resonate with an education audience, hence this update.

[45] Gould, S.J. (2007). *Punctuated Equilibrium.* Belknap Press.



(Source: CCR)

This ACI phase will benefit from a wide array of rapid improvements, which will be quite impactful, given the competitive pressure between LLMs (the main protagonists at this time being: Proprietary: OpenAI/GPT, Anthropic/Claude, Google/Bard; Open: LLaMa, Falcon, Mistral).

Software improvements:

- Continued growth in LLM tokens (both the number of tokens for training, as well as context window size [tokens in short-term memory], driven by improved processors and memory costs (Moore's Law)
- Continued algorithmic refinements of the LLMs (faster than Moore's Law by a factor of 3x-5x[46]). Of particular note are Genetic Algorithms (for constant mutation/pruning progress - "evolutionary optimization"), and hallucinations[47]
- LLMs with memory (OpenAI's Project Sunshine), allowing it to remember past interactions, for more relevant and personalized responses.
- Faster algorithms allowing for deeper context windows ("dilated attention") [48]

[46] Sevilla, J. et al. (2022). Compute trends across three eras of machine learning. *ArXiv:* Cornell University. https://arxiv.org/abs/2202.05924

[47] Ji, Z. et al. (2022). Survey of hallucination in natural language generation. *ArXiv:* Cornell University. https://arxiv.org/abs/2202.03629

[48] Ding et al. (2023). The efficiency spectrum of large language models: An algorithmic survey. *ArXiv:* Cornell University. https://arxiv.org/pdf/2312.00678.pdf

- *LangChains and APIs (with higher rate limits) opening the doors for specialized corpora to be linked together (e.g. Mathematica for algorithmic processing, etc.).*
- Multimodality models, as deployed by GPT/Whisper and Gemini/Bard already
- Multi-Agent Models,[49] each used for its advantages (like areas of the brain, as an analogy). This is related to the LangChain point above.
- Consumer Agents like Character.ai, Pi, and Poe.com.
- Autonomous agents like Auto-GPT[50]
- Access to massive amounts of sensory data of **far greater** types, frequencies, and dynamic ranges than humans (from heartbeat monitors to gamma-ray observatories; from IoT to Robots[51] to YouTube[52] to…).
- Efforts towards smaller/cheaper models (e.g., Persimmon, Mini-GPT,[53] Phi-1[54], as well as China which is under pressure due to the NVidia chip embargo).
- All-in-one frameworks for easier implementation by non-experts (e.g. LLMWare)
- Plethora of increasingly robust developer tools, such as "all-in-one" packages (e.g. Predibase)
- Legions of developers ("He with the most developers wins").[55]
- Verticalization to improve results and lower hallucinations: Health Care[56] (Stanford, Google); Finance (Bloomberg Finance Model, Columbia); Textbooks (Microsoft[57]), etc.
- Legions of Prompt designers and experimenters, in every industry

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[49] Du, Y., Shuang, L., et al. (n.d.) Improving factuality and reasoning in language models through multiagent debate. https://composable-models.github.io/llm_debate/

[50] Significant-Gravitas / AutoGPT. (2023). GitHub account. https://github.com/Significant-Gravitas/AutoGPT

[51] DeepMind has partnered with 33 research laboratories to create the most comprehensive robotics dataset to date, containing over one million robot trajectories from 22 robots, including robot arms, bi-manual robots, and quadrupeds, demonstrating over 500 skills.

[52] **It is notable that Google has access to a gem here, with YouTube: it is not only a very large untapped source of data, it is also reasonably structured by its end-users and *contains a trove of procedural information that is generally missing from other datasets.*** *The same can be said of GSuite/GMail, but with perhaps proprietariness constraints which might be avoided via anonymization.*

[53] Zhu, D. et al. (2023). MiniGPT-4: Enhancing vision-language understanding with advanced large language models. *ArXiv*: Cornell University. https://arxiv.org/abs/2304.10592

[54] Gunasekar et al. (2023). Textbooks are all you need. *ArXiv:* Cornell University. https://arxiv.org/abs/2306.11644

[55] Blue OS Museum. (2023). Steve Ballmer at .NET presentation: Developers. YouTube. https://www.youtube.com/watch?v=XxbJw8PrIkc

[56] Bolton, E. et al. (2022) Stanford CFRM introduces PubMedGPT 2.7b. Stanford University HAI. https://hai.stanford.edu/news/stanford-crfm-introduces-pubmedgpt-27b; also Google/PALM, Matias, Y. & Corrado, G. (2023). Our latest health AI research updates. Google: Health. https://blog.google/technology/health/ai-llm-medpalm-research-thecheckup/

[57] Gunasekar et al. (2023). Textbooks are all you need. *ArXiv:* Cornell University. https://arxiv.org/abs/2306.11644

- Prompt optimizing[58],[59] leading to better results on queries.
- *Latent capabilities yet-to-be-discovered,* that can probably be unlocked by finetuning and clever Reinforcement Learning reward policies[60]
- *"More is Different": Emergence[61,62] situations with unsuspected capabilities.* But this view is tempered by the semantic overreach of "emergence" rather than the use of "thresholding"; so "More is Different" could simply be "more is (just) more"[63]
- *Beyond LLMs-based systems, Reasoning Systems using* Neuro-Symbolic AI
- "Hyper-exponential": AI accelerating AI[64] ("Creating the AI researcher")

Hardware improvements:

- Co-processors at the edge,[65] meaning your laptop and smartphone will run LLMs locally and faster, not just in the cloud (Apple, Intel, Qualcomm).
- AI-specific consumer devices with different form factors (several offerings have already been announced).
- Moore-Law-enabled faster GPUs (NVidia, AMD, etc.).
- Different processor architectures (neuromorphic [IBM, OpenAI], TPU [Google], FPGAs, NVRAM/Memristor, etc.).
- Finally, possible blue-sky alternatives for faster hardware (analog, superconductive, quantum, optical, nanotubes, etc.).

Partially adding to our argumentation above, UC Berkeley's Dr. Steinhardt has modeled[66] what an "LLM2030" might be able to do. He states:

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[58] Yang, C., Wang, X. et al. (2023). Large Language Models as Optimizers. *ArXiv*: Cornell University. https://arxiv.org/abs/2309.03409

[59] Zhou, Y., Muresanu, A. I. et al. (2022). Large Language Models Are Human-Level Prompt Engineers. *ArXiv*: Cornell University. https://arxiv.org/abs/2211.01910

[60] For example, Clevecode. (2023). "Can you beat a stochastic parrot?" https://parrotchess.com/

[61] Bounded Regret. (2022). More is different for AI. *Bounded Regret Blog.* https://bounded-regret.ghost.io/more-is-different-for-ai/

[62] Ganguli, D., Hernandez, D., et al (2022). Predictability and Surprise in Large Generative Models. *ArXiv*. https://doi.org/10.1145/3531146.3533229

[63] Miller, K. (2023). AI's ostensible emergent abilities are a mirage. *Stanford: HAI.* https://hai.stanford.edu/news/ais-ostensible-emergent-abilities-are-mirage https://arxiv.org/abs/2304.15004 ; Rylan Schaeffer, Brando Miranda, Sanmi Koyejo. Are Emergent Abilities of Large Language Models a Mirage? NeurIPS 2023 https://arxiv.org/abs/2304.15004

[64] Davidson, T. (2023). What a compute-centric framework says about take-off speeds. *Open Philanthropy.* https://www.openphilanthropy.org/research/what-a-compute-centric-framework-says-about-takeoff-speed; Cotra, A. (2023). Language models surprised us. Planned Obsolescence. https://www.planned-obsolescence.org/language-models-surprised-us/

[65] Smith, M. (2023). When AI unplugs, all bets are off. IEEE Spectrum. https://spectrum.ieee.org/personal-ai-assistant

[66] Bounded Regret. (2023). What will GPT-2030 look like? *Bounded Regret Blog.* https://bounded-regret.ghost.io/what-will-gpt-2030-look-like/

- "LLM2030 will likely be superhuman at various specific tasks, including coding, hacking, math, and potentially protein design.
- LLM2030 can "work" and "think" quickly: I estimate it will be 5x as fast as humans as measured by words processed per minute [range: 0.5x-20x], and that this could be increased to 125x by paying 5x more per FLOP.
- LLM2030 can be copied arbitrarily and run in parallel. The organization that trains LLM2030 would have enough compute to run many parallel copies: I estimate enough to perform 1.8 million years of work when adjusted to human working speeds [range: 0.4M-10M years]. Given the 5x speed-up in the previous point, this work could be done in 2.4 months.
- LLM2030's copies can share knowledge due to having identical model weights, allowing for rapid parallel learning: I estimate 2,500 human-equivalent years of learning in 1 day.
- LLM2030 will be trained on additional modalities beyond text and images, possibly including counterintuitive modalities such as molecular structures, network traffic, low-level machine code, astronomical images, and brain scans. It may therefore possess a strong intuitive grasp of domains where people have limited experience, including forming concepts that people do not have."

Given all the accelerants highlighted above, one can easily conclude that LLM2030 will be *enormously* better than GPT4, even if still incapable of AGI. To some extent, this might be the clash of the scientific and engineering mindset: **the engineers can see how LLMs combined with traditional algorithms will be able to outperform humans in significantly more cognitive tasks than any product allows now, by just having better structures and "plumbing" between them.** And if they succeed, the end result may have a very large impact on society, regardless of scientific elegance. All the forces/trends described above will make this Highly-Capable AI quite probable… CCR agrees with Roy Amara, former President, Institute for the Future: "We tend to overestimate the effect of technology in the short run, and underestimate the effect in the long run."

For now, most researchers and pundits seem to agree about What AI *can* do already:

- Automation: AI can automate repetitive and tedious tasks, such as data entry, quality control, and testing, freeing up time for employees to focus on more strategic and creative tasks. Automation can improve productivity and reduce costs, particularly in industries such as manufacturing, logistics, and customer service.
- Prediction: AI can analyze vast amounts of data and identify patterns, making predictions about future events with a high degree of accuracy.

This capability can be applied in various fields, from weather forecasting to stock market predictions.

- Personalization: AI can personalize products and services, tailoring them to individual preferences, needs, and behavior. This capability is particularly valuable in marketing, where AI can analyze customer data to make personalized recommendations and improve the customer experience.
- Image and speech recognition: AI can recognize and classify images and speech, which has applications in security, healthcare, and entertainment. For example, AI can analyze medical images to detect diseases or assist in surgical procedures.
- Language processing: AI can process and analyze natural language, enabling chatbots, virtual assistants, and other communication tools to respond to user queries, requests, and commands.

LLM Limitations

There are ***profound*** technical limitations to LLMs:

- Severe anterograde amnesia, unable to form new relationships or memories beyond its intensive education. LLMs do not actively learn from, reflect on, or even remember past interactions. Their answers are limited to whatever is implied by the combination of the text prompted by the query, and the model[67] they have built up until their last training run. OpenAI is actively working on this issue.
- "Hallucinations" (confabulations), that are endemic to LLMs: they refer to instances where the model generates incorrect, nonsensical, or unrelated output, despite being given coherent and relevant input. This phenomenon can occur for several reasons: Data limitations; context misinterpretation; overgeneralization; bias in training data; and edge cases.
- Lack of world model, meaning: No real understanding of the content it serves; inability to update knowledge on its own; lack of experience-based learning; inability to contextualize information dynamically; dependence on input for generating output;[68] and lack of common-sense reasoning.[69]
- Recency: the freshness of its data depends on when the model was last trained; this is becoming less of an issue with recent models that are staying up-to-date.

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[67] There is a lot of debate about what "world models" imply, with overreach by some AI researchers: an understanding of, say, geography wouldn't support an understanding of the physical laws and causality of the world. Gary Marcus explains that this *appearance of having a structure to the knowledge doesn't mean you have an understanding of the knowledge sufficient for it to be called a "model"*. In fact, he shows that much more primitive AIs contain correlations about physical space.

[68] In other words, they need to "speak" in order to "think"

[69] Benchekroun, Y. et al. (2023). WorldSense: A synthetic benchmark for grounded reasoning in large language models. *ArXiv*: Cornell University. https://arxiv.org/abs/2311.15930

According to Meta's Yann LeCun: "One thing we know is that if future AI systems are built on the same blueprint as current LLMs, they may become highly knowledgeable but they will still be dumb. They will still hallucinate, they will still be difficult to control, and they will still merely regurgitate stuff they've been trained on. *More importantly*, they will still be unable to reason, unable to invent new things, or plan actions to fulfill objectives. And unless they can be trained from video, they still won't understand the physical world. Future systems will have to use a different architecture capable of understanding the world, capable of reasoning, and capable of planning to satisfy a set of objectives and guardrails."
In addition to the inherent limitations listed above, both researchers and pundits point out an additional list of issues, for which CCR proposes counterarguments:

What AI Can't Do	CCR's counterarguments
Creativity: AI can generate new ideas, but it lacks the creativity and originality of human beings. AI can mimic human creativity, but it cannot replicate it.	By far, the largest proportion of creativity is incremental[70] and can be guided by patterns.[71] The remaining proportion of radical creativity (imagination, originality) is indeed a lot more human, but might be harnessed by raising the "temperature" of the LLM and harvesting its hallucinations - not unlike artists and their visions while under the influence of drugs or mental illnesses. Lastly, humans also produce a lot of minor increments in their quest for a radical idea, and need to do so to reach an occasional flash of brilliance.
Emotional intelligence: AI lacks emotional intelligence and empathy, which are essential for understanding human emotions and behavior.	It cannot "understand", but it can "represent" to itself and "read"[72] human emotions. It can be taught to be empathetic, and it is naturally patient and tire-less.

[70] Christensen, C. M. (1997). *The innovator's dilemma: when new technologies cause great firms to fail*. Harvard Business School Press.
[71] Wikipedia. (2023). Triz. https://en.wikipedia.org/wiki/TRIZ
[72] Elyoseph, Z., Asraf, K., & Lvovsky, M. (2023). ChatGPT outperforms humans in emotional awareness evaluations. *Frontiers in Psychology*, *14*, 1199058. https://doi.org/10.3389/fpsyg.2023.1199058

Judgment: AI can make decisions based on data, but it cannot make ethical or moral judgments. AI lacks the ability to consider the broader social, cultural, and ethical implications of its decisions.	Safeguards are being put in place, but this does not prevent bad actors at the State level, or determined prompt hackers. Its answers can be pre-filtered in real-time, to avoid obvious biases. But, trained on human data, it will reflect our human biases.
Contextual understanding: AI cannot understand the context of situations, particularly when dealing with ambiguous or complex situations. AI can misinterpret data, leading to incorrect decisions.	Training on a multitude of real-world sources, linked via APIs or LangChains, might improve its "understanding:" ● Sensory information of all types (from cars to IoT to gamma-ray observatory), with far better dynamic range, frequencies and bandwidth than human senses. ● Procedural information out of YouTube, Patents, etc.
Common sense: AI lacks the common sense and intuition that humans possess. AI can make mistakes, particularly when dealing with unusual situations that require human judgment and experience.	This will improve via better real-world understanding per "contextual understanding" above, and as the LLM community starts embracing other algorithmic schemas (neuro-symbolic, etc.).

Similarly, **GPT4 comes up with an additional list of limitations**, for which CCR also presents a series of counterarguments:

Limitations, according to ChatGPT	**Possibly overcome by:**
Dependence on Training Data: The quality and breadth of the output are deeply tied to the training data. If an AI hasn't been trained on certain information, it can't generate accurate responses about it.	APIs to specialized tools/search systems and LangChained access to vector databases significantly minimize the initial dataset constraints.
Bias: If the data used to train the AI has biases, the AI can reproduce or even amplify those biases in its outputs	Its answers can be pre-filtered in real-time, to avoid obvious biases. But, trained on human data, it will reflect back to us our human biases.

Overgeneralization: Generative AI might overgeneralize from its training data, leading to statements that are technically accurate but might not apply to specific situations. Sometimes using vagueness to hedge against lack of knowledge.	There is plenty of work going on to at least *minimize* overgeneralizations algorithmically; and industry-specific datasets may also minimize out-of-range confabulations.
Verifiability: Generative AI can produce information quickly, but that doesn't mean the information is always correct or reliable. Verification is crucial.	Industry-specific datasets will help trustworthiness, as will Retrieval Augmented Generation schemes that allow the model to cite the sources informing its output.
Ethical Concerns: There's potential for misuse in generating misleading information, deepfakes, or other deceptive content	Safeguards are being put in place, but not very effective yet. Also, this does not prevent bad actors at the State level, or determined prompt hackers.
Resource Intensive: Training state-of-the-art generative models requires significant computational resources, which have environmental and economic implications.	Cloud-based services are eliminating the upfront infrastructure cost, making embeddings affordable even to relatively small institutions. The environmental implications are to be addressed by policymakers and industry.
Lack of Goal-Directed Behavior: Unlike humans, generative AI doesn't have desires, goals, or intentions. It responds to prompts without a "purpose."	That is a good thing, and eminently fillable by humans.

Human weaknesses:
Additionally, human weakness and the fears they engender will inform the efficacy and depth of our interactions with AI. Therefore, one should note all of the following issues:[73]

[73] As mentioned in the Introduction, this book does not tackle issues of ethics, and bias, as these are being addressed by very many organizations

- Anthropomorphization: There is a very strong tendency to anthropomorphize AI's behavior,[74] and to read a lot more into it than what reality demonstrates. Will people be able to battle this natural anthropomorphization when products are designed explicitly to activate it? (if you have doubts about human frailty, just look at the success of the far simpler "Like" button[75] and its micro-release of dopamine). According to Narayanan and Kapoor: "Developers should avoid behaviors that make it easy to anthropomorphize these tools, except in specific cases such as companion chatbots. Journalists should avoid clickbait headlines and articles that exacerbate this problem. Research on human-chatbot interaction is urgently needed." [76]
- Identity: AI already has an "Identity", in three ways: the dataset used, its algorithms and its user interface.[77] See Anthropomorphization above.
- Affective domain: even the affective domain can be hacked (e.g. a 5-year-old preferring a patient robot reading a bedtime story).[78]
- Agency: LLMs need to **"**speak in order to think", as they do not undertake cogitations/ruminations of their own volition. AI has no capacity for self-expression, and no compulsion to communicate. It has no autonomy, intentionality, volition, or Agency, but *it can be given it partially for Agents.*[79] Could that be increased to a much greater level of agency?
- Perfection: Humans demand more from machines, and expect AI to be flawless,[80] but do not expect humans to be (one automated vehicle kills a person and everyone screams "bad robot," but humans kill thousands of others while driving!). Are humans too forgiving of other humans' mistakes? Should this anthropocentricity be reconsidered?
- Fear: People got used to machines being stronger than them[81] but are struggling with machines smarter than them until they wise up.[82] Is that

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[74] Tarnoff, B. (2023). Weizenbaum's nightmares: How the inventor of the first chatbot turned against AI. *The Guardian;* Li, M. & Suh, A. (2022). Anthropomorphism in AI-enabled technology: A literature review. *Electron Markets 32*, 2245–2275.

[75] Lee, H. Y., Jamieson, J. P., et al (2020). Getting Fewer "Likes" Than Others on Social Media Elicits Emotional Distress Among Victimized Adolescents. *Child Development*, *91*(6), 2141. https://doi.org/10.1111/cdev.13422

[76] Narayanan, A. & Kapoor, S. (2023). Why people keep anthropomorphizing AI. *AI Snake Oil.* https://www.aisnakeoil.com/p/people-keep-anthropomorphizing-ai

[77] Character.ai.is a chatbot for which users can craft different "personalities" and share them online for others to chat with.

[78] Brackley, J. & Vincent, S. (2015). Humans. [Television series - Season 1, in several episodes)

[79] https://github.com/Significant-Gravitas/AutoGPT

[80] Turkle, S. (2011). Alone Together: Why We Expect More from Technology and Less from Each Other. Basic Books.

[81] Lecture by Richard Feynman from September 26, 1985 on Artificial Intelligence: https://www.youtube.com/watch?v=ipRvjS7q1DI

[82] "Human strategic guidance combined with the tactical acuity of a computer was overwhelming." "Weak human + machine + better process was superior to a strong computer alone and, more remarkably, superior to a strong human + machine + inferior process." Source: Gary Kasparov, "The Chess Master and the Computer," New York Review of Books, February 11, 2010

due to the evolutionary fear of facing a new Apex predator? Yann LeCun stated: “They won't want to dominate us because they won't have any objective that drives them to dominate (unlike many living species, particularly social species like humans). Guardrail objectives will prevent that. They will be smarter than us but will remain under our control. They will make ***us*** smarter. The idea that smart AI systems will necessarily dominate humans is just wrong.”

- Promethean wish:[83] AI researchers have long harbored a Promethean wish, being highly desirous to see their creation acquire human-like intelligence. Is this “proud Dad syndrome” clouding their forecasts?
- Anthropocentricity, again: Humans expect AI to have human-**like** intelligence; why? Richard Feynman, in a 1985 interview[84] about AI, reminded the audience that “We could try to make a machine that runs like a cheetah, but it's easier to make a machine with wheels… The airplanes don't fly like a bird. They fly, but they don't fly like a bird, okay?” Similarly, animals (from birds to octopi) do not have human-like intelligence yet are highly capable (see appendix, The Evolutionary Origins of Competencies).

Humans must accept the emergence of a fascinating new type of intelligence, with both deep and shallow capabilities, for now.

Could the future happen faster? Yes….

To be honest, the authors are of two minds: according to the above list of multiple, intertwined and accelerating improvements to come, even this Capable phase may be quite disruptive. Furthermore, there are plenty of experts who have revised their expectations downward in time,[85] based on GenAI advances, but that might very well be an overreaction to the sudden impact of LLMs, coupled with herd behavior. If the acceleration continues, all bets are off, and it is doubtful anyone could fully anticipate the effects and consequences (see the section below on Unintended Consequences), but humans must try to anticipate to the best of their abilities, and more aptly, react fast given the rate of change.

However, exponential events cannot physically remain so forever: saturation

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[83] Gonçalves, B. (2020). Dystopia or utopia? Alan Turing’s Promethean ambition about intelligence machines. *Research Gate.* https://www.researchgate.net/publication/348185600_Dystopia_or_utopia_Alan_Turing's_Promethean_ambition_about_intelligent_machines

[84] Lex Clips. (2019). Richard Feynman: Can machines think? *YouTube.* https://www.youtube.com/watch?v=ipRvjS7q1DI

[85] McKinsey and Company. (2023). Due to generative AI, experts assess that technology could achieve human-level performance in capabilities sooner than previously thought. *McKinsey Global Institute.* https://www.mckinsey.com/~/media/mckinsey/featured%20insights/mckinsey%20explainers/whats%20the%20future%20of%20generative%20ai%20an%20early%20view%20in%2015%20charts/svgz-futuregenaicollection-ex2.svgz?cq=50&cpy=Center

effects kick in, like disappearing food in a Petri dish, stunting bacterial growth (hence the "punctuated equilibria" diagram earlier in this chapter). In the context of AI, while there is substantial growth in model sizes and computational capabilities, there are concerns about hitting physical, economic, or environmental limits. As AI models continue to grow, the benefits in terms of performance will not linearly align with the increased costs, signaling a potential saturation point where scaling up might no longer be as advantageous or feasible.[86]

Potential saturation affecting the progress of LLMs:

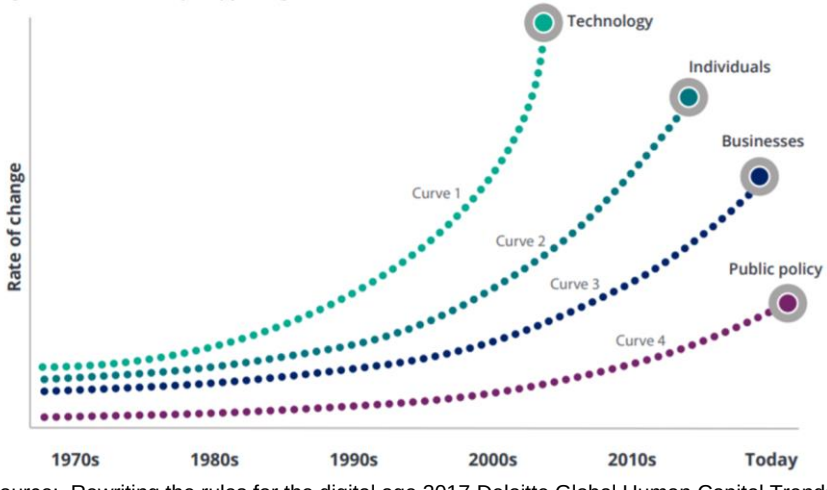
- **Technical Limitations:**
  - Diminishing Returns: LLM developers are already conceding that further bulk of models is not the pathway anymore, compared to multimodality and better datasets.
  - Running out of useful Datasets (forecast for 2026): The scarcity of high-quality and diverse datasets is a notable limitation for LLMs. Acquiring large, varied, and rich datasets has thus far been crucial for training robust models, but humanity generates high-quality data much more slowly than AI trains on it, and low-quality or biased data tends to generate low-quality and biased AI. The move to "synthetic data" is afoot, with unclear results at this stage.
  - Moore's Law plateauing: The progression of LLMs is closely tied to advancements in computing power. With transistors reaching 1 nm, the rate at which humans can advance computational capabilities via silicon improvements is potentially slowing, and reinforcing the migration to mixed architectures of CPU+GPU (PowerInfer, Apple), other types of processors (neuromorphic, etc.) or less hungry algorithms (Mixtral, Orca2).
  - **The need for subsequent breakthroughs** like Reasoning Systems (aka Neuro-Symbolic AI), pairing with Knowledge Graphs, etc.: Current LLMs primarily operate based on pattern recognition and extrapolations, lacking advanced reasoning capabilities and a deep understanding of the content. "Text is a very poor source of information," Yann LeCun said, explaining that it would likely take 20,000 years for a human to read the amount of text that has been used to train modern language models. "Train a system on the equivalent of 20,000 years of reading material, and they still don't understand that if A is the same as B, then B is the same as A." To reach the next level of AI, breakthroughs in reasoning systems[87] and other types of algorithms are essential. But the recent $100B meltdown in the autonomous vehicle industry should remind everyone that *breakthroughs are not available on demand…*

[86] Strubell, E., Ganesh, A., & McCallum, A. (2019). Energy and policy considerations for deep learning in NLP. *ArXiv*: Cornell University. https://arxiv.org/abs/1906.02243

[87] Lenat, D. and Marcus, G. (2023) Getting from Generative AI to Trustworthy AI

- **Management/ideological challenges:** Both OpenAI and Mosaic have encountered press-worthy problems, hinting in the first case at ideological drives and in the second case at management deficiencies.
- **Legal Challenges:** Large Language Models (LLMs) face substantial legal challenges, particularly around issues of data privacy, intellectual property, and usage rights. The training of LLMs often requires vast datasets, potentially encompassing proprietary, confidential, or personally identifiable information.
- **Cost:** The development, training, and deployment of LLMs entail significant costs, primarily due to the substantial computational resources required. The energy consumption and hardware expenses associated with training sophisticated models are considerable.
- **Policy decisions** intended to address ethical, security, and privacy concerns could impose stringent regulations on AI R&D, restrictions on data access and usage, and limit international collaboration (with desired and unintended consequences)
- **Geopolitical events**, like international conflicts and trade wars (not to mention real wars), can impede AI development by disrupting global collaborations and supply chains, while alliances and multi-country agreements can accelerate it by fostering shared research, knowledge, and resource pooling. There is also simultaneous acceleration due to competition, particularly between the US, China, and Europe.
- **Environmental impact**, particularly high electricity consumption and water use, can slow its progression due to increased sustainability concerns.

CCR remains concerned that AI's progress will remain significantly faster than human's ability to absorb it, despite all the limitations, per this diagram below:



(Source: Rewriting the rules for the digital age 2017 Deloitte Global Human Capital Trends)

Could Unintended Consequences Emerge? They *surely* will.

This chapter referenced the oversized impact of the Like button, which, at least, was designed deliberately to have an impact - it is the magnitude of the effect that surprised everyone. Yet that was a “known unknown.”

But one fears most the completely unanticipated effect of an “unknown unknown.” There is an excellent prior example in technology: the humble Short Messaging System (SMS, aka “text”). When SMS was deployed as part of the Global System for Mobiles (GSM) cellular system, it was a simple and lucrative way to fill unused bandwidth between voice channels, with 140 characters. No one could have anticipated that, a decade later, it would contribute to the erosion of a sense of social commitment (everyone has been stood up at the last minute via an SMS), and that two decades later, in its Twitter instantiation, it would contribute to the erosion of Democracy itself![88]

Other consequences on human intelligence:

Science will benefit from AI, to understand the mind and intelligence[89] in several significant ways:

- Modeling Cognitive Processes: AI systems, especially those based on neural networks, can mimic certain aspects of human cognition. By building and observing these systems, researchers gain insights into how the brain might process information, solve problems, and learn new things.
- Development of better ontologies, which are a natural inclination in Computer Science, given its need for precision and consistency.
- Studying Learning and Adaptation: Machine learning, a subset of AI, provides a platform to study how systems can learn from data and experience. This mirrors aspects of human learning and can offer clues about how our brains change and adapt over time in response to new information.
- Neuroscience and AI Interactions: AI models are increasingly used to interpret complex neurological data. By applying AI to brain imaging data, for instance, researchers can identify patterns that might be too subtle or complex for traditional analysis. This helps in understanding the neural basis of cognition and mental processes.

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[88] Toomey, D. (2023). What’s happening with Twitter is a threat to democracy. *The Leadership Conference on Civil and Human Rights.* https://civilrights.org/blog/whats-happening-with-twitter-is-a-threat-to-democracy/#; Yaraghi, N. (2020). Twitter’s ban on political advertisements hurts our democracy. Brookings. https://www.brookings.edu/articles/twitters-ban-on-political-advertisements-hurts-our-democracy/

[89] This is also true of Computer Science in general since its early days, as computing has contributed to Neuroscience. (Wang, X. et al. (2020). Computational neuroscience: A frontier of the 21st century. *National Science Review*, *7*(9), 1418-1422. https://doi.org/10.1093/nsr/nwaa129)

- Simulating Human Behavior: AI can simulate aspects of human behavior, which allows psychologists and neuroscientists to test hypotheses about how the mind works. For example, AI can be used to simulate how people might make decisions under certain conditions.
- Assisting in Mental Health: AI-driven tools are being developed to diagnose and even treat mental health conditions. By analyzing speech patterns, language use, and even facial expressions, AI can help in identifying signs of mental health issues, providing a new window into understanding the mind.
- Ethical and Philosophical Insights: The development of AI raises numerous ethical and philosophical questions about consciousness, free will, and the nature of intelligence. These discussions contribute to a deeper understanding of the human mind by contrasting it with artificial systems.
- Enhanced Cognitive Neuroscience Tools: AI algorithms are used to improve the tools and techniques (like fMRI, EEG) used in cognitive neuroscience. This allows for a more precise study of the brain.
- Language Understanding: Natural Language Processing (NLP), a field of AI, helps in understanding how language is processed and generated, offering insights into one of the most complex human cognitive abilities.
- Comparative Analysis: By comparing AI systems with human intelligence, researchers can identify what makes human cognition unique. This comparison can highlight the aspects of intelligence that are difficult to replicate artificially, thereby offering insights into human-specific traits of cognition.
- Personalized Education and Training: AI-driven adaptive learning systems can tailor educational content to individual learning styles and abilities, providing insights into how different minds learn best. This will be briefly discussed in Chapter Eight.

Furthermore, *how humans think* will be affected as well: Human cognition is affected by novel tools through a dynamic, reciprocal feedback loop that has been long recognized in the social sciences. This loop is exemplified by the concept of "technological determinism," which proposes that technological advancements can shape societal structures and human thought patterns:[90] As humans develop and interact with AI systems, there is a reciprocal influence. AI technologies, by providing new ways of processing and analyzing information, influence how humans think, learn, and solve problems. This aligns with Vygotsky's theory of cognitive development, which posits that social, cultural, and technological tools, play a critical role in the development of higher mental functions.[91]

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[90] McLuhan, M. (1964). *Understanding media: The extensions of man.* McGraw-Hill.
[91] Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Harvard University Press

Interactions with AI are likely to alter human cognitive processes through what scholars describe as the "extended mind" theory. This theory posits that tools and technologies can become integrated into our cognitive processes, essentially extending the mind beyond the brain.[92] In a world of everyday AI, this could manifest itself in several ways. The following examples illustrate how AI tools may become part of the human cognitive apparatus, extending, and sometimes altering native cognitive processes:

- Memory and Information Retrieval: With AI-driven devices carrying virtual assistants, humans will increasingly outsource memory tasks. This is already the case, and is the subject of academic research, with regard to the relationship between the ease of accessing information via the Internet and the way humans memorize information.[93] Instead of remembering phone numbers or important dates, for example, we now largely rely on smartphones (much as we relied on pen and paper in the past). This outsourcing may lead to changes in how humans approach memory-intensive tasks, possibly reducing human reliance on internal memory and shifting towards an external, technology-assisted form of remembering.
- Decision-Making and Problem-Solving: AI algorithms, especially those in areas like predictive analytics, are employed to make decisions or suggest solutions based on vast amounts of data. In fields like healthcare, where AI systems can analyze medical data to suggest diagnoses or treatments, this integration means that professionals are increasingly reliant on AI as a cognitive tool in their decision-making process, potentially altering the way they process information and evaluate options.

Though it is difficult to predict all of the influences AI will have on human cognition, it is clear that as AI systems become more sophisticated and integrated into everyday life, they may have significant impacts on human cognition. AI could lead to enhanced cognitive abilities in some areas, such as data processing, pattern recognition, and creating specific prompts, while potentially diminishing skills in other areas that can be outsourced to AI, like memory and analogizing.

Agents, and the birth of “Kybernetology”

Machine-to-machine (M2M) interaction in artificial intelligence (AI) refers to the ability of AI systems to communicate and collaborate without human intervention. Some existing examples are:

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[92] Clark, A., & Chalmers, D. (1998). The extended mind. *Analysis*, *58*(1), 7–19.

[93] Sharfstein, E. (2011). Study finds that memory works differently in the age of Google. *Columbia News.* https://news.columbia.edu/news/study-finds-memory-works-differently-age-google; Sparrow, B., Liu, J., & Wegner, D. M. (2011). Google effects on memory: Cognitive consequences of having information at our fingertips. *Science*, *333*(6043), 776-778.

- Autonomous Vehicles: Autonomous cars communicate with each other to share information about their positions, speed, and routes to avoid collisions and optimize traffic flow.[94]
- Smart Grids: AI-powered devices in a smart grid can communicate to balance electricity supply and demand in real-time, optimizing energy distribution.[95]
- Industrial Internet of Things: Manufacturing robots and machines in a factory can collaborate through AI algorithms to coordinate production processes and increase efficiency.[96]
- Healthcare Monitoring: Medical devices equipped with AI can communicate vital patient information to each other and healthcare providers for real-time monitoring.[97]
- Recommender Systems: Recommender systems in e-commerce can communicate with each other to improve product recommendations based on user behavior and preferences[98].

There are different types of Agents: simple reflex agents, model-based agents, goal-based agents, utility-based agents, learning agents, and hierarchical agents. Getting into their details is beyond of the scope of this book, so the reader is referred to the citation below[99].

The emergence of increasingly sophisticated Agents will prompt (pun intended) the study of their interactions at the “cognitive” level. This book’s authors predict the birth of “Computer Anthropology” dedicated to studying such interactions between “reasoned” Agents. Since the word “Cybernetics” has been used since the 50s with a different meaning, “Kybernetology”[100] should be the appropriate term for this discipline.

Conclusion

Yes, novel challenges posed by technology are more prominent than ever, ranging from workforce automation to privacy concerns. But these challenges necessitate a response rooted in vigilance and adaptability, rather than fear. As argued by Bessen, technological progress, while typically disruptive, also provides catalysts for innovation and new opportunities.[101] Scholars argue that this evolution requires a different

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[94] Thrun, S. et al. (2006). Stanley: The robot that won the DARPA Grand Challenge. *Journal of Field Robotics, 23*(9), 661-692.
[95] Farhangi, H. (2010). The path of the smart grid. *IEEE Power and Energy Magazine, 8*(1)
[96] Botta, A. et al. (2016). Integration of cloud computing and internet of things: A survey. *Future Generation Computer Systems, 56*, 684-700.
[97] Rajkomar, A., Dean, J., Kohane, I. (2019). Machine learning in medicine. *The New England Journal of Medicine, 380*(14), 1347-1358.
[98] Adomavičius, G. & Tuzhilin, A. (2005). Toward the next generation of recommender systems: a survey of the state-of-the-art and possible extensions. In *IEEE Transactions on Knowledge and Data Engineering* 17(6), 734-749.
[99] https://www.simform.com/blog/types-of-ai-agents/
[100] From the ancient Greek κυβερνήτης (*kybernḗtēs*), which means "helmsperson."
[101] Bessen, J. (2015). *Learning by doing.* Yale University Press.

workforce and advocate for educational reforms to prepare future generations with skills like critical thinking and adaptability.[102]

There is also good reason to be optimistic about AI and other technological advancements. Technology has the potential to improve human work and life and to augment our capacity to address global challenges. Vigilance is necessary to manage and reduce the risks associated with technology like AI, nonetheless, perceptions fueled by fear hinder progress and innovation. Embracing technology with a balance of caution and openness will allow society to leverage its benefits while preparing for its challenges. The following chapters will address what these changes, their impact, and our attitudes towards them will mean specifically for education in an AI world.

[102] Trilling, B., Fadel, C. & Bialik, M. (2015) *Four-dimensional education*. Amazon CreateSpace Independent Publishing Platform.

Chapter Two
Impact on Occupations

"If every tool, when ordered, or even of its own accord, could do the work that benefits it... then there would be no need either of apprentices for the master workers or of slaves for the lords." -Aristotle

"Men will set the goals, formulate the hypotheses, determine the criteria, and perform the evaluations. Computing machines will do the routinizable work…" -J.C.R. Licklider

Implications for Jobs

Many books and papers have been and are being written on the topic of AI and automation, but this text must address this topic **because much of the content learned in High School is preparatory for employability** (either via trade schools or tertiary education). The emergence of AI poses the question of "what education would still be relevant, if jobs were automated away, partially or completely?" After all, AI systems are tire-less compared to Humans. So, the trillion-dollar questions are: Will humans still need to work? Which jobs may survive or emerge?

First, there are plenty of possible advantages of using LLMs in business:

- Verticalization: "Verticalization" refers to the development of industry-specific LLMs that are tailored to cater to the unique needs and requirements of different domains. For example, in the healthcare industry, Google[103] and Stanford[104] have both developed "verticalized" medical LLMs, and a new one named OpenEvidence[105] has just been introduced. Similarly, leading business news providers Bloomberg[106] and Columbia University[107] have both developed finance LLMs.
- Rapid Prototyping & Ease of Use: LLMs can be quickly fine-tuned without extensive new model designs, facilitating rapid development cycles and quicker time-to-market.
- Dynamic Adaptation: Task-centric LLMs can be adapted on the fly to meet changing business requirements.
- Scalability and Generalization: LLMs can adapt to a wide variety of tasks by undergoing fine-tuning, making them highly flexible and reusable across different business applications.

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[103] Matias, Y. & Corrado, G. (2023). Our latest AI health updates. *Google: The Keyword.* https://blog.google/technology/health/ai-llm-medpalm-research-thecheckup/

[104] Bolton, E., Hall, D., et al. (2022). Stanford CRFM introduces PubMedGPT 2.7B. *HAI Stanford.* https://hai.stanford.edu/news/stanford-crfm-introduces-pubmedgpt-27b

[105] https://www.openevidence.com/

[106] Wu, S. Irsoy,O., et al. (2023). BloombergGPT: A Large Language Model for finance. *ArXiv:* Cornell University. https://arxiv.org/abs/2303.17564

[107] AI4Finance-Foundation / FinGPT. (2023). GitHub Repository.

- High Performance: LLMs often deliver state-of-the-art results in various applications, such as natural language processing, image recognition, and data analysis.
- Rich Representations & Knowledge Transfer: LLMs can apply learning from one domain to another (albeit in a limited way so far), thus improving efficiency and potentially revealing new insights.
- Open-source LLMs and Community Support: The open-source movement around foundation models ensures a robust ecosystem of tools, tutorials, and forums, providing businesses with ample support resources and encouraging businesses to share their developments.

There are also concerns about using LLMs in Business:

- Rapid Evolution of Models: LLMs are evolving monthly. A new release can at times be a paradigm shift, requiring engineers to start from scratch to understand how to implement it effectively. This rapid innovation cycle could be seen as a double-edged sword. On the one hand, the continual advancements mean better performance and capabilities. On the other hand, this can create a knowledge gap even among seasoned engineers who might struggle to keep up with the ever-changing landscape.
- Risk of Misuse & Safety: Safety is a growing concern, especially with the ease of creating misleading or harmful content using these models. It is essential to ensure that safety measures are integrated into the models to mitigate misuse, hence:
    - Ethical and Societal Impact: These models can perpetuate biases, stereotypes, and unfairness present in the data, leading to ethical and PR concerns.
    - Data Leakage and Security: Sensitive business information could be inadvertently encoded in the model, posing a security risk.
    - Lack of Interpretability and Transparency: LLMs are often difficult to interpret, making it challenging to understand their decision-making processes. This can be a significant issue for regulatory compliance.
    - Overfitting and Brittleness: These models can be sensitive to outliers and may produce unreliable or unpredictable results when exposed to out-of-distribution data.
    - Legal Ambiguity: Questions surrounding attribution, liability, and intellectual property rights can complicate the legal landscape for businesses using foundation models.

Reasons for Skepticism

In 2013, Oxford's Frey and Osborne created a deep concern by claiming that *"up to 47% of jobs might be automatable,"*[108] while a more sober OECD analysis in 2018 came up with a figure of 14%.[109] Frey & Osborne had used *two* conditionals to hedge "*might* be automat*able,*" but that still alarmed policymakers. While there is value in alerting the policymakers early, given the very long reaction times of the public sector, one would have expected better scholarship at the time from a brand name like Oxford: it is not a solid scientific process for an economist and a computer scientist to simply guesstimate what jobs may be automated. They seem to have learned from this mistake in their 2023 paper,[110] no longer offering quantitative forecasts.

The 2023 research done by consultancies Morgan Stanley,[111] and McKinsey,[112] indicate that, respectively, *possibly* 300M jobs and 30% of occupations could be impacted. Again, only high-level estimates are made, so there is no granular-level way to check if these numbers are believable. The World Economic Forum also published its white paper[113] on LLMs and jobs, and wisely considered the "language intensity" of tasks within occupations (given that LLMs are language-based), to state more plainly that "23% of global jobs will *change* in the next five years."

For solid research, one would need to undertake an analysis of Tests[114] vs Tasks vs Occupations: Passing an exam (law, medical, etc.) is not equivalent to the capacity to fulfill a task (for instance for a lawyer, doing background research); and occupations are made of multiple tasks (for instance, preparing for and arguing a court case), combined with the *underappreciated* "glue" between them (there is no "conveyer belt" from task

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[108] Frey, C.B. & Osborne, M.A. (2013). The future of employment: How susceptible are jobs to computerisation? Oxford Martin Programme on the Impacts of Future Technology, "Machines and Employment" Workshop Papers. https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf

[109] Nedelkoska, L. and G. Quintini (2018), "Automation, skills use and training", OECD Social, Employment and Migration Working Papers, No. 202, OECD Publishing, Paris, https://dx.doi.org/10.1787/2e2f4eea-en

[110] Osborne, M. (2023). Generative AI and the future of work: a reappraisal. Brown Journal of World Affairs. https://ora.ox.ac.uk/objects/uuid:f52030f5-23eb-4481-a7f1-8006685edbae

[111] Paulson, B. & Broderick, E. (2023). Compounding through the hype. *Morgan Stanley: Insights.* https://www.morganstanley.com/im/en-us/individual-investor/insights/articles/compounding-through-the-hype.html

[112] Ellingrud, K., et al. (2023). Generative AI and the future of work in America. McKinsey Global Institute.

[113] World Economic Forum. (2023). Jobs of tomorrow: Large language models and jobs. *White Papers.* https://www.weforum.org/publications/jobs-of-tomorrow-large-language-models-and-jobs/

[114] Major research endeavors have been dedicated to assessing how well different software, especially AI and machine learning models, perform on standard benchmark tests. These benchmark tests are key to understanding a model's capabilities, limitations, and comparative performance. The outcomes of these tests provide insights into the progress of AI, aiding in identifying both advances and areas that require further exploration.

to task). But *there may be a factor of ten in complexity from test to task, and another order of magnitude from task to occupation* – no one knows, and this needs to be understood better.

Furthermore, very few occupations have no context-dependency, so even seemingly "monotask" occupations are not that easy to automate: Driving is quite different in the plains of Manitoba from the Place de l'Etoile in Paris at rush hour. Translating to ask for your room key does not have the mission-criticality as translating at the UN. Of course, some professions might be more impacted than others, particularly the ones that are heavily language-dependent (since that's LLM's forte), but as the Translation example shows, the devil is in the details: routine translation, yes, high-stakes translation, much less likely.

The best dataset in the US is the government's O*NET database of occupations, which are *self-reported* (thus *biased*). Economists often draw from O*NET to study skill demands, wage determinants, occupational shifts, and the potential impact of technological change on employment. To better understand the make-up of jobs at a *detailed* level, and sort out which aspects are automatable, one would need to perform a Cognitive Task Analysis (CTA) of occupations, where psychologists follow professionals in each job type to learn what they actually and exactly do. To our knowledge, this has not been done, even when better analyses[115] are offered.

To better understand emerging occupations and their growth rate, one could monitor the Bureau of Labor Statistics' (BLS) growing vs declining jobs. This may seem basic and obvious, but *jobs change*[116] *much more slowly than feared* (witness the length of time it has taken cashiers' jobs to start declining, and even that decline has a lot more to do with online shopping than with the much-feared scanners,[117] which are now in retreat).

Lastly, labor economists are not futurists, and *even futurists do not have a good track record at imagining the **new** "jobs of the future"* that will emerge. The table below by the World Economic Forum shows the jobs that were ***NOT*** predicted[118] a decade prior:

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[115] Brynjolfsson, E., Mitchell, T. & Rock, D. 2018. What can machines learn, and what does it mean for occupations and the economy? *AEA Papers and Proceedings*, 108, 43-47. https://www.aeaweb.org/articles?id=10.1257/pandp.20181019

[116] **BLS, incidentally, does not forecast new occupations until the technology is out of its R&D phase. The relatively slow speed of technology diffusion is a topic that CCR will not explore here.**

[117] Handel, M.J. (2000). Is there a skills crisis? *The Jerome Levy Economics Institute of Bard College: Public Policy Brief.* https://www.levyinstitute.org/pubs/ppb/ppb62.pdf

[118] World Economic Forum. (2016). The future of jobs report. *WEF Global Challenge Insight Report.* https://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf

Job	Pay level
App developer	*High*
Driverless car engineer	*High*
Cloud computing specialist	*High*
Big data analyst/data scientist	*High*
Social media manager	Medium
Sustainability manager	Medium
YouTube content creators	Medium
Millennial generational expert	Medium
Drone operators	Medium
Uber driver	Low

The following partial list[119] displays more imagination, with the usual hit-or-miss in many cases (not counting that many *should* be automated, such as drone traffic controller):

- 3D Printed Clothing Designer
- Drone Traffic Optimizer
- Augmented Reality Architects
- Robo Advisors
- Global System Architects
- Data Scavengers
- Geo-Taggers
- Urban Agriculturists
- Machine Psychologists
- Computer Behavior Expert
- Data Hostage Negotiators
- Smart Dust Programmers
- Personality Managers

And on and on - see the complete list in the source link.

Lastly, the views about unemployment dangers completely ignore the present difficulty in finding employees for many occupations in developing and developed countries,[120] and that such a trend is accelerated by declining demographics.[121]

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[119] Zeeshan-ul-hassan, U. (2019). Jobs of the future - Are you ready? *Zeeshan-ul-hassan Usmani* (blog). https://zeeshanusmani.com/2019/09/23/jobs-of-the-future-are-you-ready/

[120] Bhagwat, A. (1973). Main features of the employment problem in developing countries. *IMF Staff Papers*, *1973*(001), A002. https://doi.org/10.5089/9781451956351.024.A002; Ferguson, S. (2023). Understanding America's labor shortage. *U.S. Chamber of Commerce.* https://www.uschamber.com/workforce/understanding-americas-labor-shortage

[121] Martinez, M. (2023). As baby boomers retire, German businesses turn to robots. *Reuters.* https://www.reuters.com/technology/baby-boomers-retire-german-businesses-turn-robots-2023-10-27/

The Sober View

As stated in the Foreword, CCR will not entertain in this book the more sci-fi-ish views of total hedonism due to machines doing all the work, or enslavement to the machines, unless these become plausible possibilities rather than philosophical elucubrations. But two possible effects are happening at this time, which can happen in parallel, as they are not mutually exclusive:

Substitution: In the context of labor economics, "substitution" refers to the concept of workers or jobs being replaced or supplanted by technological advancements. The widely cited statement, "AI won't replace you, but someone with AI will," is often considered apocryphal, but it has been substantiated and documented[122] by Harvard Business School (HBS). It suggests that while AI may not directly replace individuals in their roles, those who harness AI's capabilities will likely outperform and outcompete those who do not, emphasizing the importance of embracing AI technology and its integration into professional environments. So, in other words: *better to hop in the car, than run behind it!*

Complementarity: In labor economics, "complementarity" refers to a concept where certain technologies or skills enhance the value and productivity of human labor rather than replacing it. An excellent recent study[123] at Harvard Business School (HBS) stated: “We suggest that the capabilities of AI create a “jagged technological frontier” where some tasks are easily done by AI, while others, though seemingly similar in difficulty level, are outside the current capability of AI. ...our analysis shows the emergence of two distinctive patterns of successful AI use by humans along a spectrum of human-AI integration. One set of consultants acted as “Centaurs,”[124] like the mythical half-horse/half-human creature, dividing and delegating their solution-creation activities to the AI or themselves. Another set of consultants acted more like “Cyborgs,”[125] completely integrating their task flow with the AI and continually interacting with the technology.”

While complementarity between technology and human skills can significantly boost productivity, it also poses potential pitfalls, particularly in

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[122] Iansiti, M., et al. (2020). *Competing in the age of AI.* Harvard Business Review Press; Ignatius, A. (Ed.) (2023). AI won't replace humans - but humans with AI will replace humans without AI. *Harvard Business Review: Business and Society.* https://hbr.org/2023/08/ai-wont-replace-humans-but-humans-with-ai-will-replace-humans-without-ai.

[123] Dell'Acqua, F., et al. (2023). Navigating the jagged technological frontier: Field experimental evidence of the effects of AI on knowledge worker productivity and quality. *Harvard Business School Technology & Operations Mgt. Unit Working Paper No. 24-013*. https://ssrn.com/abstract=4573321 or http://dx.doi.org/10.2139/ssrn.4573321

[124] Wikipedia. (2023). Advanced chess. https://en.wikipedia.org/wiki/Advanced_chess

[125] Interestingly the Cyborg/Centaur analogy was first used in chess with machines https://en.wikipedia.org/wiki/Advanced_chess

long-term, real-world contexts. Over-reliance on technology can lead workers into "auto-pilot" mode, a laxity where they become *overly* dependent on, and trusting of, technological systems, and fail to actively engage with them and further refine their skills. This dynamic cultivates skill atrophy and reduces human capabilities to adapt rapidly when faced with unforeseen challenges or disruptions.[126]

In real-world occupational contexts, these two effects interact with each other and can do so to the benefit of practitioners. For example, in journalism, LLMs can assist journalists in preliminary research and content generation for standard reports. However, critical thinking, fact-checking, analysis, compelling storytelling, and the ethical considerations inherent to journalism are more difficult for machines to replicate consistently.[127] In domains requiring customer support, LLMs have taken on significant roles in handling initial customer queries, complaints, or feedback, providing instant responses on platforms like chatbots or email auto-responses.[128] This can lead to more efficient customer service, especially for frequent and basic queries. Yet, complex issues that require emotional intelligence, empathy, or intricate problem-solving continue to require human intervention. An LLM can provide information, but human agents are important for relationship-building and nuanced understanding.

Similarly, LLMs are making great leaps in helping medical practitioners by parsing through vast amounts of medical literature to provide the latest findings or suggesting differential diagnoses based on symptom input. However, the actual practice of medicine is more than data processing, involving physical examinations and interventions, interpreting non-verbal cues, and making decisions based on a combination of objective data and subjective judgment.[129]

So, to recap:

- Economists do not fully understand the difference in complexity between tests, tasks, and jobs.
- History shows that technology diffusions in businesses can take decades.
- Forecasts have notoriously missed the emergence of new occupations.
- Employment demographics are often underappreciated.
- Substitution and complementarity effects will be at play, and hard to forecast.

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[126] Autor, D. H., Levy, F., & Murnane, R. J. (2003). The skill content of recent technological change: An empirical exploration. *The Quarterly Journal of Economics*, 118(4), 1279-1333.
[127] Graefe, A. (2016). *Guide to automated journalism*. Tow Center for Digital Journalism,
[128] Huang, M. H., & Rust, R. T. (2018). Artificial intelligence in service. *Journal of service research*, 21(2), 155-172. https://journals.sagepub.com/doi/10.1177/1094670517752459
[129] Chen, J. H., & Asch, S. M. (2017). Machine Learning and Prediction in Medicine — Beyond the Peak of Inflated Expectations. *The New England journal of medicine*, 376(26), 2507.

With all these caveats in mind, one can dismiss the fear that “all jobs will disappear” any time soon. **Since jobs will still exist for the foreseeable future, the goal of education is *still* dual, per the Introduction section: psychosocial *and* economic,** not one *or* the other. *How* to do so is discussed in the rest of this book. It starts with the ultimate goal of education: Wisdom.

Chapter Three
WISDOM - Enduring Goal of Education

"Fly the middle course" - Daedalus [advice] to Icarus[130]

Why Wisdom? Societal advancement - and survival!

Wisdom has played a crucial role in human evolution, promoting group cohesion and ensuring survival. In early hunter-gatherer societies, wise elders were vital for decision-making and conflict resolution, helping the group survive environmental challenges and rival threats.[131] As societies became more complex, wisdom became even more important: Navigating social hierarchies, understanding cultural norms, and foreseeing consequences required reconciling differing perspectives and predicting future outcomes - key aspects of wisdom.[132] The human inclination for cumulative cultural evolution, where each generation builds on the wisdom of the past, underscores the significance of wisdom for both individual survival and the perpetuation of collective knowledge and insight, **fostering societal advancement.**[133]

Yet all over the world, beliefs (including religious ones) are winning against knowledge,[134] due in no small way to the influence of social media appealing to emotions.[135] André Malraux said: "Le 21ème siècle sera religieux on ne sera pas," [136] meaning that either civilization will find guiding principles (he did not mean "religions"), or will self-destruct. MIT's Danny Hillis, former founder of Thinking Machines,[137] once quipped: "Welcome to the Age of *Un*reason" [138]

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[130] Tolentino, Cierra. (2022). "The Myth of Icarus: Chasing the Sun." *History Cooperative.*
[131] King, L. A., Hicks, J. A., & Abdelkhalik, J. (2009). Death, life, scarcity, and value: An alternative perspective on the meaning of death. *Psychological Science, 20*(12), 1459–1462.
[132] Bluck, S., & Glück, J. (2005). From the Inside Out: People's Implicit Theories of Wisdom. In R. J. Sternberg & J. Jordan (Eds.), *A handbook of wisdom: Psychological perspectives* (pp. 84–109). Cambridge University Press. https://doi.org/10.1017/CBO9780511610486.005
[133] Tomasello, M. (1999). The human adaptation for culture. Annual review of anthropology, 28(1), 509-529. https://www.annualreviews.org/doi/abs/10.1146/annurev.anthro.28.1.509
[134] Kahan, D. M. (2015). Climate-science communication and the measurement problem. Advances in Political Psychology, 36, 1-43. https://www.jstor.org/stable/43783843; Norenzayan, A., & Gervais, W. M. (2013). The origins of religious disbelief. *Trends in Cognitive Sciences, 17*(1), 20–25. https://doi.org/10.1016/j.tics.2012.11.006.
[135] Lewandowsky, S., Ecker, U. K. H., & Cook, J. (2017). Beyond misinformation: Understanding and coping with the "post-truth" era. *Journal of Applied Research in Memory and Cognition, 6*(4), 353–369. https://doi.org/10.1016/j.jarmac.2017.07.008
[136] He did not mean, as some have misunderstood, "become religious"
[137] https://en.wikipedia.org/wiki/Thinking_Machines_Corporation
[138] Personal communication with Charles Fadel

Wisdom is also crucial in understanding and navigating the existential risks and emerging ethical challenges posed by climate change,[139] and human-made technologies beyond fossil fuels (AI,[140] Biotech[141] and nuclear power). Humanity is facing an "unprecedented array of social and environmental problems, many of which are human-made"[142] represented by 14 potential evolutionary dead ends for humanity.[143] **The stakes are currently higher than ever for humanity to demonstrate more collective and individual wisdom.**

We have to educate students to be the next generation of change agents, capable of tackling immense challenges. *University entrance, and employment requirements, are necessary, but not sufficient*.

But what exactly is Wisdom? Insightful discernment in context

Wisdom is generally loosely defined in popular culture as it can be considered in its broadest and most strict senses,[144] and comes associated with many complicated caveats in public opinion (especially in increasingly divisive political climates). Wisdom is commonly defined as:

Source	Definition
Oxford[145] (UK)	The ability to make sensible decisions and give good advice because of the experience and knowledge that you have
Merriam-Webster [146] (USA)	Ability to discern inner qualities and relationships**;** insight; good sense; judgment

[139] Gardiner, Stephen M. (2011). *A Perfect Moral Storm: The Ethical Tragedy of Climate Change*, Environmental Ethics and Science Policy Series, online edition. Oxford, UK: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195379440.001.0001
[140] Wilks, Yorick, Ed. (2010). *Close Engagements with Artificial Companions: Key Social, Psychological, Ethical and Design issues*. Amsterdam: John Benjamins Pub. Co.
[141] Rigaud, Nicolas. (2008). "Biotechnology: Ethical and Social Debates." Report for the *OECD International Futures Project on The Bioeconomy to 2030."* https://www.oecd.org/futures/long-termtechnologicalsocietalchallenges/40926844.pdf
[142] Glück, Judith and Nic M. Weststrate. (2022). "The Wisdom Researchers and the Elephant: An Integrative Model of Wise Behavior." *Personality and Social Psychology Review*, *26*(4), 342–374. https://doi.org/10.1177
[143] Søgaard Jørgensen, P. et al. (2023). Evolution of the polycrisis: Anthropocene traps that challenge global sustainability. *Philosophical Transactions of the Royal Society of London (B)*. DOI: 10.1098/rstb.2022.0261
[144] Mitchell, L., Knight, B., & Pachana, N. (2017). Wisdom across the ages and its modern-day relevance. *International Psychogeriatrics, 29*(8), 1231-1234. doi:10.1017/S1041610217000783
[145] Oxford Learner's Dictionary. (2023). "Wisdom."
[146] Merriam-Webster Dictionary. (2023). "Wisdom." https://www.merriam-webster.com/dictionary/wisdom

Sagesse [147]	• Higher ideal of life proposed by a moral or philosophical doctrine; the behavior of someone who conforms to this ideal • Quality of someone who demonstrates sound, informed judgment in decisions and actions • Quality of someone who acts with prudence and moderation; strength of character in actions
σοφία, sophía	• Literally translates as “clever,” “skillful,” “intelligent,” “wise” • Greek philosophy (*philo-sophia,* literally the “love of wisdom”) emphasizes recognizing one’s own ignorance and valuing epistemic humility, encapsulated in Socrates’ famous aphorism "I know that I know nothing."[148]
ཤེས་རབ་, *prajñā sherab* ཡེ་ཤེས་, *jñāna yeshe*[149]	• In Tibet, wisdom is the sixth of the six paramitas, defined as the precise discernment of all things and events. • In the word yeshe, ཡེ་, *yé* is short for ཡེ་ནས་, *yé né*, which means ‘right from the beginning.’ Some translations use ‘pristine’ or 'pure', meaning that it is the way it always was.
Hinduism	• Wisdom is a profound state of being, linked to achieving liberation and encompassing ultimate self-awareness and recognition of oneself as the foundational truth of all creation. • It involves realizing one's deep connection with all of creation and the Supreme Soul (Paramatma), reached through righteous living and conduct.[150]
prajñā (Pali, paññā)	• Buddhist traditions give central importance to developing wisdom; the ultimate aim is often presented as "seeing things as they are" or as gaining a "penetrative understanding of all phenomena.”[151]
ḥikma حكمة	• Translates from Arabic as “wisdom,” “sagacity,” “philosophy,” “rationale” or “underlying reason.”

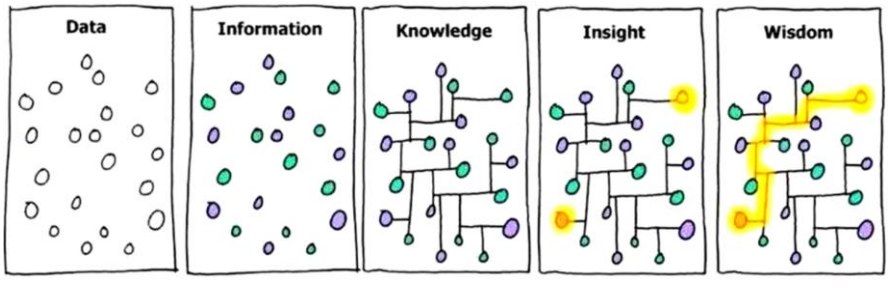
[147] Larousse. (2023). “Sagesse.” https://www.larousse.fr/dictionnaires/francais/sagesse/70506
[148] Fine, Gail (2008). "Does Socrates Claim to Know that He Knows Nothing?". *Oxford Studies in Ancient Philosophy*. **35**: 49–88.
[149] Wikipedia. (2023). “Wisdom - Rigpa Shedra.” https://www.rigpawiki.org/index.php?title=Wisdom; Wikipedia. (2023). “Primordial wisdom - Rigpa Shedra.” https://www.rigpawiki.org/index.php?title=Primordial_wisdom.
[150] Easwaran, E. (2007). The Bhagavad Gita: Classics of Indian Spirituality. Nilgiri Press.
[151] Bodhi, B. (1999). The noble eightfold path. Access to Insight. https://www.accesstoinsight.org/lib/authors/bodhi/waytoend.html

	• "Hikma" is understood as knowledge and understanding, and a means of nourishing the spirit or intellect.[152]
知人者智 自知者明	• In Taoism, wisdom is adherence to the three treasures: charity, simplicity, and humility. "He who knows other men is discerning [智]; he who knows himself intelligent [明]."[153]
智慧 "Zhì huì[154]"	• the ability to make good judgments • knowledge gained by having many experiences in life

It can also be triangulated via its **synonyms and antonyms**:[155]

- Synonyms: acumen, prudence, insight, common sense, experience, intelligence, judgment, knowledge.
- Antonyms: ignorance, imprudence, ineptness, thoughtlessness, stupidity.

Wisdom across human traditions surpasses mere information or knowledge. It is a virtue to be sought after in order to live morally and understand human life.[156] Nonetheless, information and insight, for example, are part of the development of wisdom. The cartoon below offers a visual synthesis of the differences between and progressions from data and information to wisdom:



(Source: Internet - Unknown)

Explanatory Note to the drawing above: data points exist in the world as raw material, and information is the processed and interpreted outcome that provides meaning and context to that data. Knowledge is the subsequent understanding and awareness of information and concepts and making connections. Insight, on the other hand, involves a deeper level of

[152] Wikipedia. (2023). "Hikma" https://en.wikipedia.org/wiki/Hikmah
[153] Legge, J. (1891). 《道德經 - Dao De Jing》. *Chinese Text Project.* https://ctext.org/dao-de-jing#n11624
[154] Leo, Andres. (2023). Chinese word database. https://www.chinese-word.com/data/2262-2.html
[155] Thesaurus.com. (2023). "Wisdom." https://www.thesaurus.com/browse/wisdom
[156] Sternberg, R. J., & Glück, J. (Eds.) (2022). *The psychology of wisdom: An introduction.* Cambridge University Press.

understanding that often comes from recognizing patterns, and gaining a unique perspective. More than just assimilating information, wisdom is a broader and more encompassing characteristic that involves the ability to apply knowledge and experience thoughtfully and with a sense of responsibility and empathy towards others and the world, and *ensuring choices that reflect both personal and **societal** interests*.

CCR's Synthesis Research on Wisdom

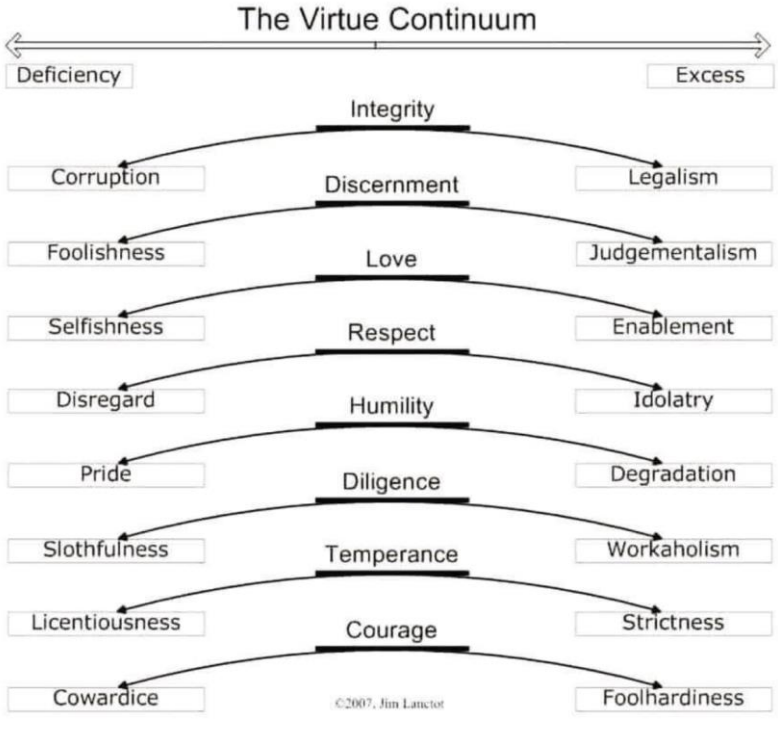
Term	Preferred Definition	Associated Terms and Constructs
Wisdom	The Golden Mean:[157] "Nothing in excess," applied self-referentially as well ☺	Balance, moderation, maturity, gravitas, common sense, proverbs

Wisdom is Balance: The never-ending evolutionary tug-of-war between selfish-to-a-point, and altruistic-to-a-point, is a dynamic equilibrium, constantly adjusting for what has been called the "Golden Mean." CCR expands it to reflect the popular proverb: "everything in moderation, including moderation itself." It implies a strong ability for metacognitive self-control (aka "executive function"), to avoid extremes, as well as a significant amount of metacognition and metaemotion, to discern when to bypass the rule *occasionally* as needed by circumstances.

The image below[158] captures the balance required by wisdom, as manifested as different degrees in the continuum. Key to wisdom is dynamic equilibrium: maintaining moderation in behavior and thought, and knowing when that moderation is necessary or not. In other words, **metacognition and metaemotion must be summoned to avoid extreme behaviors (when inappropriate, as in most circumstances).**

[157] Golden mean (philosophy). (2024). *Wikipedia*. https://en.wikipedia.org/wiki/Golden_mean_(philosophy)

[158] Lanctot, J.D. & Irving, J.A. (2010). Character and Leadership: Situating Servant Leadership in a proposed virtues framework. *International Journal of Leadership Studies, 6*(1), 28-50. https://www.regent.edu/acad/global/publications/ijls/new/vol6iss1/2_Final%20Edited%20Lanctot%20and%20Irving_pp%2028-50.pdf



(Source: Lanctot, J.D. & Irving, J.A. 2010)

Maturity: "Maturity is a trait where a person has the experience and wisdom to behave in a resolved, resolute, and secure way."[159] Maturity is often associated with wisdom and other connected traits, such as humility, introspection, and the experience of failure. Societies often place benchmarks on maturity (e.g. 18 years of age to vote; coming of age ceremonies in native societies or religious settings), but the concept, and its reality, are more complex. Maturity is not automatically gained through rituals or by attaining a certain age or status, but is rather an ongoing process throughout an individual's life.

There are several "models" of maturity that have been devised over the years. One of the most influential is Allport's 1967 maturity model.[160] This model of maturity posits that a fully mature individual exhibits traits such as self-extension, warm human interactions, emotional security, skills and tasks, self-objectification, and a unifying philosophy of life. Allport believed that true maturity is characterized by the ability to live comfortably with oneself, to form genuine and unprejudiced relationships with others, and to navigate life with a sense of purpose. More recently in 2012, Todres published a study identifying five indicators of maturity: political participation,

[159] Drew, C. (2023). *25 maturity examples*. Helpful Professor. https://helpfulprofessor.com/maturity-examples/
[160] Allport, G. W. (1961). *Pattern and growth in personality.* Holt, Reinhart & Winston.

independent economic power, responsibility and accountability, bodily integrity, and family rights.[161] The indicators gauge an individual's cogent engagement with the world around them, their ability to care for themselves and others and their ability to be responsible (and therefore be held responsible for their actions).

Gravitas is another concept often associated with maturity. Though these concepts are related, they are distinct. Gravitas refers to a quality of seriousness, dignity, or solemnity of manners. It's often associated with authority, credibility, and weightiness in one's presence or speech. On the other hand, maturity relates to a person's ability to respond to situations in an appropriate manner, showing wisdom, experience, and emotional stability.

While gravitas can be a sign of maturity, it's not the only marker. One can be mature without always displaying gravitas. Similarly, someone might exhibit gravitas in certain situations but lack maturity in other aspects of life. So, while gravitas can complement maturity, it is not strictly necessary for it.

Humility, commonly understood as the recognition of one's limitations and a genuine openness to the ideas and experiences of others in one's knowledge, is the cornerstone of wisdom and a trait that can be developed through socialization and education. To foster wisdom, we must foster humility, as realizing our limits is essential to discernment and eventually wisdom. Curricular structures that encourage self-reflection and the celebration of diverse perspectives can be instrumental in cultivating humility. As discussed above, engaging students in literature from various cultural backgrounds exposes them to a plethora of experiences and worldviews, allowing them to see the world from perspectives different from their own.[162] Classroom discussions that emphasize the Socratic method, wherein teachers pose questions that lead students to realize the limitations of their knowledge, can be instrumental in promoting intellectual humility.[163] By acknowledging the vastness of what remains unknown, students learn the value of continued inquiry and the importance of recognizing the strengths and insights of others. Exercises in exposure to diversity and other modes of thought and the limitations of thought, challenge ethnocentric, anthropomorphic, and other biases, promoting understanding and compelling students to reevaluate and, sometimes, humble their preconceived notions.

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[161] Todres, J. (2012). Maturity. *Houston Law Review, 48*(5), 1107-1165. https://houstonlawreview.org/article/4131-maturity

[162] Hanh, T. N. (1999). *The heart of the Buddha's teaching: Transforming suffering into peace, joy & liberation.* Broadway Books.

[163] Paul, R., & Elder, L. (2006). Critical thinking: The nature of critical and creative thought. *Journal of Developmental Education, 30*(2), 34. https://www.semanticscholar.org/paper/Critical-Thinking%3A-The-Nature-of-Critical-and-Paul-Elder/8bc9e8bfe26e71fdf1cb68c93d7561c478d7c032

Common sense is often associated with wisdom. While common sense typically refers to the innate or acquired ability to make practical judgments in everyday situations,[164] wisdom is seen as a profound, holistic understanding and insight into life's complexities, involving ethical reflection, compassion, and action for the common good.[165] Common sense can be viewed as a component or a stepping stone to attaining wisdom, but wisdom incorporates a deeper, multidimensional discernment and moral application of knowledge.

Dr. Ernest Davis of New York University focuses on the vagueness of definitions of commonsense both for humans and, now, for emerging AIs. "Unquestionably 'common sense' as applied to people or AIs is a vague term: it is futile to try to give a tight definition or necessary and sufficient conditions. Tasks, knowledge, and reasoning processes of various kinds can be more or less commonsensical along a number of dimensions."[166] He then enumerates features that are considered to be characteristic of commonsense in humans and AI. These points include:

- Common sense knowledge is common
- Common sense is largely sensible
- Common sense supports reasoning
- Commonsense reasoning is integrated with other cognitive abilities
- Common sense extends across tasks and modalities
- Common sense has a broad scope
- Commonsense knowledge can be distinguished from common knowledge, encyclopedic knowledge, and expert knowledge.
- Commonsense knowledge is not "book learning" explicitly taught in schools
- Commonsense is in general concerned with generalities rather than with individuals
- Commonsense reasoning is separate from purely linguistic or purely perceptual interpretation
- Most commonsense knowledge is learned early in life

Proverbs across cultures largely serve as mnemonic distillates for common sense and wisdom, encapsulating cultural knowledge and values, succinctly conveyed to impart guidance and understanding. For example, the African proverb, "It takes a village to raise a child," emanates from the shared communal responsibility in upbringing,[167] while the Chinese proverb, "Give a man a fish and you feed him for a day. Teach a man to fish and you feed him for a lifetime," accentuates the long-lasting impact of self-sufficiency

[164] Sternberg, R. J. (2005). Wisdom as a form of giftedness. *Gifted Child Quarterly*, 49(4), 277-290. https://eric.ed.gov/?id=EJ616398
[165] Baltes, P. B., & Smith, J. (2008). The Fascination of Wisdom: Its Nature, Ontogeny, and Function. *Perspectives on Psychological Science*.
[166] Davis, E. (2023). Benchmarks for automated commonsense reasoning: A survey.
[167] Mbiti, J. S. (1990). *African religions & philosophy*. Heinemann.

and education.[168] Proverbs like these, ingrained in cultures across the globe, mirror societal norms and principles, offering insight and mnemonic shortcuts, and fostering moral and ethical contemplation across generations.

Why should Wisdom be the *ultimate* goal of education? It is a holistic view for a changing world

The importance of wisdom in confronting these challenges lies in the ability to facilitate a complex, interdisciplinary understanding of multifaceted ethical questions that concern safety, long-term consequences, and global implications. Wisdom fosters a holistic perspective that integrates insights from diverse domains of knowledge (e.g. technology, ethics, law, sociology) while promoting compassion, risk management, and moral leadership. In doing so, wisdom equips individuals and societies with the critical judgment, empathy and moral courage needed to responsibly align decisions with ethical principles and the broader well-being of humanity and the planet.[169]

Wisdom is key to developing global citizens, and solving global challenges: in the words apocryphally attributed to Benjamin Franklin "*We must hang together, or surely we shall hang separately."* Current and future global challenges facing the human population necessitate cultural dexterity, appreciation for diversity and sensitivity towards different perspectives. The number and speed at which novel, visible, and accessible ethical quandaries appear in our world today is unprecedented.[170] While these dilemmas might have always existed in some form, the 21st-century context makes them more immediate to the average person's daily life. Wisdom refines the qualities necessary to navigate these complexities and lays the foundation for global citizenship, vital for cohesive and cooperative interactions in a multicultural society facing new ethical landscapes.

Wisdom and Evolution

Evolution is a key driver of human behavior that is typically not taken sufficiently into account. Evolution has wired life to propagate itself as its

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[168] Lau, D. C. (2011). *Confucius: The analects*. *Bilingual edition.* Hong Kong University Press. https://cup.cuhk.edu.hk/index.php?route=product/product&product_id=361

[169] Sternberg, R. J., Nusbaum, H., & Glueck, J. (Eds.) (2019). *Applying wisdom to contemporary world problems.* Palgrave-Macmillan.

[170] Bazerman, Max H. and Ann E. Tenbrunsel. (2011). *Blind Spots: Why We Fail to Do What's Right and What to Do About It.* Princeton, NJ: Princeton University Press. https://press.princeton.edu/books/paperback/9780691156224/blind-spots; Floridi, Luciano. (2013) *The Ethics of Information*. Oxford, UK: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199641321.001.0001; Manuel Velasquez, C. M., Andre, C., Shanks, T. S. J., & Meyer, M. J. (2010). "Thinking Ethically: A Framework for Moral Decision Making." Issues in Ethics, 7(1). https://static1.squarespace.com/static/5e67f2971cd1421e2f954980/t/5e7bcf7e9e0f5b32db9cbc1f/1585172350318/Thinking-Ethically.pdf

absolute priority. In social animals, this drive has created constant tensions between primordial fears and transcendent behaviors. Christian de Duve, Nobel prize in Medicine 1974, stated in his book *Genetics of Original Sin,*[171] "We have evolved traits [such as group selfishness] that will lead to humanity's extinction – so we must learn how to overcome them…Original sin is none other than the fault written into human genes by natural selection…". Natural selection has:

- Indiscriminately privileged all the personal qualities that contribute to the immediate success of the individual (e.g., selfishness, competitiveness, "All for Me")
- Privileged traits favoring cohesion within groups, and hostility among different groups (e.g., clannishness, "Us vs. Them")
- *Not* privileged the foresight and wisdom needed for sacrificing immediate benefit for the sake of the future (e.g. short-term reactivity, "Now, not Later")"

To which we add:

- ***"Follow the Power Leader"*** – in "VUCA"[172] times, a strong desire to follow a powerful, charismatic, seemingly assured (and very often, self-serving) leader.[173]
- Developed **only linear thinking**: the problems faced by humanity (climate change, pandemics, etc.) are exponential in nature, which our minds are not geared to understand.[174]

Given the globally dominant role of the single remaining human species, *Homo sapiens*, these tendencies above have become inherited "faults" in our human nature – faults that are actively contributing to our own (and many other species) eventual extinction.

Despite these faults in humanity's evolved behaviors, there is also a significant body of research documenting the evolutionary biology of positive behaviors, such as collaboration, communication, and ethics, in humans and other species.[175] For example, many animals, including humans, exhibit altruism, as it can help groups of social animals survive even better. Selfishness, however, particularly in humans, can come a lot easier and often its excesses are not visibly punished immediately. *It takes time for*

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[171] De Duve, C. (2009). *Genetics of original sin.* Odile Jacob Publishing. https://www.odilejacob.com/catalogue/sciences/genetique/genetics-of-original-sin_9782738147523.php

[172] Mackey, Richard H. Sr. *Translating Vision into Reality: the Role of the Strategic Leader*. (Carlisle Barracks, PA: US Army War College, 1992), 10. Footnote: 15. https://usawc.libanswers.com/faq/84869

[173] Conger, J. A., & Kanungo, R. N. (1998). *Charismatic leadership in organizations.* Sage Publications, Inc.; Festinger, L. (1957). *A theory of cognitive dissonance.* Stanford University Press.

[174] Dehaene S, Izard V, Spelke E., & Pica P. (2008). Log or linear? Distinct intuitions of the number scale in Western and Amazonian indigene cultures. *Science, 320*(5880):1217-20. doi: 10.1126/science.1156540. https://pubmed.ncbi.nlm.nih.gov/18511690/

[175] See Appendix online: "The Evolutionary Origins of Competencies", CCR 2023

society to bring this selfishness under control, as these instincts can be counteracted or mitigated: Social customs, like the Golden Rule[176] – "treating others as one wants to be treated" – can be deeply ingrained in individuals via education, community norms, religion (when benevolent), etc.[177]

The "Golden Rule" is not exclusive to anglophone traditions; it is a fundamental tenet found across cultures and religious traditions. In Confucianism there exists a similar axiom: "Do not do to others what you do not want done to yourself."[178] This principle, dating back to the 5th century BCE, demonstrates the importance of reciprocity in relationships. The Hindu text *Mahabharata* (circa 400 BCE to 400 CE) contains the verse: "One should never do that to another which one regards as injurious to one's own self."[179] Similarly, Islam promotes the ethos of considering others' feelings and rights: "None of you [truly] believes until he wishes for his brother what he wishes for himself."[180] Thus, the principle of empathetic reciprocity is deeply embedded in the moral fabric of multiple societies, transcending geographical and temporal boundaries.

Research in cognition and psychology in the animal kingdom also demonstrate the presence of 'golden rules' amongst non-human social animals. Primates engage in a number of reciprocal behaviors, including grooming and care of their young. Similarly, cetaceans share responsibility in the care for the young and protecting their groups, and dolphins are well-documented assisting injured or stranded individuals from their pod. Even insects, such as bees, ants and termites exhibit altruistic and cooperative behaviors in foraging, protecting their nests and caring for their young. Collaboration amongst social creatures is well-documented and often carries altruistic components. This may not be "wisdom," but best practice for surviving and thriving as complex groups.

Justification for Education

The shift in focus from mere knowledge acquisition to fostering wisdom in education, and making wisdom the goal of education, finds its western roots in Socratic thinking, its eastern roots in the teachings of Confucius[181] (and to

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[176] Wikipedia. (2023). Golden rule. https://en.wikipedia.org/wiki/Golden_Rule, ***not to be confused with the Golden Mean.***

[177] Jeste, D. V., & Vahia, I. V. (2008). Comparison of the Conceptualization of Wisdom in Ancient Indian Literature with Modern Views: Focus on the Bhagavad Gita. *Psychiatry*, *71*(3), 197. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2603047/

[178] Confucius. (1989). *The Analects* (D. C. Lau, Trans.), 15:23. Penguin Books.

[179] Ganguli, K. M. (1883-1896). *The Mahabharata of Krishna-Dwaipayana Vyasa*.BharataPress

[180] Al Buhkari, I. & Uddin, M.M. (2020). *Sahih al bukhari* (English Edition). Mohee Uddin; Al Nuwawai, Y.I.S. (1997). *An-Nawawi's Forty Hadith.* Cambridge Islamic Texts Society.

[181] Ames, R. T., & Rosemont, H. Jr. (1999). *The Analects of Confucius: A philosophical translation.* Ballantine Books.

a lesser degree, Taoism[182]), and its modern roots in concepts of progressive education, such as the experiential learning advocated by John Dewey[183] (and Paulo Freire's later work towards educating for critical consciousness[184]). Contemporary approaches in cognitive science, psychology and education research continue to argue for the "rationality of educating for wisdom";[185] proposing frameworks of education as a development of human capabilities, such as civic wisdom.[186] All of these theoretical views support the argument that education must adjust its goals to go beyond mere knowledge acquisition to foster wisdom.[187]

The demands for effective communication, collaboration, and conflict resolution in the globalized world require, *among other attributes,* emotional intelligence. International health crises in the past two decades (e.g. COVID-19 and the Ebola outbreak in 2014) demonstrate the extent to which emotional intelligence, in addition to expertise, is crucial to intercultural communication. In the case of the Ebola crisis, aid organizations encountered significant cultural and communicative challenges. Misinformation about the disease, unsafe burial practices, and general mistrust toward outsiders exacerbated the situation.[188] The ability to understand, communicate with, and gain the trust of local communities – which hinges significantly on emotional intelligence – is pivotal in managing global health crises.[189]

Wisdom and emotional intelligence are closely intertwined,[190] and the development of wisdom can facilitate the growth of emotional intelligence

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[182] Slingerland, E. (2003). *Effortless action: Wu-wei as conceptual metaphor and spiritual ideal in early China.* Oxford University Press.
[183] Dewey, John. (1938). *Experience and Education*. New York, NY: Kappa Delta Pi.
[184] Freire, Paulo. (1965). *Education for Critical Consciousness.* London, UK: A&C Black.
[185] Stanovich, Keith E. (2001). "The Rationality of Educating for Wisdom." *Educational Psychologist,* 36(4), 247-251. http://keithstanovich.com/Site/Research_on_Reasoning_files/edpsy01.pdf
[186] Nussbaum, Martha C. (1997) *Cultivating Humanity: A Classical Defense of Reform in Liberal Education.* Cambridge, MA: Cambridge University Press.
[187] Jakubik, Maria. (2020). "Educating for the Future: Cultivating Practical Wisdom in Education." *Systemics, Cybernetics and Informatics,* 18(7), 50-54. https://www.iiisci.org/journal/pdv/sci/pdfs/SA422DQ20.pdf
[188] Abramowitz, S., McKune, S. L., Fallah, M., Monger, J., Tehoungue, K., & Omidian, P. A. (2015). The opposite of denial: Social learning at the onset of the Ebola emergency in Liberia. Journal of Health Communication, 20(sup1), 59-65. https://pubmed.ncbi.nlm.nih.gov/28854129/
[189] McMahon, S. A., Ho, L. S., Brown, H., Miller, L., Ansumana, R., & Kennedy, C. E. (2016). Healthcare providers on the frontlines: a qualitative investigation of the social and emotional impact of delivering health services during Sierra Leone's Ebola epidemic. Health policy and planning, 31(9), 1232-1239. https://pubmed.ncbi.nlm.nih.gov/27277598/
[190] Schneider, Tamera R., Nusbaum, Howard C., Kim, Yena, Borders, Morgan R. and Tyler J. Ryan. (2023). "Emotional Intelligence Predicts Wise Reasoning." *Journal of Positive Psychology,* 18(1), 106-120. https://www.tandfonline.com/doi/abs/10.1080/17439760.2021.1991448; Steimer, Sarah. (2021). "Two Studies Show a Link Between Emotional Intelligence and Wisdom." University of Chicago, Division of Social Sciences, News. https://socialsciences.uchicago.edu/news/two-studies-show-link-between-emotional-intelligence-and-wisdom

through self-reflection, empathy and perspective taking. Wisdom, and the emotional intelligence it encompasses, are instrumental in forming the bedrock of successful interpersonal relationships in all domains of human life. Wisdom also makes individuals more capable of coping with uncertainty and ambiguity, providing the tools for adaptability and resilience. These traits contribute to the cultivation of a pro-active, forward-looking mindset, a key attribute for personal, local, and global sustainability.

Finally, wisdom recognizes the evolving nature of knowledge and the humility of admitting what one does not know, thereby battling the innate Dunning-Kruger effect.[191] This encourages a commitment to lifelong learning and open-mindedness. Wisdom is a key pillar for education, equipping individuals with a holistic skillset to navigate and contribute meaningfully to an ever-changing world.[192] **Wisdom should therefore be the key goal of education in this century.**

CCR's Framework, and Wisdom[193]

As wisdom models become more precise and actionable, it is key to integrate them into K-12 education. For example, independently, the SD-WISE is an excellent tool; however, it lacks a clear educational framework. CCR already possesses a clear framework for wisdom research and its application in the classroom. CCR's 4D Framework emphasizes the four dimensions of Knowledge, Skills, Character, and Meta-learning. Within this model, wisdom is explicitly encompassed within the character dimension, addressing moral and ethical considerations, discernment, and the application of knowledge and skills in real-world contexts with prudence and judgment. The framework also emphasizes the other three dimensions: it focuses on not just how we behave and engage with the world (character), but also on what we know (knowledge) but also how we use what we know (skills), and how we reflect on and adapt our learning (meta-learning). In this way, *CCR's framework offers a comprehensive approach to education redesign that is aligned with integrating wisdom within a broader context of learning and development.* The points below demonstrate in broad strokes how existing wisdom research aligns with the CCR framework.

1. **Knowledge**: While wisdom research emphasizes the importance of experiential and factual knowledge, CCR's focus on Knowledge aligns with this by advocating for a deep understanding via core concepts, and the capacity to use this knowledge effectively.

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[191] Duignan, B. (Invalid Date). Dunning-Kruger effect. *Encyclopedia Britannica.* https://www.britannica.com/science/Dunning-Kruger-effect

[192] Lombardo, Thomas. (2011). "Wisdom in the Twenty-First Century." *World Affairs: The Journal of International Issues,* 15(1), 132-157. https://www.jstor.org/stable/48504847

[193] See Wisdom Theories in Appendix

2. **Skills**: CCR identifies critical skills as critical thinking, creativity, communication, and collaboration. These align with the wisdom models by Jeste and Baltes which emphasize the importance of critical analysis, decision-making, and communication as components of wisdom.
3. **Character**: This dimension covers aspects such as courage, resilience, ethics, and curiosity. Wisdom research, especially Jeste's model, emphasizes ethical decision-making, emotional regulation, and prosocial behavior. CCR's focus on character education resonates with these aspects, fostering ethical and moral development which are crucial to wisdom.
4. **Meta-learning**: This involves reflection, mindfulness, and the ability to learn how to learn. This is analogous to wisdom research's attention to self-reflection and acceptance of the limitations of one's knowledge, which are key components in Jeste's and Baltes' models.

The following table summarizes the models, and their relationship with the CCR framework competencies. Sternberg's Balance Theory model is closest.

CCR Competencies		Sternberg Balance Theory	Baltes-Berlin Model	SD-WISE	Three Dimensional Model
Skills	Creativity				
	Critical Thinking				
	Communication				
	Collaboration				
Character	Curiosity				
	Courage				
	Resilience				
	Ethics				
Meta-learning	Metacognition				
	Metaemotion				

Key Challenge: Compressing Experience

The one key characteristic of wisdom that is hard to replicate in an educational setting limited to 12-20 years in duration, as acquiring wisdom is inherently a process that unfolds over time and is enriched by numerous life

experiences. Education is positively correlated with wisdom[194] and can provide a wide range of experiences as best it can, but it is not possible to compress a lifelong quest for wisdom within the span of a K-12 education. As individuals navigate through life, the errors they make and the lessons derived from these errors contribute significantly to sound judgment and decisions. These experiences are essential in gaining contextual understanding, insight, and emotional intelligence. ***Since K-12 education can in no way replicate 50+ years of varied and random experiences, it does, by design, provide an "experience compression" via its curricula (the "What") and pedagogies (the "How").***

Experience compression refers to the capacity to gather and condense the experiences of others across centuries and present them in digestible bites for one person or learner. *Of course, all education is about that compression: we do not learn a discipline by painstakingly retracing all the steps of its developers.* ***But in this case, we are looking for the best accelerants of wisdom*.** Several academic disciplines (philosophy, psychology, literature, etc.) and techniques (Socratic questioning, reflective or mindfulness practices, etc.) emphasize processes and contemplative practices that can catalyze the growth of wisdom.

Storytelling is a particularly efficient technique for this compression, as it allows for a distillation of the experiences of many people, groups, and so forth, in a brief amount of time. Some academic disciplines are able to excel in doing this more than others (e.g. history, literature) because of their proclivity to provide faster, deeper, more meaningful storytelling. By focusing pedagogical techniques towards mechanisms that focus on experience compression, educators can explicitly foster contextual understanding and other components of wisdom such as insight and discernment.

The What:

Storytelling is one of humanity's most powerful tools for compressing and conveying the complexity of human experience, allowing individuals to share and understand each other's lives, cultures, and histories. Several academic disciplines excel at storytelling, harnessing the nuances of human experience through their unique lenses:

History: *"The true use of history, whether civil or military, is not to make man clever for the next time, it is to make him wise forever."* - Sir Michael Howard.

[194] Ardelt, M., Pridgen, S., & Nutter-Pridgen, K.L. (2018). The Relation Between Age and Three-Dimensional Wisdom: Variations by Wisdom Dimensions and Education, *The Journals of Gerontology: Series B*, *73*(8), 1339–1349, https://doi.org/10.1093/geronb/gbx182

History serves as a powerful medium for cultivating wisdom in learners by providing a multifaceted exploration of human experience. The study of history engages learners in understanding human nature, societal structures, and the ethical dilemmas that have shaped the world. Examining concrete actions that people undertake, the human agents responsible for such actions, the cultural tools that aid and constrain them, their purposes, and their social and environmental contexts encourages reflective thinking, empathy, and critical analysis, fostering an appreciation for diversity and complexity.[195] Contemporary scholars such as Kern[196] argue that history should be a "practical narrative;" by examining past successes and failures, learners can gain understanding of valuable lessons applicable to present and future decisions. In doing so, they can develop intellectual curiosity, ethical reasoning, and a more compassionate view of others[197] - all skills essential to wisdom.

Drawing parallels between historical events and contemporary issues and engaging learners in debates, reflective writing, and primary source analysis to explore these topics allows them to grapple with the human challenges of different eras, and encourages empathy and ethical reasoning. Analysis of primary sources, like letters, diaries, speeches, and documents enables learners to engage directly with the past, providing firsthand insights into the experiences and values of people from different eras. Similarly, dialogue with elders and other community members, as well as the use of multimedia resources and virtual reality,[198] helps to create a personal and immersive connection to history, further deepening empathy and awareness.[199]

Literature: *"Employ your time in improving yourself by other men's writings so that you shall come easily by what others have labored hard for."* **–** Socrates.
Literature acts as a vital conduit for cultivating wisdom from across space and time in people of all ages. Through the lens of literature, learners connect with broader personal, historical, and cultural contexts, enabling a holistic view of life central to wisdom.[200] By delving into diverse human

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[195] Barton, K. C. & Levstik, L.S. (2004). *Teaching History for the Common Good.* Lawrence Erlbaum Associates Publishers.
[196] Kern, A. (2020). How to Approach History As a Pursuit of Wisdom. *CIRCE Institute.*
[197] Lee, P. & Ashby, R. (2001). Empathy, Perspective Taking, and Rational Understanding. *In* O.L. Davis Jr., E.A. Yeager, and S.J. Foster (Eds.) *Historical Empathy and Perspective Taking in the Social Studies*, 21-50. Rowman & Littlefield Publishers Inc.
[198] Bailenson, J.N., Yee, N., Blascovich, J., Beall, A.C., Lundblad, N. & Jin, M. (2008). The Use of Immersive Virtual Reality in the Learning Sciences: Digital Transformations of Teachers, Students, and Social Context."*The Journal of the Learning Sciences*, *17 (1)*, 102-141. https://www.stanfordvr.com/pubs/2008/the-use-of-immersive-virtual-reality-in-the-learning-sciences-digital-transformations-of-teachers-students-and-social-context/
[199] Bruner, J. (2004). Life as Narrative. *"Social Research, 71*(3), 691-710. https://www.jstor.org/stable/40970444
[200] Clark, C. & Rumbold, K. (2006). *Reading for Pleasure: A Research Overview.* National Literary Trust. https://files.eric.ed.gov/fulltext/ED496343.pdf

experiences across different cultures and eras,[201] literature presents radically different perspectives and ways of engaging with human reality, encouraging empathy[202] and understanding.[203] Reading and interpreting literature further add to understanding abstract concepts and the complexity and ambiguity often present in literary works push learners to develop critical thinking skills and engage with moral and ethical dilemmas, promoting wise approaches to problem-solving.[204] This fosters a greater appreciation for the multifaceted nature of real-life situations, enhancing wise decision-making. Literature also fosters emotional intelligence and self-reflection which provide a solid foundation for a compassionate and flexible approach to life's challenges.[205]

Anthropology and Sociology: *"Science gathers knowledge faster than society gathers wisdom."* - Isaac Asimov.

As disciplines that study human societies, cultures, behaviors, and interactions, anthropology and sociology are well-positioned for transmitting compressed human experience. Storytelling is integral to much of anthropology, as it often explores the myths and narratives that shape cultures, as well as the current stories that cultures tell themselves.[206] These narratives document the collective wisdom of societies, often passed down through oral traditions and rituals,[207] and provide insight into values and beliefs, contributing to a deeper understanding of human experiences.[208] Sociology primarily examines historical and societal contexts that shape human behavior. Using narratives and case studies, sociologists illustrate how individuals navigate complex social structures and norms.[209] This contextual understanding is crucial for compressing human experiences.

Encouraging students to explore connections between anthropology, sociology and other disciplines like philosophy and psychology promotes a holistic understanding of humanity.[210] Education can provide opportunities

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[201] Lyon, R. (1997). "Statement before the Committee on Education and Workforce". U.S. House of Representatives.
[202] Keen, S. (2007). *Empathy and the novel*. Oxford University Press.
[203] Sumara, D. J. (2002). *Why Reading Literature in School Still Matters: Imagination, Interpretation, Insight*. Lawrence Erlbaum Associates.
[204] Holden, J. (2004). *Creative Reading: Young People, Reading and Public Libraries.* Demos.
[205] Zunshine, L. (2006). *Why we read fiction: theory of mind and the novel*. Ohio State University Press.
[206] Hutto, D. D. (2008). *Folk psychological narratives: The sociocultural basis of understanding reasons.* MIT Press; Black, A.D. (2023). Talking an acting a pandemic: Ethnography of COVID19 in Montmartre. *Anthropologica, 65*(1), 1-25; Bruner, J. (1991). The narrative construction of reality. *Critical Inquiry, 18*(1), 1-21.https://www.jstor.org/stable/1343711
[207] Geertz, C. (1973). *The interpretation of cultures.* Basic Books.
[208] Crapanzano, V. (2014). *Anthropology and ethics: The quest for moral understanding.* Routledge; Berkes, F. (2018). *Sacred ecology.* Routledge.
[209] Becker, H. S. (1998). *Tricks of the trade: How to think about your research while you're doing it.* University of Chicago Press.
[210] Bruner, J. S. (1962). *On knowing: essays for the left hand.* Harvard University Press.

for hands-on fieldwork and immersive experiences[211] to foster empathy and understanding, via practical engagement with diverse groups and cultures. Narratives and ethnographic accounts help students connect with the lived experiences of diverse communities.[212]

Interdisciplinary Themes

A number of interdisciplinary approaches contribute to fostering wisdom by drawing insights from various fields and integrating them into a comprehensive understanding of complex issues. Among the most promising are systems thinking and sustainability/environmental literacy.

The application of systems thinking provides rich opportunities for cultivating wisdom. By recognizing the intricate relationships between components within a system, individuals can grasp the impact of their actions on diverse elements, thus cultivating a deeper understanding of the repercussions of their choices.[213] Systems thinking also unveils feedback loops and dynamic interactions, enabling the anticipation of unintended consequences and reinforcing a farsighted perspective that aligns with wisdom's essence.[214]

Systems thinking empowers individuals to embrace complexity and navigate uncertainty with discernment. This capacity to grasp intricate systems mirrors wisdom's commitment to nuanced judgment, fostering an inclination to avoid oversimplification and acknowledge the multifaceted nature of real-world challenges. It intertwines ethical considerations, encouraging the alignment of decisions with broader societal, environmental, and cultural contexts, culminating in choices that resonate with ethical wisdom.[215] As a learning-oriented approach, systems thinking also echoes wisdom's adaptability, inviting individuals to continually assess, refine, and learn from the outcomes of their choices.[216]

An excellent, recent example of systems thinking on a global scale is COP23. This global effort to address climate change recognizes the interconnectedness of global environmental impacts of climate change, the

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[211] Jackson, M. (1989). *Paths toward a clearing: radical empiricism and ethnographic inquiry.* Indiana University Press.
[212] Geertz, C. (1973). *The interpretation of cultures: selected essays*. Basic Books.
[213] Amabile, T. M., Conti, R., Coon, H., Lazenby, J., & Herron, M. (1996). Assessing the work environment for creativity. *Academy of Management Journal, 39*(5), 1154–1184. https://doi.org/10.2307/256995; Csikszentmihalyi, M. (1999). Implications of a systems perspective for the study of creativity. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 313–335). Cambridge University Press.
[214] Senge, P. M. (1990). *The fifth discipline: The Art and Practice of the Learning Organization*. Broadway Business.
[215] Floridi, L. (2019). *The logic of information: A Theory of Philosophy as Conceptual Design*. Oxford University Press.
[216] Senge, P. M. (1990). *The fifth discipline: The Art and Practice of the Learning Organization*. Broadway Business.

cultural, national, and societal contexts in which these events are situated and the economic impacts and benefits of economic incentives. The agreement aims to make holistic decisions for the well-being of the planet and its inhabitants and avoid resorting to overly simplistic solutions.

These kinds of approaches to sustainability/environmental literacy offer an impactful interdisciplinary approach to nurturing wisdom by embedding the principles of long-term thinking, ethical consideration, and holistic well-being within the context of our interconnected world. This approach recognizes that wise decision-making extends beyond immediate outcomes to encompass the well-being of future generations and the delicate balance of ecosystems.

The How:

A diverse array of strategies can be employed in K-12 education to facilitate the early development of wisdom.[217] Approaches like experiential learning, maximizing student exposure to diversity, and promoting emotional intelligence can foster the early development of wisdom:

Experiential learning plays a major role in fostering wisdom by immersing learners in real-life situations and enabling them to reflect on and learn from their experiences. This approach emphasizes learning through action, reflection, and application, contributing to the development of self-awareness and critical thinking. Experiential learning can take many forms in and outside of the classroom:

- Engaging in service-learning activities, such as volunteering or community service projects, exposes learners to diverse social contexts and challenges. By working directly with communities in need, learners gain a deeper understanding of social issues, develop empathy, and recognize the importance of contributing to the well-being of others[218]. The reflective component of service-learning also encourages learners to critically analyze their experiences and consider the broader implications of their actions.[219] These reflections can occur through journaling or mind maps, for example, in order for students to be able to look back later on these experiences and their impressions of them.
- Project-Based Learning (PBL) encourages students to acquire knowledge and skills through an inquiry-based process of exploration

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[217] Sternberg, R. J., Reznitskaya, A. & Jarvin, L. (2007). Teaching for Wisdom: What Matters is Not Just What Students Know, but How They Use It. *London Review of Education*, 5(2), 143-158. https://www.scienceopen.com/document_file/e960917e-46cc-4ff0-b4e8-563c1a461660/ScienceOpen/s5.pdf

[218] Conrad, D., & Shoemaker, S. (2010). The influence of service-learning on students' personal and social responsibility. *College Teaching, 58*(3), 77-84. https://www.semanticscholar.org/paper/The-Influence-of-Service-Learning-on-Students%27-and-Simons-Cleary/41a2bf6dbb1ce82079a3964b727f1e50433c98c8

[219] Eyler, J., & Giles Jr., D. E. (1999). *Where's the Learning in Service-Learning?* Jossey-Bass. https://eric.ed.gov/?id=ED430433

and discovery.[220] PBL shifts the traditional classroom dynamic, positioning students as active agents in their learning journey and encouraging collaboration, critical thinking, and creativity.[221] In a PBL environment, students are typically given a complex problem or project to solve, which requires them to draw on interdisciplinary knowledge and skills. The process is learner-centered, with teachers acting as facilitators rather than direct instructors. This approach allows students to engage deeply with content, develop research and problem-solving skills, and build self-management and group collaboration abilities.[222] Importantly, PBL aligns with educational objectives that emphasize not only academic knowledge but also essential life skills.[223]

- Outdoor and adventure-based learning experiences are an excellent way to challenge learners to navigate physical and mental obstacles in dynamic environments. These approaches offer a unique platform for cultivating resilience and adaptability through activities like nature exploration, team-building challenges, or outdoor science experiments. Some schools abroad have developed experiential “local wisdom-based learning models” that aim to improve students’ relationships with nature and their local land and culture.[224] These models are inspired by current environmental crises and a motivation to cultivate concepts related to morals, ethical code of conduct and responsible behavior towards the Earth. Projects like these demonstrate that allowing learners to directly interact with their environment, promotes experiential understanding and knowledge application.[225] As learners navigate unfamiliar terrain, collaborate with peers, and adapt to changing outdoor conditions, they develop confidence, critical thinking, and a deeper understanding of the natural world.[226] Reflecting on these experiences encourages learners to recognize their personal growth, as well as the broader lessons that can be applied to other aspects of life.[227]

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[220] Thomas, J. W. (2000). *A review of research on project-based learning.* The Autodesk Foundation. https://tecfa.unige.ch/proj/eteach-net/Thomas_researchreview_PBL.pdf

[221] Bell, S. (2010) Project-based learning for the 21st century: Skills for the future. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 83*(2), 39-43,

[222] Markham, T., Larmer, J., & Ravitz, J. (2003). *Project-based learning handbook: A guide to standards focused project-based learning for middle and high school teachers*. Buck Institute for Education.

[223] Miller, E. C., & Krajcik, J. S. (2019). Promoting deep learning through project-based learning: A design problem. *Disciplinary and Interdisciplinary Science Education Research*, *1*(1), 1-10. https://doi.org/10.1186/s43031-019-0009-6

[224] E Ningrum, N. & Sungkawa, D. (2018). The impact of local wisdom-based learning model students’ understanding of the land ethic. IOP Conf. Series: Earth and Environmental Science, 145 012086. https://iopscience.iop.org/article/10.1088/1755-1315/145/1/012086/pdf

[225] Balmford, A., Clegg, L., Coulson, T., & Taylor, J. (2002). Why conservationists should heed Pokémon. *Science, 295*(5564), 2367.

[226] Brown, M. (2009). Reconceptualising outdoor adventure education: Activity in search of an appropriate theory. *Australian Journal of Outdoor Education, 13,* 2, 3-13.

[227] Priest, S., & Gass, M. (2005). Effective leadership in adventure programming. *Human Kinetics.* https://us.humankinetics.com/products/effective-leadership-in-adventure-programming-3rd-edition-with-field-handbook

- Participating in simulations and role-playing exercises fosters wisdom in learners by immersing them in complex scenarios that require critical thinking and moral and ethical consideration. These exercises encourage them to step into different roles, explore multiple perspectives, and make decisions with far-reaching consequences, promoting the ability to anticipate outcomes and weigh ethical implications.[228] Through the act of embodying diverse viewpoints, learners develop their moral and ethical understandings and grapple with the complexities of human experiences.[229]

Exposing learners to diverse perspectives, particularly those involving interactions with people from different backgrounds and viewpoints, gives them access to a wide range of ideas, beliefs, ways of doing things and ways of understanding the world. Engaging with different perspectives challenges learners to consider alternative viewpoints, enhance their empathy, and develop a more nuanced understanding of complex issues. This broadening of perspective is a hallmark of wisdom, which involves the ability to see beyond one's own perspective and consider the greater good.[230] Learning to understand different perspectives, especially in conflicts, fosters open-mindedness. This *learning from others' experiences* helps in fast-tracking the wisdom acquisition process, and these techniques can be incorporated in everyday classroom activities.

While exposing learners to new perspectives, it is important to allow independent reflection, as well as active reflection with their peers. Protagonist empathy, for example, is a technique that involves learners actively reflecting in pairs or small groups. Learners reflect on questions from the perspective of the protagonist in a story, film, historical situation or current event in order to explore how they may have felt or reacted in similar circumstances. A similar approach is changing the meaning of a message or event by asking learners to center their focus differently. In small groups or as a class, teachers can prompt learners to explore an historical event, for example, from the perspective of the main players in the event, those impacted by the event decades later and those who gained or lost something from the event. Exploring narratives and “facts,” historical and otherwise, from focal points and positions demonstrates to learners that there are often many “right” or “wrong” viewpoints and that positioning is key to how meaning is interpreted and created.

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[228] Kolb, A. Y., & Kolb, D. A. (2005). Learning Styles and Learning Spaces: Enhancing Experiential Learning in Higher Education. *Academy of Management Learning & Education, 4*(2), 193–212. https://doi.org/10.5465/AMLE.2005.17268566

[229] Bransford, J. D., Brown, A. L., & Cocking, R. R. (2006). *How people learn: Brain, mind, experience, and school.* National Academy Press.

[230] Baltes, P. B., & Smith, J. (2008). The fascination of wisdom: Its nature, ontogeny, and function. *Perspectives on Psychological Science, 3*(1), 56-64.

Promoting emotional intelligence: Fostering emotional intelligence in educational environments is a critical aspect of holistic development, involving the cultivation of skills essential for recognizing, understanding, managing, and utilizing emotions effectively. This developmental process equips learners with the ability to navigate emotional landscapes both within themselves and in others, promoting a deeper level of interpersonal communication and understanding. Emotional intelligence, as conceptualized by scholars like Daniel Goleman,[231] encompasses several key components, including self-awareness, self-regulation, empathy, and social skills. These components are crucial for effective leadership, collaboration, and conflict resolution. In an educational setting, this can be facilitated through structured activities that encourage students to explore and express their emotions, as well as recognize and respond to the emotions of others. Activities such as reflective journaling, group discussions on emotional experiences, and role-playing different emotional scenarios can be instrumental. These practices not only enhance students' ability to articulate their feelings but also foster a classroom environment where emotional literacy is valued alongside academic knowledge.

In parallel, embedding emotional intelligence within the curriculum requires an integrative approach that goes beyond occasional activities. For instance, educators can incorporate emotional intelligence principles in their teaching methodologies by creating classroom dynamics that promote empathy, active listening, and respectful communication. This includes implementing teaching strategies that address emotional responses to learning materials, encouraging students to reflect on how these materials make them feel and why. Additionally, educators can model emotionally intelligent behavior, demonstrating how to navigate complex emotional situations and resolve conflicts in a constructive manner. This modeling helps students internalize emotionally intelligent behaviors and attitudes. Discussions that involve analyzing characters' emotions in literature, the emotional impact of historical events, or the emotional aspects of scientific discoveries can further reinforce this learning.

The Role of Technology: Leveraging and mitigating

"Technology is nothing. What's important is that you have faith in people, that they're basically good and smart, and if you give them tools, they'll do wonderful things with them." - Steve Jobs

Leveraging available technology to enhance wisdom:
Could technology help teach human wisdom? After all, Large Language Models (LLM) already encompass a significant portion of humanity's

[231] Goleman, D. (2006). *Emotional intelligence.* Bantam Books. https://asantelim.files.wordpress.com/2018/05/daniel-goleman-emotional-intelligence.pdf

knowledge and attitudes. Technology holds immense potential for the evolution of the cultivation of human wisdom by providing tools and platforms that facilitate knowledge acquisition, critical thinking, and global connectivity. Digital repositories of information, online courses, lectures, conferences and so forth, and AI-driven algorithms all nourish an era of highly accessible knowledge, empowering individuals to learn continuously. With a few clicks, almost anyone can explore topics spanning centuries and continents, fostering a culture of intellectual curiosity and lifelong education.

Technology not only presents information but can cultivate critical thinking in the minds of users. Interactive simulations and virtual environments create immersive laboratories of decision-making, where individuals can navigate intricate scenarios and anticipate outcomes.[232] Considerable research also supports the idea that Virtual Reality environments also show promise in cultivating empathy by offering immersive and emotionally engaging experiences (like visiting a refugee camp).[233] These experiences can enable individuals to better understand and relate to the feelings and perspectives of others.[234] These processes augment cognitive flexibility, honing the ability to consider diverse perspectives and make informed judgments—a hallmark of wisdom.

Mitigating negative uses of technology that hinder wisdom acquisition:

Though they offer numerous benefits in terms of efficiency, scalability and personal learning, contemporary technologies, including AI, can be counter-productive in fostering *genuine wisdom.* One of the primary concerns is the over-reliance on technology for decision-making: Scholars posit that the incessant reliance on the internet and digital devices is reshaping our neural pathways, making it harder for individuals to engage in deep, reflective thinking. The readily available information may lead individuals to be more superficial in their analyses, often skimming through vast amounts of data without truly understanding or internalizing it.[235]

Another strong example of the counter-productivity of technology in the development of wisdom is AI-driven algorithms on social media platforms that are designed to prioritize content that aligns with an individual's pre-

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[232] Gick, M. L., & Holyoak, K. J. (1983). Schema induction and analogical transfer. *Cognitive Psychology, 15*(1), 1–38. https://doi.org/10.1016/0010-0285(83)90002-6

[233] Bertrand, P., Guegan, J., Robieux, L., McCall, C. A., & Zenasni, F. (2018). Learning Empathy Through Virtual Reality: Multiple Strategies for Training Empathy-Related Abilities Using Body Ownership Illusions in Embodied Virtual Reality. *Frontiers in Robotics and AI*, *5*, 326671. https://doi.org/10.3389/frobt.2018.00026

[234] Parsons, T. D. (2015). Virtual Reality for Enhanced Ecological Validity and Experimental Control in the Clinical, Affective and Social Neurosciences. *Frontiers in Human Neuroscience*, 9, 660. https://www.frontiersin.org/articles/10.3389/fnhum.2015.00660/full;

[235] Carr, N. (2010). The Shallows: What the Internet Is Doing to Our Brains. W. W. Norton & Company.

existing beliefs, leading to echo chambers where users are seldom exposed to diverse perspectives.[236] This continuous reinforcement of preconceived notions can hinder the development of wisdom, which traditionally emerges from a combination of experience, knowledge, and deep reflection. Wisdom necessitates considering multiple perspectives, understanding the nuances of a situation, and recognizing the limitations of one's own knowledge. In a world dominated by algorithms that accentuate homogeneity of thought to provoke dopamine rushes, there is a real risk that individuals might be distracted from, and made disinterested in, the practice of cultivating genuine wisdom.

[236] Pariser, E. (2011). The Filter Bubble: How the New Personalized Web Is Changing What We Read and How We Think. Penguin Press.

Chapter Four
Impact on Education - High-Level

"...the symbiotic partnership will perform operations much more effectively than man alone can perform them." - J.C.R Licklider

"As machines become more and more efficient and perfect, it will become clear that imperfection is the greatness of man." - Ernst Fischer

The importance of precise terminology

To avoid vagueness, CCR's approach uses the learning-sciences-extracted, clear definitions described in its framework. For instance, Creativity is synthesized from comprehensive research through the following "subcompetencies" and "associated constructs:"

Competency	Subcompetency	Associated constructs
Creativity	Developing personal tastes, aesthetics, and style	Inspiration, Originality, Ingenuity, Vision, Inventiveness, Idea Generation, Cleverness, Resourcefulness
	Generating and seeking new ideas	
	Being comfortable with risks, uncertainty, and failure	
	Connecting, reorganizing, and refining ideas into a cohesive whole	
	Realizing ideas while recognizing constraints	

The importance of precision and context

In his 2004 book, *Making Minds Less Well Educated Than Our Own,*[237] AI expert, psychologist and educator Roger Schanck described the attributes of an educated mind, as capable of the following tasks:[238]

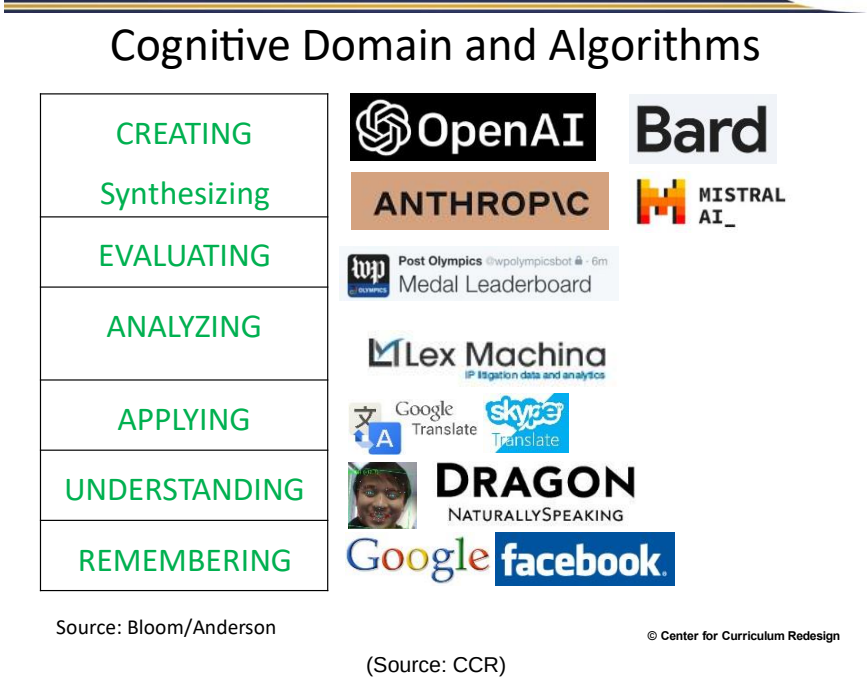
- Determining connections
- Spotting analogies
- Predicting outcomes
- Learning from failure

[237] Schank, R.C. (2004). *Making minds less well-educated than our own*. Routledge. https://www.routledge.com/Making-Minds-Less-Well-Educated-Than-Our-Own/Schank/p/book/9780805848786

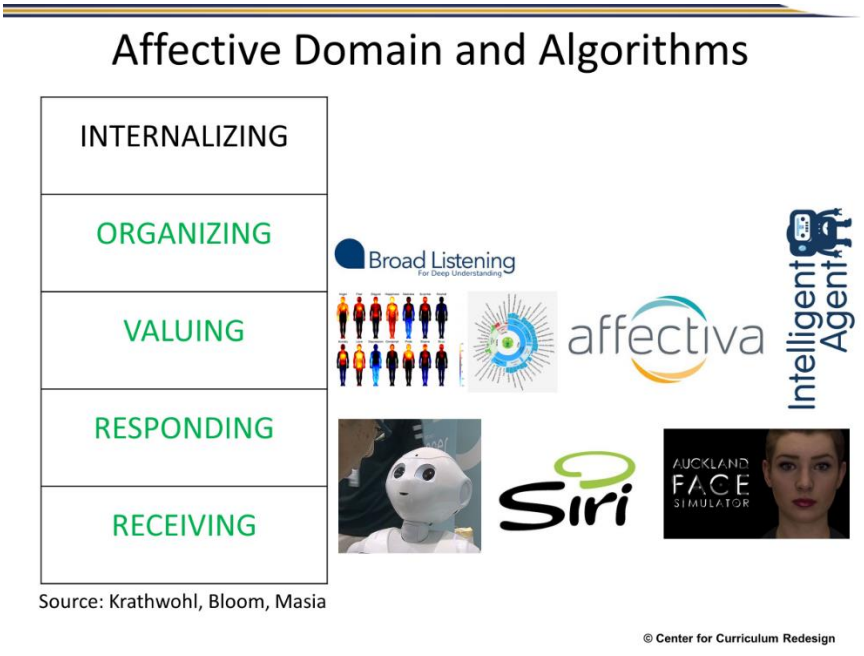
[238] Paraphrased for brevity

- Recovering from failure
- Seeking explanations
- Absorbing newness
- Handling exceptions
- Dealing with abstraction
- Generalizing reasonably
- Being self-aware

When polled during CCR's presentations, educators the world over agree that, except for self-awareness, all other tasks are within the *present* reach of AI, *with a major caveat: the devil is in the details*, as usual. "It depends" is the most common answer, highlighting the need for *precision* in the question asked (per chapter one, "limitations of language"), as well as the importance of *context* (Does one need to explain an image into words for the AI? What datasets are missing to understand the query?). Similarly, Bloom and other taxonomies in the cognitive, affective, and psychomotor domains should trigger explorations but not panic: the depictions below that CCR uses are only a cognitive shortcut to make readers take notice:



(Source: CCR)



(Source: CCR)

That said, it is important to note that the technologies have been moving UP in the taxonomies stack over time, from passive capabilities to increasingly active ones, thanks to AI (reaching analysis, synthesis, creativity, valuation, and organization, but of course unable of internalizing emotions).

As stated in the Introduction, "We cannot imagine a pedagogically sound argument that would leave a 10-year-old at home, all the time and by themselves, learning via AI on a VR headset." This means that Schooling is still required: it is our only fundamental axiom, logically justified. This ACI phase requires deep interactions between humans and machines, which need to be learned by students as an intrinsic part of their schooling.

If AI can do everything, why learn anything?

Firstly, this is a wrong (and naive) question: AI cannot "do everything" as described in prior chapters. This question about the tool negating the need is a recurring one: in recent times, debates about calculators, and later search engines, have raged in education circles. But superficial statements such as "Google knows everything" have been debunked: it "knows" nothing, it merely indexes everything it can find (and which is approximately only 5% of the total human digital output on the internet).[239] In the digital

[239] Rosen, J. (2014). The internet you can't google. *The Tennessean.* https://eu.tennessean.com/story/money/tech/2014/05/02/jj-rosen-popular-search-engines-skim-surface/8636081/; Wikipedia. (2023). Google search. https://en.wikipedia.org/wiki/Google_Search

age, the value of human learning is often overlooked despite the instant access to information. While search technology provides data and complex responses, human cognition is indispensable for critical thinking, discernment, and applying knowledge meaningfully.[240]

Because Learning requires scaffolding:

Relying on casual interactions and superficial engagement with technology over 18 years does not equip students with the necessary skills to engage with AI. For example, while scrolling through a social media feed, a student might indirectly interact with AI algorithms, but they remain unaware of the mechanics, ethical considerations, and potential impacts of such technologies. To effectively prepare students for the AI era, ***scaffolding*** (moving the student progressively towards better understanding[241]) is all the more essential. Scaffolding refers to a pedagogical approach wherein educators provide successive levels of support that help students reach higher levels of comprehension and skill acquisition. In the context of AI and emerging technologies, this means starting with foundational knowledge and progressively introducing more complex concepts as the student's comprehension deepens. Additionally, incorporating AI capabilities in classrooms and encouraging students to utilize these tools for coursework and recreation can bolster their understanding and application of AI.

Because Learning Happens in Context:

Learning happens in a context, and over time it is generalized and abstracted, but isolated information found online cannot fully capture the context in many cases. Daniel Willingham[242] compares this to studying vocabulary words. Students are asked to use new words in sentences when they are learning them, to learn not just a definition, but how the word is used in context. When students simply look up synonyms online, they often end up using them incorrectly, such as saying "he meticulously balanced on the edge" (using the definition of "meticulous" to mean "careful"). The same reasoning, he argues, should be applied to all content learning. Just having the ability to look up a fact may not be enough to apply that fact properly.

To Avoid "Unconscious Incompetence"[243]:

(Or more academically stated, "Avoiding the Dunning-Kruger Effect."[244]). One important use of knowledge is to guide people to what they do not

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[240] Willingham, D. T. (2007). Critical thinking: Why is it so hard to teach? *American Educator, 31*(2), 8-19. http://www.aft.org/sites/default/files/periodicals/Crit_Thinking.pdf

[241] Glossary of Education Reform. (2015) Scaffolding: Definition. *Great Schools Partnership: The Glossary of Education Reform.* https://www.edglossary.org/scaffolding

[242] Willingham, D. (2017) You still need your brain. *Grey Matter*

[243] Wikipedia. (2023). Four stages of competence.

[244] Kruger, Justin; Dunning, David (1999). "Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments." *Journal of Personality and Social Psychology*, 77 (6): 1121– 1134.

know and should learn more about. As adults, there is a critical mass of knowledge available to create a rough map of our understanding and its gaps. Actor John Cleese humorously explains the Dunning-Kruger ("D-K") effect as "If you're very, very stupid, how can you possibly realize that you're very, very stupid? You'd have to be relatively intelligent to realize how stupid you are." Without a minimum understanding of a subject area, the trap one is likely to fall into is not just ignorance (which can be cured with an internet search), but "meta-ignorance" (ignorance about one's ignorance[245]), which can be far more pernicious.

For example, when reasoning about economic policies, citizens must implicitly estimate various economic realities to compare them to an ideal and consider possible changes. In a 2014 Gallup survey, 63% of Americans said that they believed the crime rate had been on the rise, despite the crime rate being at a 20-year low. Those who thought crime rates were rising were 8 percentage points less likely to support stricter gun control laws.[246] If one does not know that their estimates are not representative of reality, they may not think to look up the true numbers. In fact, in this study, participants who identified with both major US political parties misrepresented the inequality in the same way and agreed on the ideal distribution. Factual information serves a crucial role in one's ability to think critically and creatively.

Having the ability to look things up may exacerbate the D-K effect: In one study,[247] participants who were allowed to use Google to answer trivia questions perceived themselves as smarter than those who were not allowed to use Google (even when the percentage of questions answered correctly was artificially equalized).

To develop Speed, Fluency, and Automaticity, used in daily life:

There is a basic level of each discipline that is necessary for day-to-day living. For example, there is a level of understanding that is necessary for basic math fluency with constructs such as weight, temperature, and money.[248] In neurotypical children, this level is achieved routinely, but it is

[245] Poundstone, W. (2016) Head in the Cloud: Why Knowing Things Still Matters When Facts Are So Easy to Look Up. Little, Brown

[246] Interestingly, 20 years prior, in 1994, people who thought crime rates were increasing were 9 percentage points more likely to support stricter gun laws, so there is some interaction with rhetoric. Kohut, Andrew (2015) Despite lower crime rates, support for gun rights increases. Pew Research Center.

[247] Wegner, D. M., & Ward, A, F. (2013) "The internet has become the external hard drive for our memories." Scientific American 309.6: 58-61.

[248] Patton, J. R., Cronin, M. E., et al (1997). A life skills approach to mathematics instruction: Preparing students with learning disabilities for the real-life math demands of adulthood. *Journal of Learning Disabilities*, 30, 178-187.

important to keep in mind which parts of the curriculum will be truly useful for all students' lives.

While anyone can look up anything at any time, having to look up everything would be completely impractical in real life, and would slow down future learning and problem-solving. For example, although one could frequently look up unfamiliar words, this process is distracting from reading. Generally, the more vocabulary one knows, the greater their reading comprehension.[249] This problem is exacerbated in settings where students have to process information in real-time, such as lectures or group work and do not have the option to look things up whenever they need to.

In such cases, a lack of fluency or automaticity (which is the combination of accuracy and speed) in lower-level components can serve as a bottleneck to learning higher-level concepts.[250] More broadly, research has shown that fluency "increases retention and maintenance of knowledge, endurance or resistance to distraction and application or transfer of training."[251]

To be part of a shared social background:

Consider giving directions to a local compared to a tourist. When speaking to a tourist, one naturally understands that it is impossible to rely on shared information or assumptions, and takes much more time to explain things that would otherwise be taken for granted.[252] Similarly, news and media are not written in a way that explains every single idea; there is a collection of background information that is assumed and relied upon. E.D. Hirsch has worked to identify what content falls into this category for the U.S. (e.g. cholesterol, absolute zero) in his work on Cultural Literacy,[253] **although this list must be adjusted for modernity** (as described in Chapter Five) and for other cultures around the world.

To acquire more complex concepts:

Every complex concept can be said to be made up of smaller pieces of information, which require automaticity to reach more complex understandings, per section above. Nonetheless, learning a concept is usually not simply the process of amassing the smaller pieces of information that comprise it. This is the thinking behind the research exploring learning progressions: "curricula should be designed to

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[249] Schmitt, N, Xiangying J, and Grabe. W. (2011) "The percentage of words known in a text and reading comprehension." The Modern Language Journal 95.1: 26-43.
[250] Binder, C. (1993). Behavioural fluency: a new paradigm. Educational Technology.
[251] *ibid*.
[252] Poundstone, W. (2016). Head in the cloud: The power of knowledge in the age of Google. Oneworld Publications. Chicago
[253] Hirsch Jr, E. D., Kett, J. F. and Trefil, J.S. (1988) Cultural literacy: What every American needs to know.

provide students with a systematic exposure to increasingly complex meanings... and grounding them in experiences with particular content and topics."[254] It may be that learning topics in a certain order or through a certain pathway will lead to the knowledge being represented and stored differently, and serve as preparation for different types of future learning. Therefore, another reason some knowledge may be included in curriculum is that it is part of a particularly effective learning progression.

Because the rate of change in information is misjudged:

There is so much hype about AI (as there was about Search) that there is severe misjudgment as to what knowledge still - or *will* still - matter. To understand this question, it is necessary to analyze each discipline and its topics to identify the speed of their variance, and their ease of adaptation:

- Slowly-variant: For instance, Philosophy does not change rapidly
- Step-variant, which is occasional:
    - Medium step: e.g., expanded Digital Literacy into "Prompt Design" requiring specific training and frequent evolution.
    - Large step: e.g., teaching concepts & competencies, or modifying assessments & pedagogies, are very big "lifts", needing to be addressed by the schools of education, and in-service professional development.
- Rapidly-variant: e.g., the choice of LLM *du jour* (or the computer language du jour) will require informal training via communities of users.

The chapter on Knowledge will clarify these complexities.

The right question is: "Given AI's powerful capabilities, and increasingly so, how do we adapt education to remain relevant?"

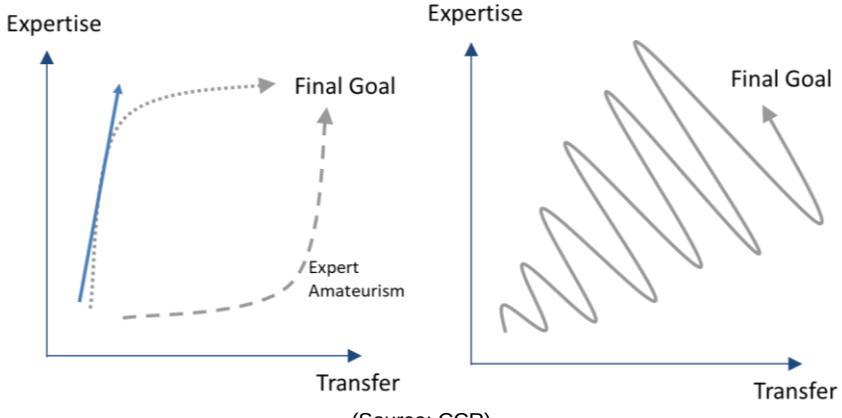
By developing both Expertise and Transfer:

Expertise is the expected result from an education; of course, this expertise is conferred at different levels and to different degrees throughout primary to tertiary education. This expertise is particularly germane to eventually finding activities, most likely remunerated. Contrary to popular opinion, Expertise is made, not born: "What consistently distinguished elite surgeons, chess players, writers, athletes, pianists, and other experts was the habit of engaging in 'deliberate' practice—a sustained focus on tasks that they couldn't do before. Experts continually analyzed what they did wrong, adjusted

[254] Mosher, F. (2017). A Hitchhiker's Guide to Thinking about Literacy, Learning Progressions, and Instruction A Hitchhiker's Guide to Thinking about Literacy, Learning Progressions

their techniques, and worked arduously to correct their errors."[255] The late Anders Ericsson was the author of the Theory of Deliberate Practice,[256] and the concept of "10,000 hours of practice" was falsely attributed to its popularizer Malcolm Gladwell.

Transfer: However, education's more fundamental but little heeded goal has always been to equip someone with enough background to *apply what has been learned in one context, to a different context and time*. This is known as "**Transfer,**" and must be nurtured explicitly, ***while traditional education was content with building expertise mostly, by conflating transfer and expertise.*** Harvard's David Perkins explains[257] how a student can learn to transfer without necessarily learning first to be an expert (as an "expert amateur"), as concepts are stated in natural language and self-explanatory (for example: in History: "History does not repeat itself but it rhymes," or in Maths: "Exponentials are deceiving then explosive"). Transfer and Expertise *reinforce* each other, hence the oscillation between the two.



(Source: CCR)

But humans keep searching for a "refuge" from AI, as described in Chapter One: it is the hope that there will be a space left untouched where people can be more "Human." Subsequent chapters will discuss where this space exists, though it is not a simple, identifiable, macro-level "refuge" - it is context-dependent: ***"It depends,"*** as described in the first section of this chapter. So, are Expertise and Transfer such "refuges"?

Can AI be an Expert? Of course. It already is, in many situations.

[255] K. Anders Ericsson, K.A., Prietula, M.J. & Cokely, E.T. (2007). The making of an expert. *Harvard Business Review.* https://hbr.org/2007/07/the-making-of-an-expert
[256] The Role of Deliberate Practice in the Acquisition of Expert Performance' (Ericsson, Krampe, & Tesch-Römer, 1993).
[257] Perkins, D. (2010). *Making learning whole: How seven principles of teaching can transform education.* Wiley.

This has been demonstrated in spades over many tasks, from games (Chess, Go, Stratego, etc.) to more scientific ones (protein folding, disease-modeling, etc.). AI is being applied to just about every occupation, as seen earlier, so expertise is not in question. However, "it takes one to know one" goes the saying, and judging AI's answers will require *both* sufficient subject-matter knowledge and critical thinking. Ethan Mollick, at the Wharton School of Business at the University of Pennsylvania, stated: *"On some tasks, AI is immensely powerful, and on others, it fails completely or subtly. And, unless you use AI a lot, you won't know which is which."*[258]

But Can AI Transfer? Yes, it can somewhat, and increasingly so

First, a clarification of taxonomies: In AI, "Transfer" is used in "Transfer Learning" (a technique), while Transfer itself is termed "Generalization."[259] CCR will use Transfer, as this book is meant for educators.

As stated in Chapter One, LLMs will have access to vast amounts of data, of modalities very much ***"****beyond text and images, such as molecular structures, network traffic, low-level machine code, astronomical images, and brain scans. It may therefore possess a strong intuitive grasp of domains where we have limited experience, including forming concepts that we do not have."*[260] It will detect analogies between fields that are far apart, and draw interesting correlations that humans will have to filter for causality.
So, Transfer is not a refuge: AI can navigate immense multi-dimensional spaces, and eventually Transfer better than humans for near- and medium-transfer. Far transfer is hard for everyone including Humans, but this may put pressure on Imagination, which will be discussed in the section on Creativity.

Consequences for Education Systems: Wider & Wiser Curricula

Why Wider? For Versatility

The world around us is changing in profound ways, and education must adapt to it. In an age of growing uncertainty, a wise strategy would be to

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[258] Mollick, E. (2023). Centaurs and cyborgs on the jagged frontier. *One Useful Thing.* https://www.oneusefulthing.org/p/centaurs-and-cyborgs-on-the-jagged
[259] Kozlov, M., & Biever, C. (2023). AI 'breakthrough': Neural net has human-like ability to generalize language. *Nature.* https://doi.org/10.1038/d41586-023-03272-3
[260] Bounded Regret. (2023). What will GPT-2023 look like? *Bounded Regret Blog.* https://bounded-regret.ghost.io/what-will-gpt-2030-look-like/

hedge against disruptions by embracing **versatility**. A K-12 education today must equip the learners with the abilities to tackle life challenges, ranging from social and political issues (global warming, pollution, inequities, etc.) to technology's disruption (Social Networks, and now particularly Artificial Intelligence). As such, **Education is NOT Training;**[261] **Education is broad, and life-related at large**, while Training is narrow and job-related (and starts partially in high school). Of course, Education and training are both needed eventually, but must not be conflated as they have different goals (psychosocial-focused for Education, Economic-focused for Training).

The future not being knowable, cultivation of versatility is a wise and appropriate strategy – think of it as a "hedge against all eventualities." Using a Swiss army knife analogy, it is best to equip learners with a broad set of tools that can be sharpened as the circumstances require - poet, physician, painter, and physicist.

(Source: Unknown – Internet)

How Wiser? By redesigning the What and the How

Wisdom is more than ever the goal of an education, as justified in Chapter Three. But to get there, it is necessary to redesign both standards/curricula (the What) and Pedagogy (the How), as there are significant gaps between emerging needs compared to the current practices.

The What:

What schools teach is abdicated to jurisdictional powers, which resist modernization due to inertia, and fear of change. Education has not yet fully adapted to the Information Age: for example, though called "STEM," only "St_M" is taught in K-12 - very little Technology, and no Engineering. Now the Internet Age, 25 years later, which David Houle[262] called the Shift Age,

[261] With a respectful nod to former MIT Professor Woodie Flowers, R.I.P.

[262] Houle, D. (2008). *Entering the shift age: The end of the information age and the new era of transformation*. Sourcebooks.

requires adapting rapidly to changing information and dealing effectively with a diversity of languages, cultures, and lifestyles. And with the AI age, the accumulated deficit of the past two ages comes back even more forcefully, augmented by a new set of challenges, reviewed herein.

As a result of this inertia, some will argue, perhaps to temper their cognitive dissonance, that the What does not matter "as long as you learn". CCR profoundly disagrees: why focus the teaching on old content, if better options are available? For example, why waste time learning trigonometric functions that matter to very few, and have been largely automated, rather than data science, which is useful across many disciplines and is in hot demand?

All Four Dimensions Matter:

As a summary, Harvard's Chris Dede summarizes the situation well:[263]
"The current curriculum and high-stakes tests often prioritize fostering skills at which AI excels, such as reckoning skills involving calculative prediction and formulaic decision-making. However, AI cannot easily replicate human judgment, which is a deliberative thought process that is flexible and contextual based on experiential knowledge, ethics, values, relationships, and culture."

As described in our 2015 book *Four-Dimensional Education*, and more relevant than ever, this means paying attention to all four dimensions of Education: **Knowledge, Skills, Character, and Meta-Learning.**[264]
The "4D" Model remains robust (with clarifying caveats that will be explained in subsequent chapters, and the appendix):

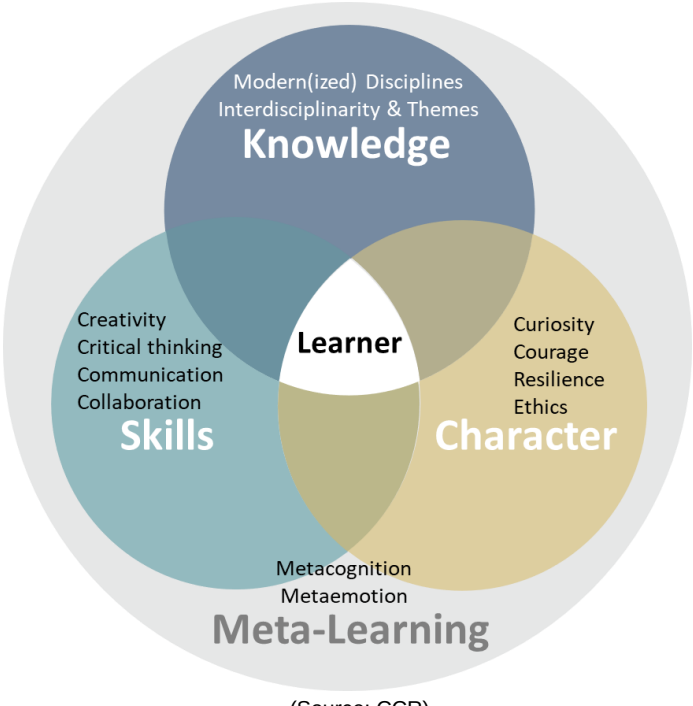
- Knowledge: "What we Know" (see Chapter Five)
  - Declarative knowledge is more challenged than ever by LLMs, which is an amplification of historical trends (scripts[265], books, Internet, search engines). As explained earlier, it does not mean that humans do not need base knowledge, it means they need to be a lot more *discriminant about what is essential and* ***relevant*****.**
    Also, and counterintuitively, there is a need for a broader set of declarative knowledge, to respond to the need for versatility. David Epstein, author of "Range,"[266] contrasts "kind" and "wicked" learning environments, explaining that while structured, predictable "kind"

[263] Cao, L. & Dede, C. (2021). Navigating a world of generative AI: Suggestions for educators. *Harvard Graduate School of Education: Next Level Lab.* https://bpb-us-e1.wpmucdn.com/websites.harvard.edu/dist/a/108/files/2023/08/Cao_Dede_final_8.4.23.pdf
[264] CCR Framework Rev. 1.2: https://curriculumredesign.org/framework/
[265] Bemoaned by Socrates: "Your invention will enable them to hear many things without being properly taught, and they will imagine that they have come to know much while for the most part they will know nothing. And they will be difficult to get along with since they will merely appear to be wise instead of really being so." (Plato. [1925]. *Plato in twelve volumes, vol. 9* Translated by Harold N. Fowler. William Heinemann Ltd.)
[266] "Range: Why Generalists Triumph in a Specialized World" (2019) Riverhead Books
Epstein, D. (2019). *Range: Why generalists triumph in a specialized world.* Riverhead Books.

environments can favor early specialization, *real-world* "wicked" environments often reward a wide range of experiences. He also stresses that a sampling period, where one explores various interests before settling on one, can lead to more career satisfaction and success. Epstein argues against early specialization in education, stating it can limit children's ability to explore their potential and adapt to new situations, and investigates "match quality" - the fit between one's interests, abilities, and their career, and how a broad range of experiences can enhance it. However, it is crucial to state an AND mindset at this stage: Per IBM Research's T-shaped model,[267] it is perfectly possible to build depth AND breadth, not one or the other - Expertise AND Transfer. This is CCR's position, as the subsequent chapters will explore.

    - LLMs increase the pressure toward teaching more conceptual knowledge (core concepts) and procedural knowledge (projects). Success at medical, legal and other tests highlights the significant extent to which these tests are based on memorization of declarative knowledge (to be fair, coupled with some deductive capacities).
- Competencies: In Chapter Six we will review in detail the importance of each competency in light of AI, and its likelihood of being automated. But here is a peek preview:
    - Skills ("How we use what we know"): Are both challenged and augmented by AI.
    - Character ("How we behave and engage in the world"): Some remain significantly Human (for instance, Ethics), and must be leant on, while others are helped *and* pushed (for instance, Curiosity).
    - Meta-Learning ("How we reflect, adapt and learn how to learn"): Metacognition and Metaemotion are more critical than ever, leading to Learning how to Learn.

[267] Demirkan, H. & Clinton Spohrer, J. (2018). Cultivating T-shaped professionals in the era of digital transformation. *IBM Research.* https://research.ibm.com/publications/cultivating-t-shaped-professionals-in-the-era-of-digital-transformation



(Source: CCR)

In addition to the goals of a modern education described by the Venn diagram above, there is also a growing need to personalize Education (see Chapter Seven). This personalization comprises four drivers: Motivation, Identity, Agency, and Purpose - of which motivation and purpose will remain quintessentially human:

(Source: CCR)

The How:

There is an enormous amount of experimentation happening worldwide, and large amounts are being invested in essentially two major academic aspects of AI (this book will not cover administrative aspects). AI is being used to automate the:

- Design: By teachers and curriculum developers, of curricula, lesson plans, and assessments, as well as a large number of smaller-impact tools.
- Delivery: Right away, there is a significant focus on teacher- and student-led experimentations on AI use in instruction (via Prompts for the most part), which this book will not cover: It is a rapidly shifting field better served by timely blogs.
  Over time, teachers might have an AI assistant that offers personalized learning suggestions for students based on their progress and learning style. Students might also eventually use an Intelligent Tutoring System (ITS) directly.

Chapter Eight will thus focus on the Design aspect first and foremost, showcasing how all the recommendations can be designed together cohesively. Given the extremely dynamic and fluid situations at play, which will decant only over time, this book will not cover the Delivery aspects except for a short section on Adaptive Learning and ITS.

What about "Learning AI"?

This question, bandied around in policy circles, is very imprecise as it mixes AI as a discipline and AI as a tool. One does not need to learn Computer Science to operate a smartphone, and one does not need to learn AI algorithms to use an LLM. The table below shows the difference between AI as a What (at two levels: digital literacy for everyone, and as CS for the specialists) and the How (AI as an education tool).[268]

Level	WHAT (knowledge)	HOW (teaching) *[EdTech applies]*
HIGH	**Learning ICT *itself*** (Acquire Disciplines: **Computer Science** (incl. A.I.) + Electrical Engineering)	**Learning through/via/with ICT** • Through: Simulations/Gaming, AR/VR, Adaptive Learning/AI
LOW	**Learning *about* ICT** (Acquire ICT functional knowledge [aka "***digital literacy***"]: e.g. use many apps (e.g. spreadsheets, search, now LLMs and other AI, etc.)	• Via: asynch/synch virtual classrooms • With: use for Problem-solving e.g. GIS/GPS + search; etc.)

(Source: CCR)

[268] **None of which is to be confused with Digital Infrastructure/Access ("plumbing").**

But would all these recommendations be the same if AGI was reached? ASI?

First of all, it is a huge logical leap to state that just because AGI is reached (and at what level, this will be highly debated), all jobs will disappear - this seems very implausible for all the reasons discussed in Chapter Three. But let's play with this scenario anyway:
If AI does take over all jobs, leaving us free from the need to train for employment, what should the focus of education be? Secondary education, typically beyond age 14, is a preparation for tertiary stages like VET or university, which are traditionally job-related. However, in a scenario where jobs are significantly impacted, the high school years could shift focus away from employability. *Assuming guaranteed incomes*, this would allow for more discretionary time for individuals to engage in their epicurean interests. Therefore, education would pivot all the more towards cultivating students' identity, agency, and especially their motivation and purpose for a jobless world. This approach underscores the importance of a broad and deep education that fosters "MIAP" – Motivation, Identity, Agency, and Purpose – as none of these needs would vanish in the absence of traditional employment. And from a psychosocial perspective, it is likely that education requirements would just be re-targeted. So even in this extreme scenario, the aforementioned recommendations remain applicable – voilà! But, considering the human propensity to generate ever more work for themselves, this vision should be viewed with healthy skepticism. IF such shift is truly observed, it may inspire a new perspective, perhaps taking a leaf from the French flair for work-life balance. 🙂

For ASI, all bets are off; the reader's guess is as good as anyone's.

Chapter Five
Knowledge for the Age of AI

"Knowledge is power." - Francis Bacon
"*We are drowning in information but starved for knowledge."* - John Naisbitt

Chapter Four addressed the need for continued learning and relevance of Knowledge in an age of AI. This chapter will delve into more specificity regarding the Knowledge Dimension.

What is Knowledge?

Historically, education has centered on the Knowledge Dimension. A Zen metaphor draws a connection between one's mind and a cup, and knowledge as water to fill it. In the world before the internet, it was reasonable to view the primary function of education as enabling learners to "fill their brains" with facts and ideas that they could carry for a lifetime. In a world with near-universal internet access and fast-improving AI, this model of "filling brains" warrants significant refinements.

In pursuit of education's traditional mission — "filling learners' brains"— knowledge was taxonomized into a variety of disciplines. The Hellenistic tradition posed seven liberal arts for university education: grammar, logic, rhetoric, astronomy, geometry, arithmetic, and music. Masters of these liberal arts qualified to pursue additional study in philosophy, theology, law, and medicine. The Chinese tradition encompassed literature and poetry, calligraphy, painting, history, philosophy, mathematics and astronomy, martial arts, medicine, and music. Millennia have passed, and the oral tradition has almost completely ceded to written tradition, which is now succeeded by the information age. Nonetheless, these disciplines remain core to the education experiences of most people today. Encyclopedias have (re)classified time and again these disciplines through a variety of mechanisms, and new tools only increase the ability to taxonomize.

CCR's synthesis research on Knowledge

A research synthesis of the different "types of knowledge" revealed a variety of breakdowns. To ensure breadth in this research, CCR reviewed three of the most-cited academic papers, the synthesis of three search engines and repositories of information (Google, Bing, and Wikipedia), and chatted with three different LLMs (GPT4, Claude, and Poe Assistant). To round out the

field to ten, we added the insights of the most linked-to search result: a business technology platform[269] which offers information solutions.

Not surprisingly for academic research, there is no agreed-upon breakdown of the different types of knowledge. These ten sources generated fifty-eight (!) different "types of knowledge," with only four of the types appearing in half of the sources, and with less than a third showing up more than once. Of course, different fields have different objectives in asking this question. Historians seek documentation of what has happened, information technologists taxonomize to make the storage of knowledge more efficient, and epistemologists seek to differentiate between belief and truth. Each field has created different systems of taxonomizing to gain a lens that distills the rather amorphous blob of "knowledge" into something useful for that field. CCR's goal is the same, in synthesizing these sources to design a taxonomy that is *useful for education.* Historically, the field of education has not had much of a need to differentiate between different types of knowledge, as all of the different types of knowledge seemed useful for students to learn. *The age of the internet established a need to differentiate the types of knowledge. The artificial intelligence revolution cements this need.*

The field of education has only scratched the surface of grappling with the challenges of near-ubiquitous internet access, even though that access is migrating from our workplaces to our homes, to our pockets, and soon ever closer to our bodies. Education has struggled to design solutions for shifting students away from memorization of facts to the utilization of those facts, which remain almost always just a click away. Students are still discouraged from collaborating on assignments, despite a workplace world demanding teamwork and collaboration. "Closed book" assessments remain commonplace, let alone "closed internet," and there remains a common stigma around the legitimacy of Wikipedia as a valid source of information, despite it being one of the most robustly designed and transparently verified accomplishments in human history.

Synthesis

In synthesizing the fifty-eight identified "types" of knowledge, the ten sources leveraged a variety of different characteristics to differentiate the categories of knowledge. Three stood out, which we will refer to as three distinct **axes of knowledge**:

1. The knowledge **classification**, or how the knowledge manifests in its usage, for example, as a fact or a procedure.
2. The knowledge **acquisition method**, or how the individual acquires the knowledge, for example, via personal experience.

[269] GetGuru. (2023). The 7 types of knowledge: Definitions, examples and more. GetGuru Blog. https://www.getguru.com/reference/types-of-knowledge

3. The knowledge **domain**, or the area or sphere of content within which the knowledge is relevant, for example, cultural or technological knowledge, often grouped by **Discipline.**

Further complexifying the exercise is that many of the studied knowledge types fit into what CCR categorizes as the other *dimensions* of education—skills, character, and meta-learning. These dimensions naturally overlap with knowledge, and this is the central message of CCR's Venn diagram visualization. Despite the overlaps, they are kept deliberately distinct, so educators can more effectively and explicitly teach them.

This, too, is the goal of designing the three knowledge axes. The axes allow the creation of differentiations in knowledge, and subsequently, student learning experiences can be optimized with techniques and resource allocation to optimize each. The primary concern is in *increasing educator fluency* in different types of knowledge, as they should not be taught the same way, nor scoped and sequenced the same way. Here's a look at each axis in further detail.

Knowledge Classification: Only four of the different "types" of knowledge appeared in over half of the researched sources. Three of the four fit into the knowledge classification axis (the other will be discussed as an acquisition method), and serve as useful for educators. They are:

1. **Declarative** knowledge, or the understanding of facts, information, and data that can be explicitly stated or described.
2. **Procedural** knowledge, or the understanding of how to perform specific tasks, processes, or actions.
3. **Conceptual** knowledge, or the understanding of how compounds of knowledge are built into patterns and other organizing principles.

Main Types	CCR Synthesis	Related
Declarative	Declarative	Propositional; Factual; Semantic
Conceptual	Conceptual	Attitudinal
Procedural	Procedural + (higher order thinking) Skills	Cognitive
OTHER - Combos:		
Causal	Conceptual + Metacognition	
Strategic	Procedural + Competencies	
Metacognitive	Conceptual + Metacognition	Self-Knowledge; Meta-Knowledge
Relational	Procedural + Competencies	Incl. Concepts
Cultural	Declarative + Procedural	
Moral	Declarative + Ethics	
OTHER - Different Axis		
Explicit/Implicit; Tacit; A priori/a posteriori; Episodic; Contextual; Experiential; Conditional; Motor/Meta-Motor; **Epistemic**		

(Source: CCR)

There is an additional category that all of these distinct pieces of knowledge build to—epistemic expertise. **Epistemic** knowledge is featured by experts in fields who can "think like a mathematician," "a historian" or "an engineer." These experts[270] have internalized a variety of concepts, recognize them as a toolkit, and consider them as lenses to apply in a variety of situations. This epistemic knowledge allows these individuals to create new declarative, procedural, and conceptual knowledge in their fields.

Historically, education gave the most attention and resources to declarative knowledge, by equipping students with the facts they need to understand the world around them. The memorization of vocabulary words, mathematical formulas, scientific laws and principles, and historical events and figures all fit into this category.

As a consequence of this focus on declarative knowledge, education has been primed to treat *all* knowledge as declarative. Curricula typically are structured around declarative knowledge, and assessments—particularly "closed response" assessments—seek to determine if students know the "right" facts. The surprising success[271] of AI in passing various exams has highlighted how much such tests are about recall and memorization, not deep understanding.

Procedures and concepts are often taught the same way as declarative knowledge. Students might memorize the steps of a science experiment, a handful of historical thinking skills, the structure of an essay, or an algorithm for solving a math problem. Deep change is needed here, and so is differentiating the curricular design and pedagogical strategies for teaching each classification. Memorizing the useful procedure is not enough, what is needed is the ability of the individual to execute it *while understanding it*. The memorized concept is useful only to the extent the internalization of the concept shapes the worldview of the individual. For students to consistently execute procedures, and to internalize concepts, they need to be taught explicitly, and in a manner distinct from declarative knowledge.

It should be noted that not all knowledge will fit neatly into each of these three categories. The scientific method, for example, can be taught as any of all three:

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[270] Expertise can also, interestingly enough, blind an individual in helping determine what is important in their field! Because a lot of concepts have become second-nature to these individuals, the "curse of expertise" can make them miss some of the building blocks of understanding that are necessary to a learner. *This creates a KEY reason to include more than traditional experts in the curricular design process.*

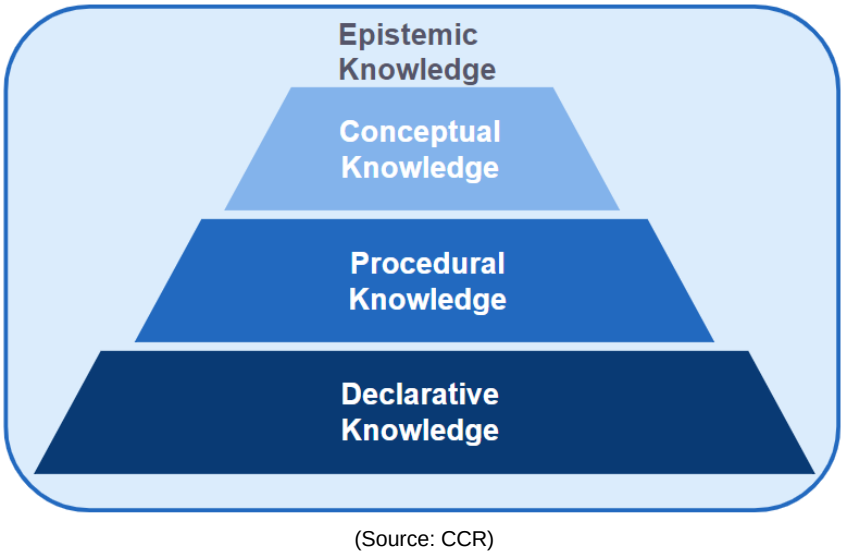
[271] Varanasi, L. (2023). GPT-4 can ace the bar, but it only has a decent chance of passing the CFA exams. Here's a list of difficult exams the ChatGPT and GPT-4 have passed. *Business Insider.* https://www.businessinsider.com/list-here-are-the-exams-chatgpt-has-passed-so-far-2023-1#but-the-bot-did-pass-a-stanford-medical-school-clinical-reasoning-final-14

- As declarative knowledge, the scientific method's definition can be memorized as "a systematic approach for acquiring and verifying knowledge."
- As procedural knowledge, the scientific method can be executed as a multi-step process, often referred to as Observe, Question, Hypothesize, Predict, Experiment, Analyze, Conclude, Communicate.
- As conceptual knowledge, there are a variety of concepts that scientists regularly and expertly deploy as a product of internalizing the scientific method. They include recognizing that: Science requires empirical evidence; Evidence can be acquired via observation and testing; New evidence leads to the refinement of old bodies of knowledge.

Each classification benefits from different curricular design and pedagogical approaches. The declarative knowledge definition, of course, can be taught via traditional means—familiarizing students with the term, encouraging memorization, and frequently using the term in context. The procedure is best taught via authentic execution of experiments, and the gradual release of responsibility to students in having autonomy and agency in performing them. The concepts of the scientific method require repeated exposure, resonant examples to facilitate both near and far transfer, and well-designed assignments and projects that push students to internalize the concepts as flexible tools in their ever-growing scientific toolkit.

The Journey to Expertise

In looking at these distinct knowledge classifications, it can be useful to examine a learner's journey toward integrating all three, culminating in knowledge. Deep expertise is the combination of all four levels.



(Source: CCR)

To illustrate a need to push education to educate toward conceptual understanding, exponentials in mathematics is a good example to use (Exponential growth is a key topic of mathematics education and is typically taught in introductory algebra to students at the start of their teenage years): Decision-making during the COVID-19 pandemic illustrated key gaps in humanity's collective *conceptualization* of exponential growth, even if a large number of adults performed exponential calculations in schools. In CCR's courses, the concept is distilled into the phrase that exponentials are *"deceiving, then explosive."* That is, they start deceptively slow, then rise explosively. In the case of the COVID-19 pandemic, recognition that the virus would spread exponentially would spur *early* collective action to head off the disease before it became unmanageable. Unfortunately, even efforts to "flatten the curve" and "stop the spread" emerged too late, and the world still collectively suffers the impact.

To bring a student to the level of *epistemic knowledge*, the place to start remains declarative knowledge. In the case of exponents, one would begin simply by memorizing that "exponents are deceiving then explosive." Memorization of this *phrase* makes it declarative knowledge—an assessment might ask, "How do exponentials behave?" and a learner could reply with that correct answer. Even though this phrase is a concept, the learner has not yet *internalized* the concept.

To get there, a potential next step would be to leverage the declarative information in the execution of procedures. A combination of theoretical numeric calculations ("What is 2 to the fifth power?") and practical real-world problems ("If a person starts with two pennies, and they double each day, how many pennies will there be on the fifth day?") will create opportunities for students to practice applying this newly acquired declarative knowledge. With practice, students will begin correctly calculating exponential growth, and master the procedures.

Nonetheless, a student will not have internalized the concept. Their declarative and procedural knowledge will remain tied to the contexts in which they are taught. To internalize the concept, a student needs to be exposed to the concept in a variety of contexts to facilitate Transfer. Students might be introduced to how exponential growth occurs in the spread of viruses, population growth, or social media engagement. Each new context allows the student to recognize that the scenario features exponential growth, and that "exponents are deceiving, then explosive" applies. With enough distinct contexts, the student internalizes the conceptual knowledge.

Knowledge Acquisition Methods

After the declarative, procedural, and conceptual knowledge classifications, the next most commonly referenced "knowledge types" in our synthesis were "tacit knowledge" (in 5 of the 10 sources) and "explicit knowledge" (in 4 of the 10 sources). These two types differ in the complexity of gaining and sharing knowledge—explicit knowledge is easy to structure and share and tacit knowledge is difficult and typically requires lived experience. Highlighting the difference would be explicit knowledge of a workplace's policies and procedures, contrasted with the tacit knowledge of a workplace's cultural norms. The former could be shared via a handbook, the latter would require time and, likely, personal lived experiences.

Two other knowledge "types" emerged in the research, from the field of philosophy. The Latin phrases *a priori* and *a posteriori* refer to whether a deduction is made with or without personal experience. A priori knowledge is a form of knowledge independent of experience, and rather through purely theoretical deduction. *A posteriori* knowledge is knowledge based on observation and experience*. A priori* knowledge overlaps heavily with explicit knowledge, in that a person does not need personal observation or experience to acquire such knowledge. *A posteriori* knowledge overlaps with tacit knowledge, in that it typically requires personal experience to acquire the knowledge.

To forward the goal of building a framework useful for educators, while recognizing that these terms do not necessarily lend themselves well to quick understanding, CCR has adapted these terms into the following two knowledge acquisition methods:

1. **Experiential knowledge**, or that gained via personal experiences, observations, and reflections.
2. **Theoretical knowledge**, or that gained without personal experience, instead relying on deduction and logic.

In these two acquisition methods, experiential knowledge represents a posteriori and explicit knowledge, while theoretical knowledge includes a priori and tacit knowledge. Though these terms did not appear frequently in CCR's research, they were selected for utility, so educators could quickly understand what they represent.

The term "experiential learning" already is widely deployed in education, initially designed by David Kolb and his proposed "experiential learning cycle"[272] which advocated for learners to leverage direct experiences to make observations and then meaning. Project-based learning operates in a

[272] Kolb, D. A. (1984). Experiential learning: Experience as the source of learning and development (Vol. 1). Englewood Cliffs, NJ: Prentice-Hall.

similar space, enabling students to learn by doing. Both experiential learning and project-based learning have their champions, institutes, models, and frameworks, recognizing that direct experiences are in some cases the *only* way for a person to learn something. Additionally, these direct experiences" serve as opportunities for students to learn theoretical knowledge as well.

For example, students could embark on an experiential learning project to study the trees at a local park. In doing so, students can acquire an experiential knowledge of what trees look and feel like and how their roots interconnect. They could also examine the texture of leaves and look for other organisms in the ecosystem. This knowledge would not be acquirable in a classroom, even (as of now) with the latest virtual reality headset. Details such as the smell of the air, the perceived size of a tree, and the sight of a worm nibbling a leaf, are all experiential knowledge.

Experiential learning experience can *also* be used to teach theoretical knowledge. Students could develop an understanding of photosynthesis by examining the brightness and color of leaves, or further their theoretical understanding of the oxygen-carbon dioxide cycle by considering the different ways humans and trees "breathe." Though these things can be taught in a classroom without direct experience, experiential learning more efficiently facilitates meaning-making from these facts as it engages learners holistically.

Still, we should be cognizant that these types of rich, real-world experiences are resource-intensive. A school might be in a setting with no proximity to trees. It costs money to transport students on a field trip. It could be winter. Furthermore, as the experience will be unique to the context of each school, there is an additional burden on the teacher to customize the experience effectively for their classroom. It is difficult to easily turn a purchased curriculum or lesson plan into a rich real-world experience.

The distinction between the experiential and theoretical knowledge acquisition methods therefore serves as a reminder for schools to recognize the power of real-world experiences, and to optimize their resources to generate these experiences to help students acquire the valuable, relevant knowledge offered solely by these experiences, and well worth the necessary resource.

Knowledge as Substrate for Competencies

Competencies will be discussed in detail in the next chapter; nonetheless, knowledge cannot be discussed in a vacuum. The perceived importance of teaching students how to think, learn, and apply socio-emotional skills, often overshadows discussions about what content should be taught in the first

place. However, it is important to note that learning is highly context-dependent and competencies are thus best taught through some fitting content substrate or medium.[273] There is also reason to believe that some content may be better aligned for teaching some competencies than others.[274]

Nineteen of the synthesized "knowledge types" overlap with the other three dimensions of the CCR framework. They are referenced as follows:

Skills	**Character**	**Meta-Learning**
Cognitive Process Skills Procedural Knowledge Strategic Knowledge Cognitive Strategies	Moral Knowledge Ethical Knowledge Ethical Theories Moral Principles Attitudinal Knowledge	Cognitive Process Skills Psychomotor Knowledge Affective Knowledge Narrative Knowledge Spiritual Knowledge Strategic Knowledge Self-Knowledge Higher Knowledge Meta-Knowledge Metacognitive Knowledge Self-Awareness Cognitive Strategies Motor Skills Metacognitive Strategies Attitudinal Knowledge

These overlaps are a *feature* of the CCR framework, not a bug. Consider the following execution of a complex strategy: the publication of a software product. A project lead would need:

- A firm understanding of the declarative knowledge surrounding the software project: facts about how the product works, what solutions it provides, and how it stacks up against competition.
- The conceptual knowledge to chunk complex information together to make decisive and clear judgments: The lead will leverage a toolkit of concepts such as how software deployment is fluid and patchable, or that an individual's first few seconds in a user interface colors the entire experience.

[273] Heald, J. B., Lengyel, M., & Wolpert, D. M. (2022). Contextual inference in learning and memory. *Trends in Cognitive Sciences*, *27*(1), 43-64.
[274] Dunn, K. et al. (2021). *Embedding competencies within disciplines.* Center for Curriculum Redesign. https://curriculumredesign.org/wp-content/uploads/Embedding-Competencies-within-Disciplines-aka-Top4-CCR-June-2021.pdf

- The procedural knowledge to understand how the software accomplishes its solutions and the procedures necessary to bring the product to market: soft launches, building a user feedback system, etc.
- Robust competencies from the Skill Dimension: Some of these would overlap with the above—the toolkit of conceptual knowledge aids critical thinking, and baseline declarative knowledge (which is the foundation for creative and effective execution of the procedures), will demand strong collaboration and communication.
- A firm character: To effectively gather declarative knowledge, an individual would leverage their curiosity. There will be challenging times demanding courage and resilience, and the successful release of any software product requires a firm ethical understanding of its impact
- The ability to learn in real-time, as new information shifts the calculus behind decisions: A strong foundation in the Meta-Learning Dimension will enable the lead to manage a variety of complex, dynamic interplays. They also will be able to manage and allocate resources across all of the competing demands in their life.

AI's Impact: Redesigning Disciplines[275]

Justifications for the modernization of Traditional Disciplines in K-12:

The justification was covered earlier in this chapter, and in the preceding chapter, particularly under the section "Consequences for Education Systems,"

Content Modernization of Traditional Subjects (aka) Disciplines: *Using Mathematics as an example*[276]

Content modernization of traditional disciplines can be achieved at three levels:

A. ***Minor changes:*** rearranging content items and making minor tweaks, as historically and painstakingly executed by jurisdictions, due to academic inertia and political difficulties. These aspects are not within the scope of this book.

B. ***Significant rework****:* this is what CCR has accomplished[277] in concert

[275] Note: We will use the word "Standards" to differentiate from "Curriculum" . In some jurisdictions, the two are used interchangeably, while Standards refers to a terse list of content goals, while curriculum implies a deeper set of teacher-related materials.
[276] Beyond Mathematics, CCR has done similar work for Computer Science, World History, World Literature, Health and Physical Education (HPE), etc. thus proving that the process is replicable in disciplines beyond mathematics.
[277] Bialik, M. et al. (2021). *Mathematics for the modern world.* Center for Curriculum Redesign. https://curriculumredesign.org/wp-content/uploads/Mathematics-for-the-Modern-World-1.pdf

with Australia's Curriculum, Assessment and Reporting Authority (ACARA). The standards conserve most of the structure of a typical K-12 subject, with significant enhancements from the following process:

1. Analyzed the needs for different topics (for the OECD[278])
    - Recommended attention given to traditional areas of Mathematics, too often covered insufficiently in schools: number sense, estimation, irregular shapes, proportionality, basic probability, and exponentials.
    - Recommended topics in Mathematics of modern relevance[279] that are rarely, if ever, covered in schools: Bayesian probability, and Discrete/Computational mathematics (algorithms & graphs, complex systems, game theory).
2. Developed the Core Concepts of Mathematics at two layers of granularity: Discipline-level, and Branch-level. This step was most complex for Mathematics because the discipline confuses content and concept, but others such as History have traditionally done a better job at separating the two. Here are two examples from Engineering (Discipline) vs Computer Science (Branch):
    - Discipline: Fragility: When designing and building a product, it is important to consider the ways that the product may behave under stress, how it can be misused or how it might simply fail.
    - Branch: Garbage In/Garbage Out: Computers do what they are programmed or (in the case of AI) trained to do. Most computer errors are the result of *human* errors in input data, design, or Programming.
3. Identified the top Competencies that pertain to Mathematics:[280] Critical thinking; Resilience, Metacognition, and Growth Mindset.

C. ***Deepest redesign*: Personalization:** Educators have identified the need to personalize education, particularly beyond middle school which represents a common trunk to all students. CCR has thus identified three levels of complexity for the student to be tasked against, depending on their potential and interest in each discipline: *Produce; Interpret; Appreciate.* The following example about complex systems and forest fires will explain the difference between all three levels: if you are a firefighter about to risk your life, wouldn't you want to question your local government about whether the firebreaks and water wells have been placed strategically? Because you know that forest fires are fractals (Appreciate) and want to make sure the

[278] Center for Curriculum Redesign. (2021). PISA mathematics in 2021. https://curriculumredesign.org/wp-content/uploads/Recommendations-for-PISA-Maths-2021-FINAL-EXTENDED-VERSION-WITH-EXAMPLES-CCR.pdf
[279] Center for Curriculum Redesign.2021). *Mathematics for the modern world.* https://curriculumredesign.org/wp-content/uploads/ccr-case-for-math-social.mp4
[280] Dunn, K. et al. (2021). *Embedding competencies within disciplines.* Center for Curriculum Redesign. https://curriculumredesign.org/wp-content/uploads/Embedding-Competencies-within-Disciplines-aka-Top4-CCR-June-2021.pdf

policymakers (Interpret) and the mathematicians (Produce) have done their job right (exactly as you can ask questions to your accountant or lawyer).

This is traditionally done in many jurisdictions by offering variants of each class (Honors, regular, vocational) and binning students accordingly. However, the implementation is historically poor, as *it is mainly the same content, simply adjusted for speed of coverage, not for depth of coverage*. Why would an electrician need to learn to solve polynomials? (and, to boot, by hand?) even if given more time than the STEM-College-bound student…

Level	P/I/A		
Level 3 (STEM-bound)	Produce	Produce	Produce
Level 2 (College-bound)	Produce	Produce	Interpret
Level 1 (VET-bound)	Produce	Interpret	Appreciate
Example	Exponentials	Quadratics	Cardioid, cycloid etc.

(Source: CCR)

Justifications for the inclusion of Modern Disciplines in K-12:

Based on the relative growth of various occupations,[281] three modern disciplines emerge as crucial to the modern world, but are generally not taught systematically in K-12. They are eminently justifiable as follows:

1) **Technology and Engineering (T&E)**: *Educators talk about STEM, but only teach "St_M" at best.* Currently, the STEM acronym primarily represents science and mathematics in the K-12 curriculum, with technology and engineering being overlooked. By incorporating engineering education into schools, educators can provide students with a more comprehensive and integrated STEM experience, which is also naturally project-based.[282] This will ensure that students receive a well-rounded education that prepares them for the diverse challenges and opportunities they will encounter:

- Driving innovation and economic growth: T&E is crucial in the modern world as it drives innovation and economic growth more than any other discipline.[283] It provides the foundation for designing and implementing solutions to various societal challenges, from infrastructure development to energy

[281] Center for Curriculum Redesign. (2018). ONETExplorer. https://curriculumredesign.org/onetexplorer_raw/

[282] Center for Curriculum Redesign and Australian Learning Lecture. (2021) *Passion Projects Portal.* https://passionprojects.curriculumredesign.org/

[283] Murphy, K. M. et al. (1990). The allocation of talent: Implications for growth. *NBER Working Paper No. w3530.* https://papers.ssrn.com/sol3/papers.cfm?abstract_id=226816

management. Furthermore, it would support the cultivation of a workforce capable of tackling complex, real-world problems and driving the economy forward.

- Fostering interest in STEM disciplines: While computer science has garnered significant attention in recent years, other STEM fields hold equal potential for student engagement and innovation. CCR has developed a comprehensive set of standards for six branches of engineering, including civil, design, electrical, graphic, manufacturing, and mechanical so that K-12 schools can offer students a well-rounded STEM education. This broad range of opportunities will enable students to explore their interests and aptitudes, encouraging more of them to pursue STEM careers
- Bridging the gap between the natural and the human-made worlds: In K-12 education, the predominant focus on the natural world (through science curricula) often leaves the man-made world underexplored. Engineering education can bridge this gap and provide students with a comprehensive understanding of both realms. By learning about the technologies and systems that shape their everyday lives, students can develop a more profound appreciation of the interconnectedness of science, technology, and human achievement.
- Complementing scientific minds: Engineering is a natural extension of the scientific mind, as it involves the practical application of scientific principles. ***Engineering scales Science.***
- Development of Competencies: T&E encourages students to think critically, develop problem-solving skills, and apply their scientific knowledge in practical ways. This fusion of theory and practice will ensure a well-rounded education that prepares students for the challenges they will face in their academic and professional lives.
- Developing critical Core Concepts: Engineering education helps students develop critical core concepts that are invaluable in real-world functioning. For instance, the concepts of prototyping before production, and feedforward rather than feedback, can be applied across a variety of fields and industries.
- Linking to invention processes: Incorporating engineering into K-12 education enables the introduction of inventive methodologies, such as the Theory of Inventive Problem Solving (TRIZ).[284] TRIZ, as an example, provides a systematic approach to innovation and problem-solving that can tackle pressing global challenges.

2) **Social Sciences:** the need to understand oneself and others is at

[284] Wikipedia. (2023). Triz. https://en.wikipedia.org/wiki/TRIZ

a premium in the modern world, yet jurisdictions generally do not teach, or, at best, make optional, social sciences disciplines such as **psychology, sociology, anthropology, and political science.**

- Psychology helps students understand human behavior and mental processes. It exposes them to cognitive biases, heuristics, and self-fulfilling prophecies, as well as developmental milestones and variations in abilities.
- Sociology helps students understand how social groups, institutions and cultures shape human behavior and experience. It shows them the influence of social forces like inequality, discrimination and socialization on individuals and society.
- Anthropology expands students' concepts of culture by studying diverse human groups past and present. It fosters an appreciation of cultural differences and the common humanity across cultures and provides insights into human evolution and how it has shaped human behavior and society.
- Political science teaches students about the political systems and structures that shape laws, policies, and civic life. It promotes an understanding of government functions, citizenship, and political participation. Students develop informed opinions on contemporary political issues and debates, including principles of democracy, justice, liberty and equality on which western political systems are based.

3) **Entrepreneurship/Business**: one hears nowadays that "*Entrepreneurship is **the** job of the future*" and CCR agrees wholeheartedly, as job creation happens chiefly in small-to-medium-sized businesses (or SMBs).[285] Yet again, this discipline is not mandatory or widely/even available, despite its intrinsic value, and the value of **branches such as economics, accounting, marketing, sales, and law, and themes such as financial literacy.** It does:

- Prepare students for the real world: These subjects teach practical skills that students will use in their personal and professional lives. They provide an understanding of how the economy and business world work.
- Develop an entrepreneurial mindset: Teaching entrepreneurship at a young age can foster an innovative, opportunity-seeking mindset. This can help students identify problems and come up with creative solutions.
- Foster financial literacy. Subjects like economics, business and

[285] International Labour Office, Geneva. (2015). Report IV: Small and medium-sized enterprises and decent and productive employment creation. *International Labour Conference.* https://www.ilo.org/wcmsp5/groups/public/---ed_norm/---relconf/documents/meetingdocument/wcms_358294.pdf

personal finance teach students to manage money, understand markets and make sound financial decisions. This is crucial for students' future well-being.
- Develop real-world, employable capabilities in marketing and sales: These are in high demand by employers.
- Inspire career interest: Exposing students to different business and legal careers at an early age can spark their interest and inspire them to pursue further education in those fields.
- Help the economy: When more students develop business and entrepreneurial skills, it could lead to more startups, innovation, and jobs in the future economy.
- Teach key competencies difficult to develop otherwise, such as Courage.

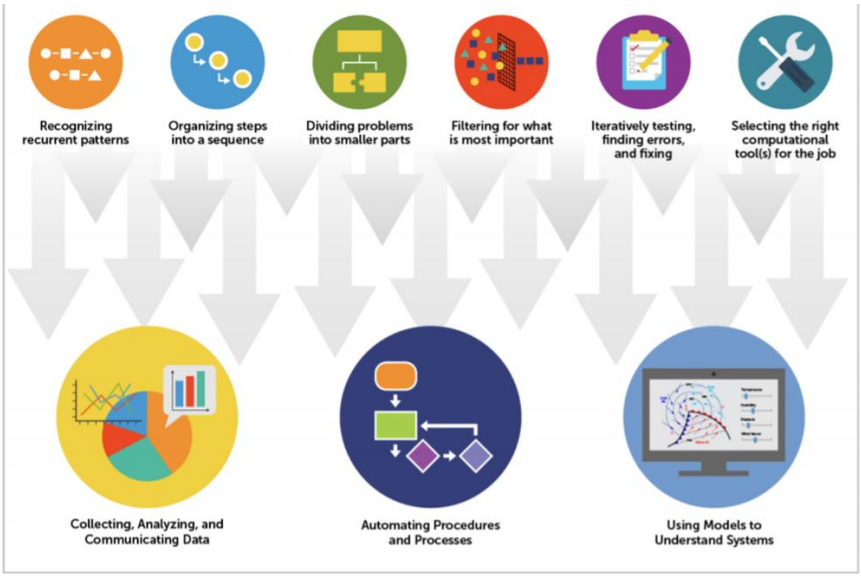
All these modern disciplines also foster the development of different Competencies that are complementary to the ones shouldered by traditional disciplines.

Interdisciplinarity, and cross-cutting Themes

In “Four-Dimensional Education,” CCR has discussed an important aspect to the twenty-first-century curriculum—themes. Themes represent common strands of learning that run through many of the disciplines—traditional and modern—and which matter to many jurisdictions and cultures. Teachers, students, and curriculum designers will find countless ways to highlight them throughout the essential areas of study. Rather than repeat this section, the reader is encouraged to download a free copy of that book and consult the section starting on page 95. The key interdisciplinary themes identified by CCR in 2015 are still quite relevant today. As a quick reminder, they are:

- **Environmental Literacy**
- **Global Literacy**[286]
- **Information Literacy**
- **Systems Thinking**
- **Design Thinking**
- **Digital Literacy**
- **Computational Thinking** is a new addition: Its justification lies in the necessity for all students to understand logical, threaded thinking, *as applicable to a variety of disciplines, not just computer science*. The following representation provides a complete view of the process:

[286] Sometimes and confusingly called global competence by other groups. The Themes should not be confused with the Competencies of the CCR framework.



(Source: Digital Promise[287])

This chapter clarified the need and processes for curriculum redesign for the Knowledge dimension. The following chapters will do the same for Competencies, and their key Drivers.

[287] https://www.edutopia.org/article/using-stories-support-computational-thinking

Chapter Six
Competencies for the Age of AI

"Rather a mind shaped than a head full. [Plutôt une tête bien faite que bien pleine]" - Michel de Montaigne
"Artificial intelligence is not a substitute for human intelligence; it is a tool to amplify human creativity." –Fei-Fei Li

Rev. 1.2: Update needed for an age of AI

The CCR Competencies Framework 1.0 was published five years ago after an extensive 3-year phase of analysis and synthesis of more than 100 frameworks from around the world, and 861 learning sciences papers,[288] making it by far the best-researched compared to its peers. The CCR team set five parameters for the design process so that the developed framework would be:

1. Comprehensive, to ensure all high-level thinking about education design is addressed, with no gaps.
2. Compact, to enable actionability via a finite number of parameters, so users can act on them.
3. Uncorrelated as much as possible, while respecting that all constructs inherently interact with one another and that ontological or linguistic perfection would be illusory.
4. Appropriate abstraction, featuring competencies and subcompetencies at roughly equivalent levels of abstraction and relatedness.
5. Globally Relevant, to avoid cultural dependence, while striving to provide common understandings for effective cross-cultural communication.

An additional, implicit goal in the deployment of the framework has been **stability**. Recognizing that educational terminology can come and go, the CCR Framework prioritizes stability so its users do not have to frequently update resources and materials. For this reason, in the half-decade during which CCR has used and propagated this framework, no changes have been made, despite occasional requests to do so.

However, CCR's "Education Engineering"[289] mindset recognizes that, with blind adherence in the face of new evidence, the mission to ensure that the education field keeps pace in a changing world would fail. The launch of

[288] Center for Curriculum Redesign. (2020). Theory of change and research process. https://curriculumredesign.org/wp-content/uploads/CCR-Theory-of-Change-and-Research-Process.pdf
[289] Fadel, C. (2020). Education Engineering. *Center for Curriculum Redesign.* https://curriculumredesign.org/wp-content/uploads/Education-Engineering-QA.pdf

CCR's framework as "Version 1.0" was titled deliberately. CCR recognized that a moment would come when the momentum and direction of change would outweigh the benefits of preserving the framework, and an update would be launched. CCR recognizes that moment in the rapid proliferation of AI, and this provides an ideal reason for "Version 1.2." The five initial design parameters remain unchanged. The comprehensive, multi-year development process is described in CCR's paper "Theory of Change and Research Process."[290] Version 1.2 seeks to optimize the framework for these goals, and its change logs from Rev 1 are available in the Appendix.

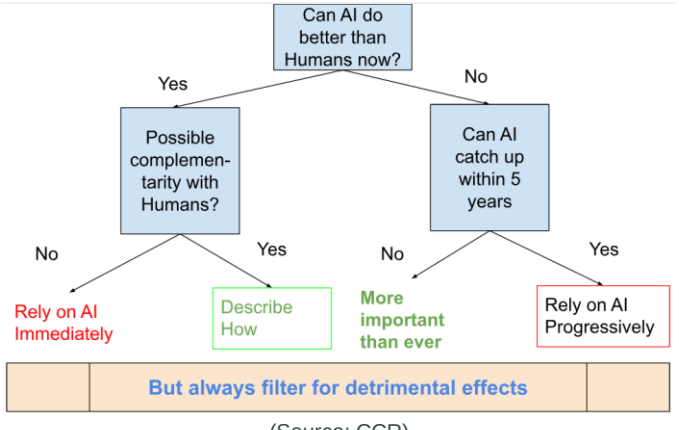
Complementarity AND Substitution of Competencies

CCR identified competencies and their composite "subcompetencies" that were important before AI. It is now necessary to determine to what extent AI has changed (or will change) the importance of each subcompetency. **The highly researched nature of CCR's framework, and its clarity through precision, is a unique tool to explore AI's impact in depth, while staying away from imprecise language (and therefore, empty debates).**

As AI consistently outperforms humans in various tasks and demonstrates the potential for complementarity with human capabilities in other areas, CCR asks four key questions to gain valuable insights into the evolving landscape of competencies and their vulnerability to the pervasive influence of AI. These questions are:

1. *Does AI* (or automation) *outperform humans at this subcompetency?*
2. *If so, does the AI have a possible complementarity with humans?*
3. *If not, can AI catch up with human performance at this (sub)competency within the next 5 years?*
4. *Could AI have a detrimental effect on human performance?*

The following flowchart describes CCR's decision process:



(Source: CCR)

[290] Center for Curriculum Redesign. (2020). Theory of change and research process.

Creativity:

"Although novelty, surprise and value are three key components to measure if AI is being creative, I think a fourth element must also be introduced if we are going to herald real creativity in AI: originality of a truly independent nature." -Marcus du Sautoy

Subcompetency	Does AI outperform humans?	Does AI complement humans?	Can AI catch up in the next 5 years?
CRE1: Developing personal tastes, aesthetics, and style	NO	YES	MIXED
CRE2: Generating and seeking new ideas	YES	YES	YES (already there)
CRE3: Being comfortable with risks, uncertainty, and failure	YES	YES	YES (already there)
CRE4: Connecting, reorganizing, and refining ideas into a cohesive whole	MIXED	YES	YES
CRE5: Realizing ideas while recognizing constraints	NO	YES	MIXED

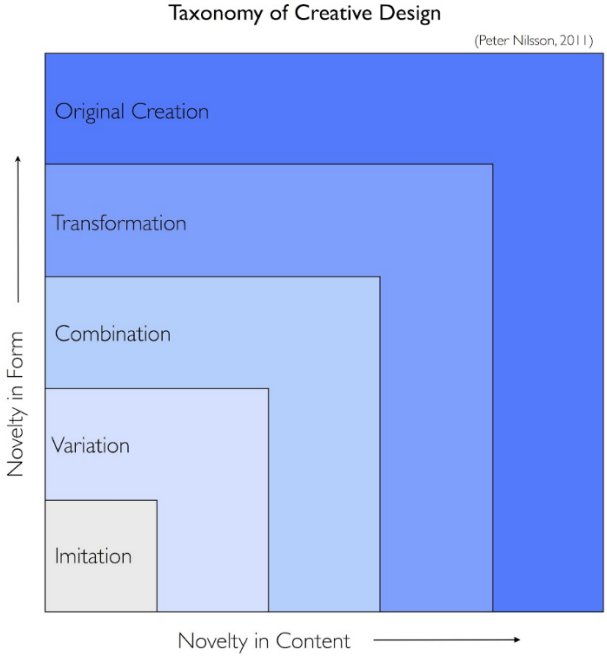
AI's creativity,[291] such as DeepDream by Google, is rooted in complex algorithms that generate or modify content based on patterns learned from data.[292] These algorithms can produce novel outputs, but their creativity is

[291] Carey, T.L. (2021). Beethoven's unfinished 10th symphony brought to life by artificial intelligence. https://www.scientificamerican.com/podcast/episode/beethovens-unfinished-10th-symphony-brought-to-life-by-artificial-intelligence/, https://www.youtube.com/watch?v=Rvj3Oblscqw. An extraordinary accomplishment, but qualified by many as "extremely boring" for its lack of inventiveness; Kaufman, S.B. (2014). The real link between psychopathology and creativity. *Scientific American.* https://blogs.scientificamerican.com/beautiful-minds/the-real-link-between-psychopathology-and-creativity/#

[292] Mordvintsev, A., Olah, C., & Tyka, M. (2015). DeepDream - a code example for visualizing Neural Networks. Google Research Blog. https://blog.research.google/2015/07/deepdream-code-example-for-visualizing.html?m=1

fundamentally deterministic, following human-programmed instructions (yet, with wide boundaries). AI's capacities for creativity are expanding, with examples including algorithmic composition of music, automated content creation, and generative art. For instance, OpenAI's MuseNet can compose classical music that mimics the style of human composers,[293] while AI algorithms like GANs ("Generative Adversarial Networks") have been used to create novel artworks, some of which have been auctioned at Christie's.[294] AI-driven tools like GPT-4 have also shown potential for generating creative writing, including poetry and prose. The scope of AI creativity is predicted to grow as these systems become more sophisticated, learning to combine styles and concepts in unprecedented ways, potentially leading to more novel creations.[295]

Peter Nillson's "Taxonomy of Creative Design"[296] served as a valuable tool for analyzing different axes of creative tasks, even in pre-AI times:



(Source: Peter Nilsson)

[293] Payne, C. (2019). MuseNet. OpenAI Blog. https://openai.com/research/musenet
[294] Elgammal, A., Liu, B., Elhoseiny, M. et al. (2017). CAN: Creative adversarial networks, generating "art" by learning about styles and deviating from style norms. *ArXiv: Cornell University.* https://arxiv.org/abs/1706.07068
[295] Boden, M. A. (2018). AI and creativity. In *The Oxford Handbook of Artificial Intelligence* (pp. 209-232). Oxford University Press. https://philpapers.org/rec/BODCAA-6
[296] Nilsson, P. (2011). "The Challenge of Innovation. In Critical Thinking and Creativity: Learning Outside the Box." Paper Presented at the Proceedings of the 9th International Conference of the Bilkent University Graduate School of Education (Turkey), Ankara (pp. 54-62). Ankara, Turkey: Bilkent University

AI already can perform at levels comparable to or outperform humans at the imitation, variation, combination, and transformation rungs. Of course, the rungs of this taxonomy have porous boundaries. The tier of original creation draws us into the discipline of philosophy—what is *truly* original? Thinking of AI only as a "stochastic parrot"[297] would place an impassable ceiling on how *truly* original a creation AI can generate. Expert creative humans—or humans raised in education systems optimized to preserve their wide imaginations from young ages —still hold deep societal value, especially in collaborating with powerful AI systems, in solving the hardest global challenges.

For the less difficult challenges humans face on a day-to-day basis, CCR's research[298] shows that AI can complement human creativity in all Creativity's subcompetencies; and, in some, AI already outperforms humans. This is counterintuitive to humans, given their common perception that Creativity is only about flashes of brilliance.

CRE1: AI does not have "personal" tastes, but can mimic styles based on training data. In this way, it can be a helpful tool with which humans can further develop their tastes, discover new styles and aesthetics and advance creative projects.[299]

Developing personal tastes, aesthetics, and style is a human process interwoven with subjective experiences, emotions, cultural influences, personal identity, and so forth. Currently, AI lacks the subjective experiences and consciousness required for this development and it is highly unlikely that AI will surpass humans in these capacities in the near future.[300]

CRE2: AI may outperform humans at generating new ideas, if programmed for innovation,[301] especially as technology continues to improve. AI can generate ideas with speed and efficiency, both on their own and in tandem with humans.

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[297] Bender, Emily M.; Gebru, Timnit; et al (2021-03-01). "On the Dangers of Stochastic Parrots: Can Language Models Be Too Big? 🦜". Proceedings of the 2021 ACM Conference on Fairness, Accountability, and Transparency. FAccT '21. New York, NY, USA: Association for Computing Machinery. pp. 610–623. doi:10.1145/3442188.3445922 . ISBN 978-1-4503-8309-7. S2CID 232040593.

[298] Center for Curriculum Redesign. (2023). *AI and subcompetencies surveys.* Internal report, CCR. Unpublished.

[299] Biehlman, P. (2023). 'You've got to be data driven' -the fashion forecasters using AI to predict the next trends. *The Guardian.* https://www.theguardian.com/technology/2023/oct/01/ai-artificial-intelligence-fashion-trend-forecasting-style; Zhang, Z., Fort, J. M., & Giménez Mateu, L. (2023). Exploring the potential of artificial intelligence as a tool for architectural design: A perception study using gaudí's works. *Buildings*, *13*(7), 1863. https://doi.org/10.3390/buildings13071863

[300] Searle, J. R. (1984). *Minds, brains, and science.* Harvard University Press

[301] E.g. MIT. (2023). Supermind ideator. https://ideator.mit.edu/auth/sign-up/waitlist

Predicting the extent to which AI will advance in idea generation in the next five years involves much speculation. While improvements in AI's creative abilities are expected, surpassing the human capacity for generating and seeking fundamentally new ideas across all domains seems unlikely within this timeframe.[302]

CRE3: AI inherently comfortable with risks, uncertainty, and failure, as it is emotionless. This contributes to its ability to calculate risk and suggest atypical actions in response (as described in Chapter One), which can augment human decision-making capabilities.[303]

AI's approach to risk is based on data and algorithmic calculations rather than physical or emotional (dis)comfort. AI can process uncertain situations, especially when equipped with algorithms designed for uncertain environments, such as Bayesian networks. However, AI's handling of uncertainty is fundamentally different from human (dis)comfort with uncertainty. The experience of comfort is unlikely to be within AI's reach within the near future, unless significant efforts are made to mimic these human experiences.

CRE4: AI excels at connecting, reorganizing, and refining ideas, and at efficiently summarizing and organizing data; it can support humans in generating and refining ideas.[304] AI still requires human prompting, and human judgment should be applied to ensure ideas are cohesive.

Connecting and reorganizing ideas cohesively, as humans accomplish in creative processes, involves a level of abstraction and conceptual integration with which AI struggles. This ability is rooted in human creativity, intuition, and experiences, which are challenging for AI to emulate without future technical breakthroughs.

CRE5: Realizing ideas, particularly in the context of complex, socially and emotionally nuanced environments, is difficult for AI, mainly due to its limitations compared to human capabilities and adaptability in these contexts (not to mention the lack of physicality, unless embedded in a robot).[305]

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[302] Engelbart, D. (1962). Augmenting human intellect: A conceptual framework. *SRI Summary Report* AFOSR-3223. https://www.lri.fr/~mbl/ENS/FONDIHM/2020/papers/Englebart-Augmenting62.pdf

[303] Russell, S. J., & Norvig, P. (2014). *Artificial intelligence: A modern approach.* Third Edition. Pearson.

[304] Boden, M. A. (2009). Computer models of creativity. *AI Magazine, 30*(3), 23-34. https://ojs.aaai.org/aimagazine/index.php/aimagazine/article/view/2254

[305] Picard, R. W. (2000). *Affective computing.* MIT Press. https://mitpress.mit.edu/9780262661157/affective-computing/

AI's abilities to realize ideas while recognizing constraints within the next five years is a complex question. It involves assessing AI's projected capabilities in areas like problem-solving, creativity, and the understanding of practical limitations. One of the primary challenges for AI in the near future is fully understanding and responding to complex, real-world constraints, which often require contextual understanding, flexibility, and adaptability.[306] Humans excel in dynamically adjusting to such constraints, leveraging intuition and experience.

Critical Thinking:

Subcompetency	Does AI outperform humans?	Does AI complement humans?	Can AI catch up in the next 5 years?
CRI1: Identifying, clarifying, and organizing information	YES	YES	YES (already there)
CR12: Assessing validity and quality of information	NO	YES	YES
CRI3: Weighing pros and cons of alternative choices	MIXED	YES	MIXED
CRI4: Applying sound reasoning to decision-making	MIXED	YES	MIXED
CRI5: Reflecting critically on one's own reasoning and assumptions	MIXED	YES	MIXED

AIs demonstrate a growing capacity for certain types of critical thinking, especially in domains where pattern recognition, and data analysis are involved. For example, AI can outperform humans in complex strategic games like Chess and Go, which require foresight and evaluation of

[306] Lake, B. M. et al. (2017). Building machines that learn and think like people. *Behavioral and Brain Sciences*, 40. *ArXiv:* Cornell University. https://arxiv.org/abs/1604.00289

possible outcomes.[307] Additionally, AI applications in healthcare can critically analyze medical data to diagnose diseases from imaging (X-ray, pathology) with higher accuracy than human counterparts in some cases.[308] Nonetheless, AI's critical thinking remains limited to its algorithms and the data on which it has been trained; it lacks the human ability to engage in reflective thought or understand context in the way humans do.[309]

The future of critical thinking in AI is centered on its capacity to analyze large datasets, identify patterns, and make predictions based on available information, which can augment human decision-making processes. For instance, AI has been utilized in finance to evaluate investment risks and opportunities by analyzing market trends and financial reports with a level of speed and precision unattainable by humans.[310] As AI technology advances, there is potential for these systems to engage in more sophisticated critical thinking tasks, such as constructing arguments and evaluating their validity, although these functions are contingent on the AI's algorithms and are not indicative of autonomous reasoning.[311] AI's capabilities in data analysis, pattern recognition, predictive modeling, and scenario simulation also make it a valuable tool for strategic planning and decision-making. For business, AI can analyze market trends, consumer behavior, and economic indicators to inform strategies.[312] In the military sector, AI is used for strategic simulations and warfare analysis.[313] AI also contributes to environmental strategy by modeling climate change scenarios or optimizing resource use.[314] These are just a few examples of AI's potential for augmenting human strategizing.

CRI1: CCR's research shows consensus that AI excels identifying, clarifying and organizing information (e.g. through data analysis and summarization). Nonetheless, AI still benefits from human oversight, particularly contextual clarification.[315]

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[307] Silver, D., Schrittwieser, J. et al. (2017). Mastering the game of Go without human knowledge. *Nature*, *550*(7676), 354-359. https://doi.org/10.1038/nature24270
[308] Esteva, A., Kuprel, B. et al. (2017). Dermatologist-level classification of skin cancer with deep neural networks. *Nature*, 542(7639), 115-118.DOI: 10.1038/nature21056
[309] Marcus, G., & Davis, E. (2019). *Rebooting AI: Building artificial intelligence we can trust.* Pantheon.
[310] Bahrammirzaee, A. (2010). A comparative survey of artificial intelligence applications in finance: artificial neural networks, expert systems, and hybrid intelligent systems. *Neural Computing and Applications, 19*(8), 1165-1195. https://link.springer.com/article/10.1007/s00521-010-0362-z
[311] Walton, D. (2016). *A pragmatic theory of fallacy*. University of Alabama Press.
[312] Brynjolfsson, E., & McAfee, A. (2014). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies.* W. W. Norton & Co.
[313] Scharre, P. (2018). *Army of none: Autonomous weapons and the future of war.* W.W. Norton and Co.
[314] Rolnick, D., et al. (2019). Tackling climate change with machine learning. *ArXiv:* Cornell University. https://arxiv.org/abs/1906.05433
[315] Davenport, T. H., & Ronanki, R. (2018). Artificial intelligence for the real world. *Harvard Business Review.* https://hbr.org/webinar/2018/02/artificial-intelligence-for-the-real-world

AI has made huge strides in processing and organizing vast amounts of data, outperforming humans in specific tasks that involve pattern recognition, data analysis, and information retrieval. However, surpassing human capabilities in a broader, more nuanced sense, especially in tasks involving contextual interpretation, is dependent on further technical breakthroughs that are not predictable.

CRI2: AI can identify contradictions, but struggles to assess the validity and quality of information better than humans, and sometimes makes up information (hallucinates).[316] AI can be used as a tool to enhance human information assessment and will improve with time, but humans should remain vigilant in their use of AI, with the motto, "trust but verify."

It is also important to note that humans need to ask the *right* questions to properly evaluate AI-generated responses. How humans prompt chatbots largely defines the properties of their responses; ill-formed questions will lead to bland, false or confabulations.

Assessing the validity and quality of information often requires understanding context, nuance, and complex interrelations, areas where AI faces limitations that may not be overcome within the next five years.[317] Yet AI can benefit from multiple datasets connected via LangChain or API that will allow it to see interconnectedness in a vast range of data, with sensory information humans do not have (x-ray, etc.) as well as learn procedures from YouTube. However, as AI often relies on existing databases, it may struggle with newly emerging information or complex fact-checking scenarios.

CRI3: Many tech experts argue that, in a closed system where all values are well defined, AI can weigh pros and cons of choices better than humans.[318] However, since most choices contain nuance due to context (nuances that are difficult to predict and define as parameters), AI remains a collaborative tool, incapable of being a fully independent judge when it comes to human interactions.[319] To improve, AI needs to be trained with appropriate feedback and continue augmenting its capabilities of 'reasoning' within human contexts.

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[316] Nie, Y., Bansal, M. (2017). Shortcut-stacked sentence encoders for multi-domain inference. In *Proceedings of the 2nd Workshop on Evaluating Vector Space Representations for NLP.* https://aclanthology.org/W17-53.pdf; Zellers, R. et al. (2018). SWAG: A large-scale adversarial dataset for grounded commonsense inference. In *Proceedings of the 2018 Conference on Empirical Methods in Natural Language Processing.* https://aclanthology.org/D18-1009/

[317] Power, D. J. (2007). A brief history of decision support systems. DSSResources.COM, 40. https://dssresources.com/history/dsshistory.html

[318] Sutton, R. S., & Barto, A. G. (2018). *Reinforcement learning: An introduction.* MIT Press.

[319] McKendrick, J & Thurai, A. (2022). AI isn't ready to make unsupervised decisions. *Harvard Business Review,* https://hbr.org/2022/09/ai-isnt-ready-to-make-unsupervised-decisions

Predicting whether AI will surpass humans in weighing the pros and cons of alternative choices within the next five years is challenging: "it depends," as it does better already at probabilistic choices (games, etc. per Chapter One). This task involves only processing vast amounts of data and also understanding subtleties, nuances, and context-specific factors that are crucial in decision-making. While AI has made significant advances in predictive modeling, the nuanced judgment required in complex decision-making may remain a human domain, even in five years.

CRI4: Though AI can make (and/or inform) decisions based on clear criteria, it does not possess “sound” reasoning.[320] However, AI can be an excellent assistant for suggesting new possibilities and perspectives to facilitate human reasoning and decision-making.[321]

Sound reasoning encompasses not just the logical or algorithmic processing of information, which AI excels at, but the understanding of context, subtleties, and ethical considerations, areas where AI currently faces limitations. AI, particularly those based on current machine learning paradigms, often struggle with decisions requiring an understanding of context, subtleties, and unstructured data. These limitations arise from AI's reliance on quantifiable data and predefined algorithms, a reliance that may not be overcome within five years.

CRI5: AI does not reflect critically with its own reasoning and assumptions, *per se*. Nonetheless, it can be programmed with algorithms that prompt reflection about its performance, such as Reinforcement Learning, or Generative Adversarial Networks (GAN). One network, the generator, creates data, while the other, the discriminator, evaluates it. This could be considered a form of very basic AI critical thinking.

Reflecting critically on one's own reasoning and assumptions is a deeply introspective and self-aware process. It is a metacognitive activity and this level of self-awareness and reflective thinking is currently beyond the capabilities of AI, and it is unlikely that AI will surpass humans in this aspect within the next five years.

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[320] Marcus, G. (2018). Deep learning: A critical appraisal. *ArXiv*: Cornell University. https://arxiv.org/abs/1801.00631; Penrose, R. (1989). *The emperor's new mind: Concerning computers, minds and the laws of physics.* Oxford University Press.
[321] Olenick, M. & Zemsky, P. (2023). Can GenAI do strategy? *Harvard Business Review.* https://hbr.org/2023/11/can-genai-do-strategy

Communication:

Subcompetency	Does AI outperform humans?	Does the AI complement humans?	Can AI catch up in the next 5 years?
COM1: Asking questions and actively listening	MIXED	YES	MIXED
COM2: Sharing one's vision and inspiring others	NO	YES	NO
COM3: Clearly and concisely articulating ideas or messages	YES	YES	YES
COM4: Communicating with fidelity across distinct modes and mediums	NO	YES	MIXED
COM5: Adapting messages according to audience	YES	YES	YES

Chatbots are increasingly sophisticated in mimicking human communication.[322] For example, Google's BERT represented a significant leap forward, allowing the system to grasp the context of words within a sentence more effectively.[323] Yet, these systems function on pattern recognition and data processing, with neither genuine understanding nor intent. While the output might seem similar, the underlying processes are not.

The potential for augmentation in AI's communication capacities is focused on advanced natural language processing (NLP), enabling more nuanced and context-aware interactions with humans. These interactions aim toward AI that can understand and respond to spoken language with a level of sophistication similar to a human interlocutor. OpenAI's GPT series

[322] Vinyals, O., & Le, Q. (2015). A neural conversational model. arXiv preprint arXiv:1506.05869. https://arxiv.org/abs/1506.05869
[323] Devlin, J., Chang, M. W. et al. (2019). BERT: Pre-training of deep bidirectional transformers for language understanding. *Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics.* https://arxiv.org/abs/1810.04805

demonstrates significant potential for generating human-like text, indicating that future AIs could engage in complex dialogues, craft narratives, or even simulate empathetic exchanges by predicting appropriate responses based on the input received.[324] AI can also perform well at sentiment analysis of text (e.g. sentiment classification).[325] However, the transition from processing text to understanding the subtleties of human communication, such as irony and non-literal language, is a research challenge that continues to evolve.[326]

COM1: CCR's research demonstrates general agreement that AI can ask questions, and to a certain extent "listen." Nonetheless, AI's current incapacity to comprehend context and body language influences its ability to genuinely listen, as humans understand the concept.[327] However, AI's limitless attention span and ability to generate questions almost instantaneously make it a uniquely useful tool to augment and/or supplement human conversation.

There are several points to consider when projecting upon AI's capacities to surpass humans in asking questions and actively listening, notably AI's capabilities in Natural Language Processing (NLP) and interactive communication. Active listening requires contextual understanding, interpreting emotional nuances, and empathetic responses. AI lacks the ability to genuinely understand emotions and context because its responses are currently based on pattern recognition and pre-programmed algorithms. Similarly, crafting questions that are insightful, contextually appropriate, and promote understanding is a complex task that AI may not reliably perform at a human level within the next five years.[328]

COM2: AI does not possess vision or seek to inspire others, unless programmed to do so. Nonetheless, AI has diverse potential uses to help humans share their individual or collective vision and inspire others.[329]

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[324] Brown, T. B., Mann, B. et al. (2020). Language models are few-shot learners. *ArXiv: Cornell University.* https://arxiv.org/abs/2005.14165

[325] Jumpstart. (2023). Sentiment classification. *Jumpstart Aleph.* https://app.aleph-alpha.com/jumpstart/sentiment-classification; Young, T. et al. (2018). Recent trends in deep learning based natural language processing. *IEEE Computational Intelligence Magazine, 13*(3), 55-75. https://arxiv.org/pdf/1708.02709.pdf

[326] Norvig, P., & Russell, S. J. (2016). *Artificial intelligence: A modern approach*. Pearson.

[327] Bender, E. M., & Koller, A. (2020). Climbing towards NLU: On meaning, form, and understanding in the age of data. In *Proceedings of the 58th Annual Meeting of the Association for Computational Linguistics*. https://aclanthology.org/2020.acl-main.463/; Vinciarelli, A., Pantic, M., & Bourlard, H. (2009). Social signal processing: Survey of an emerging domain. *Image and Vision Computing, 27*(1), 1743-1759. https://www.sciencedirect.com/science/article/abs/pii/S0262885608002485

[328] Gao, J., Galley, M., & Li, L. (2019). Neural approaches to conversational AI. *Foundations and Trends in Information Retrieval, 13*(2-3), 127-298. https://arxiv.org/abs/1809.08267

[329] Hirschberg, J., & Manning, C. D. (2015). Advances in natural language processing. *Science, 349*(6245), 261-266. https://www.science.org/doi/10.1126/science.aaa8685; Malone,

To determine whether AI may surpass humans in sharing personal vision and inspiring others within the next five years involves understanding the nature of inspiration and the limitations of AI in emotional intelligence and creativity. Inspiration, as a human experience, is deeply tied to empathy, creativity, and the ability to connect with others on a personal level with authenticity and emotional resonance. AI can be programmed to communicate effectively, enthusiastically, and persuasively, and therefore may soon excel at inspiring others. Nonetheless, a "personal vision" is something AI would require explicit algorithms to achieve, and may not be possible in the human sense

COM3: AI excels at clearly and concisely articulating, summarizing and adapting messages. This capability is rooted in AI's ability to process and analyze vast amounts of textual data, understand language patterns, and generate coherent and relevant text outputs.[330]

Determining AI's future capabilities in this subcompetency necessitates evaluating advancements in NLP) and AI communication abilities. AI can articulate ideas and messages based on patterns learned from vast datasets. However, this articulation often lacks the nuances, contextual understanding, and adaptability of human communication. AI excels at language processing, but continues to struggle with understanding context, especially in complex, socially or emotionally nuanced situations.[331] Human communication involves not just content but subtleties like tone, intent, and cultural context. While AI will certainly continue to improve, surpassing the full scope of human ability in articulating ideas clearly and concisely, particularly in complex and varied contexts, will likely remain a challenge in the near future.

COM4: Humans currently outperform AI in their ability to communicate with fidelity across different mediums, but AI can be used as a collaborator to enhance and speed up human communication in a variety of modes. Debate remains concerning whether AI can surpass the human ability to communicate in non-text-based modalities in the near future (e.g. verbal interaction, emotional expression, body language, and visual communication).[332]

T. W., Laubacher, R., & Johns, T. (2011). The age of hyperspecialization. *Harvard Business Review.* https://hbr.org/2011/07/the-big-idea-the-age-of-hyperspecialization

[330] Brown, T. B., Mann, B. et al. (2020). Language models are few-shot learners. *ArXiv: Cornell University.* https://arxiv.org/abs/2005.14165; Gatt, A. & Krahmer, E. (2018). Survey of the state of the art in natural language generation. *Journal of Artificial Intelligence Research, 61*(1), 65–170.

[331] Jurafsky, D., & Martin, J. H. (2019). *Speech and language processing.* Pearson.

[332] Bengio, Y., Courville, A., & Vincent, P. (2013). Representation learning: A review and new perspectives. *IEEE Transactions on Pattern Analysis and Machine Intelligence.*

AI has diverse capabilities in different communication mediums, such as text (e.g. NLP), speech (through speech recognition and synthesis), and visual mediums (using computer vision). However, each medium presents unique challenges, and AI's ability to communicate seamlessly and effectively across these different forms remains limited.[333] Developing AI that can integrate information and communicate effectively across multiple modes (like text, speech, and visual cues) is a complex task, will be challenging to complete within the next five years, although GPT4, Bard and others already are taking steps in that multimodal direction.

COM5: AI can also greatly complement human abilities to convey a message clearly and appropriately to diverse audiences.[334]

Whether AI can surpass humans in adapting messages according to an audience within the next five years involves assessment of potential advancements in NLP, audience sentiment analysis, and AI's understanding of human social dynamics (the latter being the most difficult hurdle). Understanding and adapting to the nuances of different audiences requires a comprehension of social, cultural, and emotional contexts. Though AI can analyze audience data (e.g. user preferences, demographics, and engagement patterns), this analysis predominantly relies on observable data and may not fully capture subtler aspects of audience preferences and expectations.[335]

Collaboration:

Subcompetency	Does AI outperform humans?	Does AI complement humans?	Can AI catch up in the next 5 years?
COL1: Taking and sharing responsibility	NO	YES	NO

https://ieeexplore.ieee.org/document/6472238; Kress, G., & van Leeuwen, T. (2006). *Reading images: The grammar of visual design.* Routledge.

[333] Baltrušaitis, T., Ahuja, C., & Morency, L.-P. (2019). Multimodal machine Learning: A survey and taxonomy. IEEE Transactions on Pattern Analysis and Machine Intelligence, 41(2), 423-443. https://ieeexplore.ieee.org/document/8269806

[334] Hovy, D. (2016). The social impact of natural language processing. In *Proceedings of the 54th Annual Meeting of the Association for Computational Linguistics.* https://aclanthology.org/P16-2096/; Johnson, M., et al. (2017). Google's multilingual neural machine translation system: Enabling zero-shot translation. *Transactions of the Association for Computational Linguistics* https://aclanthology.org/Q17-1024/; Sun, Y. et al. (2019). Mitigating gender bias in natural language Processing." In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics.* https://aclanthology.org/P19-1000.pdf

[335] Agarwal, N., & Liu, H. (Eds.). (2012). Modeling and data mining in blogosphere. Morgan & Claypool Publishers.

with others			
COL2: Optimizing team resources and unique skills and perspectives of individuals	YES	YES	YES
COL3: Navigating and resolving interpersonal conflict	NO	MIXED	NO
COL4: Giving and receiving constructive feedback	MIXED	YES	MIXED
COL5: Actively supporting and showing compassion for team members	NO	YES	MIXED

AI collaboration, exemplified by multi-agent systems, is an “emergent” property resulting from coded protocols and decision-making frameworks.[336] While they can "collaborate" based on predefined parameters, their interactions lack the organic evolution and intricate nuance present in animal behaviors.

AI is anticipated to exhibit enhanced collaborative capabilities, functioning alongside humans in roles ranging from companionship to co-workers. The concept of collaborative AI is shaped by developments in multi-agent systems where AI agents learn to communicate, coordinate, and negotiate with each other to achieve common goals.[337] Microsoft's Project Bonsai exemplifies how machine teaching and reinforcement learning can be used to train autonomous systems to perform real-world tasks in concert with human experts.[338] Robotics, too, is a testament to AI collaboration, with platforms like Boston Dynamics' Spot robot designed to navigate and adapt to environments collaboratively with human input, indicating a trend towards

[336] Foerster, J., Assael, Y. M., de Freitas, N., & Whiteson, S. (2016). Learning to communicate with deep multi-agent reinforcement learning. In Advances in Neural Information Processing Systems, 2137-2145

[337] Stone, P., Veloso, M., & Kraus, S. (2010). Multiagent systems: A survey from a machine learning perspective. *Autonomous Robots, 8*(3), 345-383. https://dl.acm.org/doi/10.1023/A%3A1008942012299

[338] Microsoft. (2020). Project Bonsai. https://www.microsoft.com/en-us/ai/autonomous-systems-project-bonsai

more interactive and cooperative AI-human interfaces.[339] These advancements suggest that future AIs will not only work in parallel with humans but will also enhance teamwork by integrating with human strategies and adapting to group dynamics, promoting efficiency and synergy in joint tasks.[340]

COL1: CCR's research demonstrates agreement that an essential aspect of collaboration focuses on innately human components, such as taking and sharing responsibility, which incorporates empathy, accountability, and the ability to learn from mistakes.[341] Without these abilities, AI cannot outperform humans and will struggle to catch up with humans anytime soon.

AI's capacities for taking and sharing responsibility with others imply advances in programming crucial facets of responsibility, a concept rooted in social interactions, ethics, and empathy. Currently, AI lacks the ability to genuinely understand or engage in these complex human dynamics. Responsibility also involves ethical awareness and the capacity for moral judgment, which, depending on programming priorities, may or may not remain beyond AI's capabilities in the short term.[342]

COL2: Despite these limitations, AI can still be a useful collaborator with humans, by optimizing team resources and individual skills through, for instance, assigning responsibilities and tracking performance within teams, offering suggestions and scaffolding for effective feedback, and suggesting ways for humans to be more compassionate towards each other.[343]

AI's capabilities in management and resource optimization are impressive and likely to improve. It remains that optimizing unique skills and perspectives of different individuals in a team setting requires a deep comprehension of human behavior, interpersonal dynamics, and individual

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[339] Boston Dynamics. (2023). Spot: The agile, mobile robot. *Boston Dynamics.* https://bostondynamics.com/products/spot/

[340] Shirado, H., & Christakis, N. A. (2017). Locally noisy autonomous agents improve global human coordination in network experiments. *Nature, 545*(7654), 370-374. https://www.nature.com/articles/nature22332

[341] Bovens, M. (1998). *The quest for responsibility: Accountability and citizenship in complex organisations*. Cambridge University Press. Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology, 44*(1), 113–126. https://doi.org/10.1037/0022-3514.44.1.113; Woolley, A. W, et al. (2010). Evidence for a collective intelligence factor in the performance of human groups. *Science, 330*(6004), 686–688. https://doi.org/10.1126/science.1193147

[342] Floridi, L., & Sanders, J. W. (2004). On the morality of artificial agents. *Minds and Machines: Journal for Artificial Intelligence, Philosophy and Cognitive Science, 14*(3), 349–379. https://doi.org/10.1023/B:MIND.0000035461.63578.9d

[343] Anagnostopoulos, A. et al. (2012). Online team formation. *WWW '12: Proceedings of the 21st international conference on World Wide Web*, 839–848 https://doi.org/10.1145/2187836.2187950;
Davenport, T. H., & Harris, J. (2007). *Competing on analytics: The new science of winning.* Harvard Business Review Press; Rahwan, I. et al. (2019). Machine behaviour. *Nature, 568*, 477–486. https://doi.org/10.1038/s41586-019-1138-y

motivations. These are areas where AI currently, and may continue to, lack proficiency in spite of its ability to read some cues, such as facial expressions, better than humans.

COL3: Within the area of conflict resolution, AI can provide extensive analysis and suggest strategies towards navigating interpersonal conflict. However, skepticism remains about AI's ability to offer the depth of emotional support necessary to resolve conflicts that involve humility, empathy, and truly supporting others.[344]

Given the current state of AI and the inherent complexities of interpersonal conflict resolution, it is unlikely that AI will surpass human capabilities in this domain within the next five years. The human ability to empathize, understand emotional nuances, and navigate complex social interactions continues to be essential in conflict resolution, but AI can help with gaming scenarios.

COL4: AI can provide constructive, personalized feedback on specific tasks such as writing and editing texts, language learning, and so forth. It is also inherent to AI's architecture to receive feedback.[345] This, coupled with a lack of emotion and sense of self, means AI excels at receiving feedback with no qualms.

Constructive feedback is not just about accurate content of feedback, but also ensuring that the manner of delivery is considerate of the recipient's feelings and receptive to their responses. AI currently does not possess emotional intelligence in the human sense, which is crucial for giving constructive feedback. That said, because the nature of the human-AI relationship is different from a human relationship with a coworker, friend, or other feedback-giving individual, it is possible that a person will be more accepting of feedback which is less "charged" when it comes from an AI. Either way, it is possible that within the next five years AI can be programmed to mimic human social dynamics and empathetic responses sufficiently to surpass humans at this subcompetency.

COL5: AI can provide tools to promote active support for team members. However, compassion is not yet within AI's purview, though AI may be

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[344] George, J. M. (2000). Emotions and leadership: The role of emotional intelligence. *Human Relations, 53*(8), 1027–1055. https://doi.org/10.1177/0018726700538001; Owens, B. P., Johnson, M. D., & Mitchell, T. R. (2013). Expressed humility in organizations: Implications for performance, teams, and leadership. *Organization Science, 24*(5), 1517–1538. https://doi.org/10.1287/orsc.1120.0795; Picard, R. W. (2000). *Affective computing.* MIT Press. https://mitpress.mit.edu/9780262661157/affective-computing/

[345] Christiano, P., et al. (2017). Deep reinforcement learning from human preferences. *ArXiv:* Cornell University. https://arxiv.org/abs/1706.03741; Dragan, A., Abbeel, P., & Russell, S. (2016). Cooperative inverse reinforcement learning. *ArXiv:* Cornell University. https://arxiv.org/abs/1606.03137

programmed to mimic this behavior to a certain extent.

Actively supporting and showing compassion for team members requires empathy, emotional intelligence, and understanding of interpersonal relationships. These areas are fundamentally human traits that AI cannot genuinely replicate at this time. AI systems can simulate empathetic and compassionate responses and, in the future, these capacities, in concert with AI's infinite patience and availability, may give AI certain advantages over humans in providing compassionate support.

Curiosity:

Subcompetency	Does AI outperform humans?	Does AI complement humans?	Can AI catch up in the next 5 years?
CUR1: Seeking to understand deeply	NO	YES	NO
CUR2: Surveying opportunities and exploring novel experiences	NO	YES	NO
CUR3: Seeking different perspectives to broaden understanding	YES	YES	YES
CUR4: Envisioning and prioritizing one's interests and passions	NO	YES	NO
CUR5: Finding joy in learning and being a lifelong learner	NO	YES	NO

AI's capacities for curiosity are designed and engineered based on iterative mathematical optimizations such mimicking evolutionary pressures ("genetic algorithms") and reinforcement learning. AI models like DeepMind's agents

have been designed with intrinsic motivation systems to promote exploration or "curiosity" in unfamiliar environments.[346]

AI's potential to exhibit curiosity in the future hinges on its ability to engage in intrinsic motivation-driven learning, a domain gaining traction within AI research. Such systems use mechanisms like intrinsic motivation, mirrored from the human psychological concept, to explore environments autonomously, seeking novel stimuli without external rewards—a process termed as 'curiosity-driven learning'.[347] This approach is exemplified in the work of Deepak Pathak's research team, who developed an AI that learns by exploring unseen environments, using an 'intrinsic curiosity module' that incentivizes the discovery of new features or patterns.[348] As AI progresses, it's expected that algorithms will increasingly adopt models of curiosity akin to those found in developmental psychology, enabling them to self-direct their learning process, explore data efficiently, and possibly develop a form of artificial curiosity.[349] Such capacities could revolutionize how AIs approach problem-solving and data analysis, transforming them from passive receivers of information to active knowledge seekers.

CUR1: AI does not seek to "understand deeply" as humans understand this action. The development of genuine "understanding" in AI agents is not predicted shortly and may not even be necessary.[350] There remains consensus that AI excels at providing information, and thus can assist humans in making sense of data and guiding future exploration.

AI's understanding is often limited to the literal interpretation of text and lacks the broader comprehension that comes with human cognitive and emotional experiences. Understanding context, emotions, and subtle nuances in human interactions are essential aspects of deep understanding. Human cognition is adept at interpreting these subtle cues, an area where AI falls short. AI is not programmed to "understand deeply" and therefore is unlikely to surpass humans at this subcompetency within five years.

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[346] Pathak, D., Agrawal, P., Efros, A.A., & Darrell, T. (2017). Curiosity-driven Exploration by Self-supervised Prediction. In Proceedings of the 34th International Conference on Machine Learning. https://proceedings.mlr.press/v70/pathak17a.html

[347] Oudeyer, P.-Y., Kaplan, F., & Hafner, V. V. (2007). Intrinsic motivation systems for autonomous mental development. *IEEE Transactions on Evolutionary Computation, 11*(2), 265-286. http://www.pyoudeyer.com/ims.pdf

[348] Pathak, D., Agrawal, P., Efros, A. A. et al. (2017). Curiosity-driven exploration by self-supervised prediction. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition Workshops* (pp. 16-17). https://arxiv.org/abs/1705.05363

[349] Gottlieb, J., Oudeyer, P.-Y., Lopes, M. et al.. (2013). Information-seeking, curiosity, and attention: computational and neural mechanisms. *Trends in Cognitive Sciences, 17*(11), 585-593. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4193662/

[350] Marcus, G. (2018). Deep learning: A critical appraisal. *ArXiv*: Cornell University. https://arxiv.org/abs/1801.00631; Searle, J. R. (1980). Minds, brains, and programs. *Behavioral and Brain Sciences, 3*(3), 417-424. https://www.cambridge.org/core/journals/behavioral-and-brain-sciences/article/abs/minds-brains-and-programs/DC644B47A4299C637C89772FACC2706A

CUR2: Seeking opportunities and novel experience are biological traits that are not applicable to AI.

AI's potential to independently explore novel experiences and survey opportunities like a human is a complicated issue. AI is currently predominantly data-driven, which means it does not possess the intrinsic motivation and creativity that humans have for exploring novel experiences and will unlikely surpass humans at these competencies in the next five years. However, there is a potential that AI could be programmed to seek novelty in an AI form of experience. In this case, AI would surpass humans, but in a different form of 'experience.'

CUR3: AI, particularly in applications involving NLP and data analysis, can rapidly process and analyze information from diverse perspectives. However, although AI can incorporate diverse perspectives, aggregate information, and recognize commonalities, its ability to "make meaning" is limited by its lack of conscious understanding and contextual awareness.

Understanding the nuances of diverse viewpoints requires empathy, cultural awareness, and emotional intelligence, attributes that AI does not possess. Its ability to independently seek and integrate different human perspectives as part of a broader understanding is also an undertaking AI is unlikely to master within five years. However, it is possible that AI will be programmed to seek to understand different digital, algorithmic or other forms of 'viewpoints' and perspectives. Because AI can be linked to sensors that surpass human senses and can be embodied in robots, vehicles or devices that have different capabilities than humans, it is possible AI may eventually seek perspectives humans cannot directly access.

CUR4: Envisioning and prioritizing personal interests and passions are interests of biological creatures, but not necessarily of programs. Therefore, AI does not outperform humans,[351] but it is not programmed to do so. AI can nonetheless enhance human exploration of new ideas by brainstorming opportunities, suggesting relevant resources, and personalizing learning.

Identifying and prioritizing personal passions and interests is an intrinsic human experience. Human interests and passions are intertwined with emotional experiences, personal values, and life experiences. AI will likely continue to lack the ability to genuinely understand these subjective aspects

[351] Damasio, A. R. (1999). *The feeling of what happens: Body and emotion in the making of consciousness.* Harcourt Brace; Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*(1), 54–67. https://doi.org/10.1006/ceps.1999.1020; Russell, S. J., & Norvig, P. (2009). *Artificial intelligence: a modern approach.* Prentice Hall.

of human life as AIs are programmed to support human interests, rather than pursue their own.

CUR5: Being emotionless, AI does not find joy in things, and is not a "*life*-long" learner, as it does not possess a life span as living creatures do.

The concept of being a 'lifelong learner', as humans understand it, involves ongoing curiosity, adaptability, and the pursuit of personal interests and passions. Joy in learning, as humans experience joy, is tied to emotional states, achievement, and personal growth. AI's 'learning' is a process of data optimization and pattern recognition, devoid of joy or personal satisfaction (and unlikely to possess these within the next five years), but AI's learning can operate for extended, accelerated periods of time far exceeding human life spans.

Courage:

Subcompetency	Does AI outperform humans?	Does AI complement humans?	Can AI catch up in the next 5 years?
COU1: Pursuing ambitious goals, despite risks	NO	YES	NO
COU2: Leading with initiative and accountability	NO	YES	NO
COU3: Engaging with others in a vulnerable way	NO	MIXED	NO
COU4: Acknowledging one's strengths and weaknesses	NO	YES	MIXED
COU5: Believing in one's agency and self-efficacy	NO	YES	NO

Terms like courage do not apply in a traditional sense to AI. AI can be programmed to make decisions while prioritizing certain outcomes, even if

they involve high risk. But AI does not "feel" fear, it simply processes data and follows algorithms.[352] It is “fear-less.”

Though traditional AIs may not experience emotions like fear, advanced AI could be designed to simulate courage-like behaviors through risk-aware decision-making algorithms. AI can be designed to prioritize certain actions in high-stakes scenarios, where there's a significant potential for negative outcomes. By programming AI with a risk-sensitive reward structure, it learns to prioritize actions that balance the potential for higher rewards against the risks of negative outcomes.[353] "Chance-constrained" path planning for autonomous vehicles represents another step towards embedding courage-like decision-making in AI, allowing systems to navigate environments under uncertainty and safety constraints.[354] The development of capabilities like these would enable AIs to operate effectively in high-stakes scenarios, for example coordinating rescue missions or financial trading, where bold decision-making is critical.

COU1: In terms of pursuing ambitious goals despite risks, research agrees that AI's lack of genuine ambition and fear, combined with the absence of inherent accountability,[355] limits its capacity for true risk-taking.[356] Nonetheless, since AI excels in quantifying risks and providing data-driven insights, respondents also agreed that it can help humans navigate risk.

While AI will continue to advance in its technical capabilities, its potential to surpass humans in pursuing ambitious goals and risk-taking within the next five years is highly unlikely. The human aspects of ambition, intrinsic motivation, and emotional decision-making in risk assessment are beyond AI’s current and foreseeable capabilities.

COU2: Scholars acknowledge that qualities like leading with initiative, accountability, and emotional intelligence are distinctly human traits.[357] AI can nevertheless assist humans by offering insights, error-checking, and data-driven accountability.[358]

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[352] Russell, S. J., & Norvig, P. (2009). *Artificial intelligence: a modern approach.* Prentice Hall.
[353] Garcia, J., & Fernández, F. (2015). A comprehensive survey on safe reinforcement learning. *Journal of Machine Learning Research,* 16, 1437-1480. https://www.jmlr.org/papers/volume16/garcia15a/garcia15a.pdf
[354] Majumdar, A., & Pavone, M. (2020). How should a robot assess risk? Towards an axiomatic theory of risk in robotics. In *Proceedings of the IEEE International Conference on Robotics and Automation* (ICRA). https://arxiv.org/abs/1710.11040
[355] Bostrom, N., & Yudkowsky, E. (2014). *The ethics of artificial intelligence*. Cambridge University Press.
[356] Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 47*(2), 263-291. https://www.jstor.org/stable/1914185
[357] Goleman, D. (1995). *Emotional intelligence.* Bantam Books, Inc.; Yukl, G. (2010). *Leadership in organizations.* Pearson Education.
[358] Brynjolfsson, E., & McAfee, A. (2014). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies.* W W Norton & Co.

Leadership involves qualities like social and emotional intelligence, empathy, and ethical accountability, which are beyond the current, and likely, scope of AI capabilities within the near future. Though AI will likely advance in technical decision-making, surpassing human abilities in many facets of leadership roles, aspects of initiative and accountability (which are rooted in human cognition and, often, ethical reasoning), are unlikely to be completely within the reach of AI in the next five years.

COU3: AI remains limited in its capacities for emotional experience and self-reflection, therefore vulnerability in social interactions is not currently replicable by AI.[359]

While AI may become more adept at recognizing and responding to emotional cues, genuinely replicating the human experience of vulnerability remains a challenge. The advancement in AI's ability to simulate aspects of vulnerable interactions will likely continue, but the depth and authenticity of these interactions as experienced by humans will remain a distinctly human trait for the foreseeable future.

COU4: AI does not have self-awareness or consciousness, and therefore it cannot acknowledge its own strengths and weaknesses in the way a human would understand self-acknowledgement. Nevertheless, AI can assist humans identify patterns in their strengths and weaknesses in certain tasks (e.g. writing, calculation, foreign language proficiency) and can provide objective assessments and feedback on human performance.[360]

AGI aims to create AI with broad, human-level intelligence, but this field is still speculative, especially regarding aspects like self-awareness.[361] AI's potential for advancement in self-awareness within five years remains speculative. Realizing AGI and related self-awareness capabilities are also complex challenges that may not be resolved in this timeframe.

COU5: Researchers posit that believing in one's agency and self-efficacy, requires a concept of 'self' and the depth of consciousness lacking in AI models. AI's current capabilities allow for supporting human self-improvement through prompts, feedback, and goal monitoring but fall short of replicating genuine self-awareness.[362]

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[359] Brown, B. (2012). Daring greatly: How the courage to Be vulnerable transforms the way we live, love, parent, and lead. Penguin.
[360] Jordan, M. I., & Mitchell, T. M. (2015). Machine learning: Trends, perspectives, and prospects. Science, 349(6245), 255-260. https://www.science.org/doi/10.1126/science.aaa8415
[361] Goertzel, B., & Pennachin, C. (Eds.). (2007). *Artificial general intelligence*. Springer.
[362] Damasio, A. (2010). *Self comes to mind: Constructing the conscious brain.* Pantheon/Random House; Fogg, B. J. (2009). A behavior model for persuasive design. In

AI will likely continue to operate based on algorithms that inherently lack personal beliefs, desires, or consciousness.[363] Beliefs, like self-efficacy, are tied to consciousness and self-awareness, characteristics for which AI is not capable of.

Resilience:

Subcompetency	Does AI outperform humans?	Does AI complement humans?	Can AI catch up in the next 5 years?
RES1: Persevering through challenges and seeking help when needed	NO	YES	MIXED
RES2: Building strong social networks	NO	YES	NO
RES3: Establishing and maintaining effective habits	MIXED	YES	MIXED
RES4: Managing stress to maintain performance	NO	YES	NO
RES5: Motivating oneself via meaning or purpose	NO	YES	NO

Resilience in AI could refer to its ability to continue functioning amid failures or adapt to new data. Through advanced machine learning techniques, AIs can learn to quickly adapt to new tasks or situations after initial exposure.[364] Yet, this resilience is due to redundant coding, error checks, or machine

Proceedings of the 4th International Conference on Persuasive Technology. https://dl.acm.org/doi/10.1145/1541948.1541999

[363] Dehaene, S., Lau, H., & Kouider, S. (2017). What is consciousness, and could machines have it? *Science, 358*(6362), 486-492). https://www.science.org/doi/10.1126/science.aan8871

[364] Finn, C., Abbeel, P., & Levine, S. (2017). Model-agnostic meta-learning. In *Proceedings of the 34th International Conference on Machine Learning*, Volume 70 (pp. 1126-1135).

learning adaptability, not an evolved response to external pressures. It is "tire-less."

Future AIs could exhibit resilience, in a machine sense, by further adapting their efficiency at recovering from errors, disruptions, or changes in their environment. AI can be endowed with robustness against adversarial attacks, with research demonstrating how training with adversarial examples can harden neural networks against such attacks.[365] By incorporating these strategies, AIs could augment their capabilities to maintain performance and effectiveness under system stress or after experiencing disruption.

RES1: In terms of persevering through challenges and seeking help, AI can provide resources, guidance, and even emotional support to humans. AI's strengths in performing repetitive tasks, data analysis, and providing information consistently without fatigue, allow humans to persist through challenges requiring judgment, creativity, and emotional intelligence.[366]

AI lacks emotional intelligence, consciousness, and the ability to experience psychological states.[367] AI can be programmed to mimic help-seeking behaviors or to continue functioning in the face of errors, yet this does not equate to human perseverance or the emotional and psychological processes involved in seeking help. AI continues to advance in various fields, however, replicating the human-like emotional and psychological processes required for perseverance and seeking help is not currently a priority goal within the next five years.

RES2: AI can assist in the building of social networks by increasing accessibility, making connections, and fostering relationships,[368] but research expresses concern that the presence of AI within human social networks may reduce how humans perceive the authenticity and utility of these networks (e.g. the flood of bots on Twitter and the gradual disuse of the platform by human users).[369]

Replicating the emotional and empathetic aspects of human behavior necessary for building social networks is a profound challenge, likely beyond the scope of what can be achieved in the next five years. AI does not experience emotions or empathy and lacks self-awareness - all critical

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[365] Madry, A., Makelov, A., Schmidt, L. et al. (2017). Towards deep learning models resistant to adversarial attacks. *ArXiv: Cornell University.* https://arxiv.org/pdf/1706.06083.pdf
[366] Russell, S. J., et al. (2009). *Artificial intelligence: a modern approach.* Prentice Hall.
[367] Russell, S., & Norvig, P. (2016). *Artificial intelligence: A modern approach.* Pearson.
[368] Burke, M., & Kraut, R. E. (2014). Growing closer on Facebook: Changes in tie strength through social network site use. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.* https://dl.acm.org/doi/10.1145/2556288.2557094
[369] Taylor, J. (2023). Bots on X worse than ever according to analysis of 1m tweets during the first Republican primary debate. *The Guardian.*

components for navigating the complexities of human social interactions.[370]

RES3: AI does not form habits as humans understand the practice, but converges towards a specific style of its own due to its 'tire-lessness." Human habits are behaviors developed over time through repetition and that often become automatic. AI, on the other hand, operates based on algorithms and programming determined by humans, and it lacks the cognitive and psychological mechanisms that lead to habit formation in people. Nonetheless, AI has strong potential and capacities to assist individuals in forming and maintaining habits by offering personalized reminders and suggestions based on biometrics and behavioral analytics.[371]

AI does not possess personal motivations, self-discipline, or the ability to adapt behavior based on complex psychological states. Rather they operate based on algorithms and data inputs, not on intrinsic motivation or self-regulation. Because of this, the ability to autonomously establish and maintain effective habits as humans do[372] is likely beyond AI's capabilities (and needs) within the next five years.

RES4: AI, lacking consciousness, emotions, and a biological body, does not experience stress in the way living organisms do. AI systems may degrade in performance under certain conditions (like slowing down, freezing, etc.), but this is not 'stress' in the way humans understand the experience. It is a technical limitation or a need for more computational resources.[373] Yet, it is not necessary for AI to have the experience of human stress, for it to be a useful tool to help humans manage stress. Virtual therapists,[374] wearable AI for monitoring physiological signals,[375] and personalized stress management suggestions are a few examples of how AI can help humans with everyday stress.

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[370] Barrett, L.F. et al. (2019). Emotional expressions reconsidered: Challenges to inferring emotion from human facial movements. Psychological Science in the Public Interest : A Journal of the American Psychological Society, 20(1), 1-68. https://pubmed.ncbi.nlm.nih.gov/31313636/

[371] Swan M. (2013). The quantified self: Fundamental disruption in big data science and biological discovery. Big Data, 1(2):85-99 https://pubmed.ncbi.nlm.nih.gov/27442063/; Thaler, R. H., & Sunstein, C. R. (2008). Nudge: Improving decisions about health, wealth, and happiness. Yale University Press.

[372] Wood, W., & Neal, D. T. (2007). A new look at habits and the habit-goal interface. Psychological Review, 114(4), 843–863. https://doi.org/10.1037/0033-295X.114.4.843

[373] Hinton, G., & Salakhutdinov, R. (2006). Reducing the dimensionality of data with neural networks. *Science, 313*(5786), 504-507. https://www.science.org/doi/10.1126/science.1127647

[374] Inkster, B., Sarda, S., & Subramanian, V. (2018). An empathy-driven, conversational artificial intelligence agent (Wysa) for digital mental well-being: Real-world data evaluation mixed-methods study. *JMIR mHealth and uHealth, 6*(11):e12106. https://mhealth.jmir.org/2018/11/e12106/

[375] Sano, A., & Picard, R. W. (2013). Stress recognition using wearable sensors and mobile phones. In *Proceedings of the IEEE International Conference on Body Sensor Networks.* https://docplayer.net/4789395-Stress-recognition-using-wearable-sensors-and-mobile-phones.html

AI cannot, and is unlikely to, possess (or need to possess) the capacity in the near future, of stress management in the human sense, as it does not experience psychological stress or emotions. AI operates based on algorithms and data, not on emotional or psychological responses. Managing stress involves recognizing and responding to emotional and psychological stressors; a process requiring self-awareness, emotional regulation, and adaptive coping strategies.[376] Nonetheless, AI's capabilities to deal with AI forms of stress will continue to improve, resulting in AI capable of handling systems and operational failures with the best solutions based on their data.[377]

RES5: AI tools can aid individuals in finding purpose and staying motivated by identifying new interests, setting goals, monitoring progress, and supporting habits through features like journaling and reflective exercises.[378]

AI does not possess intrinsic motivation or the ability to find personal meaning or purpose. This is largely due to the fact that it does not experience psychological states or emotions. It is not capable of self-motivation in the human sense, as it does not have personal beliefs or desires. This kind of development would require breakthroughs in AI achieving consciousness and emotional understanding, which are not imminent based on current technological capabilities.

Ethics:

Subcompetency	Does AI outperform humans?	Does AI complement humans?	Can AI catch up in the next 5 years?
ETH1: Identifying and describing ethical concepts, rights, and responsibilities	MIXED	YES	MIXED
ETH2: Making ethical decisions and standing up for the rights of others	NO	YES	NO
ETH3: Understanding	NO	YES	NO

[376] Lazarus, R. S., & Folkman, S. (1984). Stress, appraisal, and coping. Springer.
[377] Jordan, M. I., & Mitchell, T. M. (2015). Machine learning: Trends, perspectives, and prospects. Science, 349(6245), 255–260. https://doi.org/10.1126/science.aaa8415;.
[378] Taylor, D.L. et al. (2021). Personalized and adaptive learning. In Ryoo, J., Winkelmann, K. (eds) *Innovative Learning Environments in STEM Higher Education*. Springer.

and showing compassion for the perspectives of others			
ETH4: Recognizing and implementing one's moral code	MIXED	YES	MIXED
ETH5: Contributing to the broader group or community	NO	YES	MIXED

When expressly designed to make *ethical* decisions, AI does not "feel" empathy or fairness but follows predefined algorithms or learns from datasets, often vast datasets embedding human ethics and practices. There's ongoing research on developing AIs that make morally right decisions in various contexts, like self-driving cars deciding in life-threatening situations.[379] Anderson and Anderson[380] have developed an AI system that can make ethical decisions in the context of health care by simulating the reasoning process of an ethicist.

Research in the field of machine ethics aims to embed ethical principles into AI, such as through the implementation of decision-making frameworks that can navigate moral dilemmas. One approach is the use of reinforcement learning, where AI learns ethical behavior by receiving rewards for actions that are deemed ethically correct.[381] One good example of an ethical approach to AI creation is Anthropic. Anthropic was founded by former senior members of OpenAI in 2021 in order to create Claude, an LLM and chatbot alternative to GPT with a distinctive approach towards AI safety and ethics. The development of Claude was driven by a desire to focus on creating AI models that are safe, trustworthy, and aligned with human values. Anthropic' s methodology, "Constitutional AI," is intended to minimize the risk of the AI producing toxic, biased, or unethical outputs. These principles are derived from various sources, including the United Nations Declaration of Human Rights and the European Union's data privacy rules, and also incorporate a wide range of perspectives, including non-Western ones.

[379] Bonnefon, J. F., Shariff, A., & Rahwan, I. (2016). The social dilemma of autonomous vehicles. Science, 352(6293), 1573-1576.
[380] Anderson, M., & Anderson, S. L. (2007). Machine ethics: Creating an ethical intelligent agent. *AI Magazine, 28*(4), 15-26. https://ojs.aaai.org/aimagazine/index.php/aimagazine/article/view/2065
[381] Abel, D., MacGlashan, J., & Littman, M. L. (2016). Reinforcement learning as a framework for ethical decision making. In Workshops at the Thirtieth AAAI Conference on Artificial Intelligence. https://david-abel.github.io/papers/wkshp_aaai2016_rl_ethics.pdf

ETH1: CCR's research shows that the ability of AI to identify and describe ethical concepts and responsibilities depends upon its algorithms, rather than values that are personal to the AI. Since the focus of AI development has been on capabilities, rather than ethics, humans currently hold an edge when reasoning through complex ethical scenarios.[382] Nevertheless, humans are also more likely to deceive themselves about the alignment between their actions and their ethics.

Many advancements in AI, particularly in natural language processing, will improve the ability of AI systems to simulate discussions about ethics. Still, surpassing human ability in genuine ethical understanding and reasoning within five years is highly speculative. True understanding of ethical concepts requires AIs capable of engaging with abstract, context-dependent concepts, likely to remain beyond technological capabilities in the near future.[383] Nonetheless, identifying and describing these concepts, as already defined within human cultures, is a capability that AI could be programmed to excel at beyond human capacities, if this programming was made a priority.

ETH2: AI can be programmed to reason and act ethically,[384] but there is concern that if AI was allowed to revise its moral code, it might slide down a slippery slope. Despite this, AI is a valuable tool for finding inconsistencies in human moral judgments, identifying biases in human reasoning, and understanding the consequences of decisions.[385]

Standing up for the rights of others requires a sense of justice, empathy, and personal courage, which are human characteristics linked to emotions and social understanding. AI can simulate ethical decision-making based on predefined rules or data patterns, but this is fundamentally different from the human process of ethical reasoning. The ability of AI to understand complex ethical scenarios and stand up for the rights of others in a human sense is beyond its capabilities in the short term.

ETH3: There is consensus that, though AI can mimic compassion, without

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[382] O'Neil, C. (2016). *Weapons of math destruction: How big data increases inequality and threatens democracy*. Crown; Wallach, W., & Allen, C. (2009). *Moral machines: Teaching robots right from wrong.* Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195374049.001.0001

[383] Wallach, W., & Allen, C. (2009). Moral machines: Teaching robots right from wrong. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195374049.001.0001

[384] For instance, Asimov's famous three laws of Robotics: Wikipedia. (2023). Three laws of robotics. https://en.wikipedia.org/wiki/Three_Laws_of_Robotics

[385] Jiang, L. et al. (2021). Can machines learn morality? The Delphi experiment. *ArXiv:* Cornell University. https://arxiv.org/abs/2110.07574; Kahneman, D., Slovic, P., & Tversky, A. (1982). *Judgment under uncertainty: Heuristics and biases.* Cambridge University Press; The physics arXiv Blog. (2021). Ethical AI matches human judgements in 90 per cent of moral dilemmas. *Discover.* https://www.discovermagazine.com/technology/ethical-ai-matches-human-judgements-in-90-per-cent-of-moral-dilemmas

physical qualities such as eye contact and body language, AI is currently unable to provide genuine empathy.[386] However, questions of non-verbal communication and other physical qualities may be mitigated through robotics, which would give physicality to AI. However, robots of this type are not yet prevalent. Research suggests that AI can act as a compassionate guide for humans by suggesting ways to empathize and assisting in finding the right words in sensitive situations.[387]

AI simulations are not equivalent to human compassion or empathy, both of which are based in psychological processes and social cognition.[388] The development of AI with capabilities for compassion and perspective-taking involves challenges that extend beyond current research priorities. While algorithms, particularly natural language processing, may improve AI's ability to recognize and process human emotions and perspectives, surpassing human ability in genuine compassion within five years is highly unlikely.

ETH4: AI does not have a moral code of its own, and therefore can neither recognize or implement a personal code of morality. However, AI can be programmed to imitate and implement human moral reasoning.[389]

Developing and adhering to a moral code involves complex psychological processes, including moral reasoning, empathy, and self-reflection.[390] All of these processes are rooted in human consciousness, cultural contexts, and personal experiences, which are integral to human nature. Given the state of AI and the nature of human moral reasoning, it is highly unlikely that AI will surpass humans in recognizing and implementing a moral code within the next five years.

ETH5: AI has significant potential for contributing to broader groups and communities. Many scholars posit that AI can contribute to communities in nonphysical ways through analyzing community needs, resource optimization, and enhancing access to information and services.[391] Humans can leverage these tools to improve group outcomes.

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[386] Turkle, S. (2011). *Alone together: Why we expect more from technology.* Basic Books.
[387] Miner, A. S., et al. (2020). Chatbots in the fight against the COVID-19 pandemic. *NPJ Digital Medicine, 3*(65), 1-4. Picard, R. W. (2000). *Affective computing.* MIT Press.
[388] Batson, C. D. (2009). These things called empathy: Eight related but distinct phenomena. In J. Decety & W. Ickes (Eds.), The social neuroscience of empathy (pp. 3–15). Boston Review. https://doi.org/10.7551/mitpress/9780262012973.003.0002
[389] Anderson, M., & Anderson, S. L. (2011). Machine ethics: Creating an ethical intelligent agent. *AI Magazine, 28*(4), 15-26.
[390] Kohlberg, L. (1981). The philosophy of moral development: Moral stages and the idea of justice. Harper & Row.
[391] Meijer, A., & Torenvlied, R. (2016). Social media and the new organization of government communications: An empirical analysis of Twitter usage by the Dutch police. *The American Review of Public Administration, 46*(2), 143-161. Tackling climate change with machine learning. *ArXiv*: Cornell University. https://arxiv.org/abs/1906.05433

Contributing to communities or groups involves complex social behaviors, including empathy, understanding social dynamics, and acting with a sense of shared values and goals.[392] These contributions are often driven by a combination of motivation, emotional intelligence, and a sense of belonging. All of these aspects are rooted in human psychology and social interaction and absent from AI's current realm of practice.

Metacognition & Metaemotion:

Subcompetency	Does AI outperform humans?	Does AI complement humans?	Can AI catch up in the next 5 years?
MET1: Adapting flexibly to meet each situation's specific needs	NO	YES	NO
MET2: Reflecting on processes, learning, and identity	NO	YES	NO
MET3: Understanding one's emotions and reactions	NO	YES	NO
MET4: Recognizing and coordinating one's body and its needs	NO	YES	MIXED (Robots)
MET5: Determining goals, plans to achieve those goals, and reviewing one's progress	NO	YES	NO
MET6: Monitoring comprehension and managing information accordingly	MIXED	YES	MIXED

[392] Putnam, R. D. (2000). Bowling alone: The collapse and revival of American community. Touchstone Books/Simon & Schuster. https://doi.org/10.1145/358916.361990

MET7: Evaluating one's actions and their consequences	NO	YES	MIXED
MET8: Considering other points of view	YES	YES	YES
MET9: Recognizing, engaging, and empathizing with the emotions of others	NO	YES	NO
MET10: Cultivating positivity, patience and compassion	NO	YES	MIXED

AI can be designed to monitor their operations and adjust their behaviors (e.g., self-tuning algorithms), but they lack genuine self-awareness. Their "reflection" is devoid of consciousness and is more of a computational adjustment based on programmed metrics.[393] AI can process information in real time, react to immediate inputs, and even use predictive analytics, but it doesn't possess a conscious experience or emotional context.

The potential capacities for meta-learning in AI depend upon their ability to learn how to learn, enabling them to adapt to new tasks efficiently without extensive retraining. This domain involves developing algorithms that can generalize learning from one domain to another. A prominent example is the Model-Agnostic Meta-Learning (MAML) algorithm,[394] which has demonstrated the capacity to rapidly adapt to new tasks with a limited number of examples. Further advances have optimized this process, enabling quicker adaptation and reduced computational expense.[395] The future of meta-learning in AI holds the promise of creating systems that can learn new skills or knowledge in a more human-like manner, significantly reducing the data needed for learning and allowing for quick pivots to unfamiliar tasks, which could revolutionize the flexibility and application range of AI technologies.

MET1: Since AI requires well-defined tasks to excel, humans remain much more adaptable and do far better in complicated, ambiguous, or

[393] Metcalfe, J., & Shimamura, A. P. (Eds.). (1994). *Metacognition: Knowing about knowing.* The MIT Press. https://doi.org/10.7551/mitpress/4561.001.0001
[394] Finn, C., Abbeel, P., & Levine, S. (2017). Model-Agnostic Meta-Learning for Fast Adaptation of Deep Networks. In *Proceedings of the 34th International Conference on Machine Learning* (ICML). https://proceedings.mlr.press/v70/finn17a.html
[395] Raghu, A., Raghu, M., Bengio, S., & Vinyals, O. (2019). Rapid learning or feature reuse? Towards understanding the effectiveness of MAML. *ArXiv:* Cornell University.

unpredictable situations,[396] but AI can assist both in understanding the situation, and by suggesting or questioning approaches.

AIs can adapt within the constraints of their algorithms and learning algorithms, but this is typically limited to specific domains or tasks and AI's ability to adapt to new and complex situations in a flexible, human-like manner is constrained by technological limitations.[397] Additionally, limitations in AI's cognitive and emotional flexibility are likely to remain significant barriers to its capacity to surpass humans within the next five years.

MET2: AI systems can 'reflect' on their performance in a metaphorical sense by learning from data, adjusting to feedback, and optimizing algorithms.[398] AI 'reflection' is a process grounded in data-driven learning and algorithmic optimization, lacking the self-awareness and conscious introspection characteristic of human thought.

Surpassing human abilities in self-reflection, learning in the existential sense, and understanding identity within five years is highly unlikely for AI. AI can be designed to analyze its performance and make adjustments to improve efficiency or accuracy in specific tasks. Nevertheless, this is not equivalent to human-like reflection or introspection.[399] AI is not programmed for self-awareness or understanding its own 'identity', as it operates based on algorithms without personal experiences or emotions. These advancements would require AI achieving consciousness and self-awareness - not within the purview of projected research.

MET3: AI may also help humans understand their emotions and reactions as a digital therapist who both facilitates self-reflection and helps humans find rational explanations for their feelings.[400] While this can support humans in empathizing, it does not permit AI to empathize itself - it mimics empathy (which is profoundly and easily anthropomorphized by humans).

AIs do not possess emotional intelligence in the human sense. They operate based on algorithms and data, and any 'understanding' of emotions

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[396] Marcus, G. (2018). Deep learning: A critical appraisal. *ArXiv*: Cornell University. https://arxiv.org/abs/1801.00631; Sawyer, R. K. (2006). *Explaining creativity: The science of human innovation.* Oxford University Press.
[397] Sutton, R. S., & Barto, A. G. (2018). Reinforcement learning: An introduction. MIT Press
[398] Sutton, R. S., & Barto, A. G. (2018). Reinforcement learning: An introduction (2nd ed.). The MIT Press; Thrun, S., & Pratt, L. (1998). Learning to learn. Kluwer Academic Publishers
[399] Sutton, R. S., & Barto, A. G. (2018). Reinforcement learning: An introduction. MIT Press.
[400] Inkster, B., Sarda, S., & Subramanian, V. (2018). An empathy-driven, conversational artificial intelligence agent (Wysa) for digital mental well-being: Real-world data evaluation mixed-methods study. *JMIR Mhealth Uhealth, 6*(11):e12106. https://mhealth.jmir.org/2018/11/e12106/; Morris R.R., Schueller S.M. & Picard R.W. (2015). Efficacy of a web-based, crowdsourced peer-to-peer cognitive reappraisal platform for depression: randomized controlled trial. *Journal Medical Internet Research, 17*(3):e72.

is purely computational, lacking the subjective experience and depth of human emotional awareness.[401] The ability to understand and reflect on emotions requires self-awareness and consciousness, which are likely beyond AI's capabilities within the next five years.

MET4: AI does not outperform humans when it comes to being mindful of one's physical needs, as AI does not have physical needs, per se. Robots are limited in their access to the right sensors to recognize physical needs, but can have access to a large number and multiplicity of types of sensors.[402] Nonetheless, AI can help humans understand and manage their physical needs, including diets and exercise regimens, by interpreting physiological and personal data to suggest actions for maintaining health and well-being.

Considering the state of AI and the corporality and emotionality of human bodily awareness, it is unlikely that AI will surpass humans in recognizing and coordinating one's body and its needs within the next five years. The lack of a physical body, sensory experiences, and consciousness in AI are barriers to achieving this.[403] Advancements in robotics and sensory technology can enhance AI's ability to interact with and respond to the physical environment. Nonetheless, surpassing the nuances of human ability in self-body recognition in the near future is a major challenge. Such advancement would require a shift in how AI is integrated with physical entities, moving beyond current technological capabilities and conceptual understanding of AI.

MET5: AI does not possess personal goals, rather, these are programmed by humans.[404] However, given all the details and constraints of a problem, AI is decent at creating plans for humans to execute to achieve their goals and monitor progress.

Given the nature of human goal-setting, planning, and self-review processes, it is unlikely that AI will surpass humans in these areas within the next five years. The lack of self-awareness, personal motivation, and consciousness in AI are barriers to achieving such capabilities. AI's ability to review and adjust its course of action is limited to the parameters defined within its algorithms and is not indicative of true self-reflection or critical thinking.

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[401] Picard, R. W. (1997). Affective computing. MIT Press

[402] Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology, 59*, 617-645. Murphy, R. R. (2019). *Introduction to AI robotics.* MIT Press; Siciliano, B., & Khatib, O. (2016). *Springer handbook of robotics.*

[403] Pfeifer, R., & Bongard, J. (2006). How the body shapes the way we think: A new view of intelligence. MIT Press.

[404] Poole, D., & Mackworth, A. (2017). *Artificial intelligence: Foundations of computational agents.* Cambridge University Press.

MET6: Monitoring one's comprehension involves notions of self-awareness and metacognition, which are facets attributed to conscious beings, not AI. Current AI technologies, including advanced machine learning models, do not possess self-awareness or consciousness and therefore do not monitor their comprehension in the self-aware manner humans do. However, AI possesses feedback mechanisms that can be interpreted as monitoring performance or accuracy.[405]

AI, particularly those based on machine learning, successfully optimize information management tasks, and adjust responses based on statistical learning. This adaptive behavior is a result of programmed algorithms and does not reflect understanding or self-regulated adjustment of comprehension. Because of this, AI's ability to manage information based on self-awareness and reflective thinking is not projected within the near future.

MET7: AI's lack of self-awareness limits its ability to evaluate the consequences of its actions.[406] Despite this, AI can support humans in reflecting on cause-and-effect scenarios and analyzing potential consequences. AI performs better at evaluating consequences in well-bound problem spaces, such as chess, but to surpass humans, AI must improve at both understanding context and considering the ethical implications of actions.

AI can be programmed to analyze outcomes, but this analysis does not equate to the human process of self-evaluation and understanding the broader implications of actions. The ability to evaluate actions in the broader context of human values, ethics, and social norms is beyond AI's capabilities and will likely remain so within the near future as this would require AI to develop capabilities akin to human consciousness, moral reasoning, and self-awareness, capacities beyond the scope of predominant schools of AI research.

MET8: Experts concur that AI, particularly LLMs, can portray a broad range of possibilities and viewpoints, generally, more broadly than humans, but there is debate over the depth to which AI considers these perspectives due to AI's inability to genuinely understand.[407]

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[405] Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. MIT Press; Hinton, G. E., & Sejnowski, T. J. (1999). Unsupervised learning: computation In: G. E. Hinton et al. T. J. Sejnowski (Eds.) Unsupervised learning: Foundation computation. MIT Press. vii-xv.
[406] Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist, 34*(10), 906–911. Penrose, R. (1989). *The emperor's new mind: Concerning computers, minds and the laws of physics.* Oxford University Press; Wallach, W., & Allen, C. (2009). *Moral machines: Teaching robots right from wrong.*
[407] Marcus, G., & Davis, E. (2019). *Rebooting AI* Pantheon

Considering other points of view is a facet of empathy and involves the ability to understand and share feelings, thoughts, and attitudes of others. This cognitive and emotional process is central to human social interactions and requires self-awareness, emotional intelligence, and social cognition. Perspective-taking in humans is especially linked to the ability to form social relationships and engage in moral reasoning. Developing AI that can understand and consider multiple human perspectives in a nuanced and empathetic manner remains difficult, and would require that AIs could process and understand emotional and social contexts.

Nonetheless, AI is increasingly capable of interacting between themselves in what is known as machine-to-machine (M2M) interactions. M2M refers to the ability of AI systems to communicate and collaborate with each other without human intervention. This concept is fundamental for the development of complex AI applications and systems, and is covered in Appendix in the section on Agents.

MET9: AI lacks emotions and any perceived understanding or expression of emotions by AI is not genuine. But AI can effectively engage with human emotions by analyzing videos, text, facial expressions or voice intonation and can suggest empathetic responses.[408]

AI does not experience emotions and therefore does not empathize, in the human sense. Its interactions with human emotions are based on programmed responses and algorithms.[409] The development of AI that can empathize with human emotions necessitates advancements in AI's ability to analyze and emotionally relate to human experiences, a feat that will probably exceed its capabilities within the next five years.

MET10: AI is unable to cultivate positivity and compassion due to its inherently impersonal and emotionless nature, but it has infinite patience[410]. This allows AI to be a tireless companion, providing mindfulness nudges and recognizing emotions to cultivate a positive culture. Experts believe if the focus of AI development shifted to creating a world of positivity, patience, and compassion, it would be possible to catch up to human performance, but this is unlikely given other objectives.[411]

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[408] Schuller, B., et al. (2013). *Computational paralinguistics: Emotion, affect and personality in speech and language processing*. Wiley. Vinciarelli, A., Pantic, M., & Bourlard, H. (2009). Social signal processing: Survey of an emerging domain. *Image and Vision Computing, 27*(1), 1743-1759.

[409] Picard, R. W. (1997). *Affective computing*. MIT Press

[410] Witness the little daughter in the TV series HUMANS (first season) who grows very attached to her kind and patient "synth" while her mother is tired after work

[411] Russell, S. J., & Norvig, P. (2009). *Artificial intelligence: a modern approach.* Prentice Hall; Picard, R. W. (2000). *Affective computing.* MIT Press.

Compassion, in particular, involves empathizing with others in times of need and is rooted in human social interactions and moral reasoning. AI will continue to improve in its ability to simulate responses that appear compassionate or positive, but these are based on programmed algorithms and do not represent genuine emotional understanding or empathy. Developing AI with the capability for genuine emotional experiences, akin to human positivity and compassion, would require a paradigm shift in AI research and development; one focusing on emotional intelligence and empathetic understanding in AI.

Vulnerability as an asset for humans

Human vulnerability does not just concern weaknesses. Vulnerability is about the awareness and understanding of limitations and challenges. This awareness influences how humans develop, interact with, and implement AI, ensuring that these technologies are more aligned with human needs and ethical standards. Some of the major benefits of human vulnerability include:

- Empathy and Emotional Intelligence: When people are aware of their emotional weaknesses and struggles, they are more likely to understand and connect with others' emotions. Empathy is crucial in developing AI systems that are sensitive to human emotional needs.
- Creativity: Vulnerability is characterized by uncertainty, risk, and emotional exposure, which are closely linked to creativity, and lead to innovative approaches that guide human action and can lead AI development.
- Ethical Judgment: Understanding and experiencing vulnerability can deepen ethical judgments. This allows humans to consider the impact of AI decisions on the most vulnerable populations, ensuring that these technologies are developed and used responsibly.
- Understanding Context and Nuance: Vulnerability is an emotional state where an individual is open to expressing their thoughts, feelings, and uncertainties. This experience fosters the ability to relate to other complex human contexts, differences, and nuances. This understanding is key when designing AI to incur its responsiveness to the subtleties of human communication.
- Adaptability and Learning from Failure: Failure often leads to feelings of vulnerability. Yet, it is through this vulnerability that individuals can open up to introspection and personal growth. The process of confronting failures helps in acquiring new insights and perspectives. By accepting human fallibility, people become more adaptable and capable of using human failures to improve AI.
- Collaboration: Vulnerability can foster stronger collaborative interactions in many ways: it contributes to trust building between individuals and

teams, it fosters open communication and nurtures a safe space to express ideas, and facilitates empathy in groups. Acknowledging limitations and the need for support can lead to more effective teamwork between humans and AI, where each compensates for the other's weaknesses.

- Emotional and Psychological Support: In contexts like therapy, an understanding of human vulnerability is crucial. This understanding can guide the development of AI that provides emotional and psychological support in a more empathetic and effective manner.

The importance of vulnerability presents yet another case for the importance of elevating the Meta-Learning dimension. Meta-learning allows for awareness (MET2: Reflecting on processes, learning, and identity), engagement with feelings about those vulnerabilities (MET3: Understanding one's emotions and reactions), generalizing this information and applying it to the world (MET8: Considering other points of view + MET9: Recognizing, engaging, and empathizing with the emotions of others), and, finally, with all that information, do something with it (MET5: Determining goals, plans to achieve those goals, and reviewing one's progress) in order to adapt to a new situation (MET1: Adapting flexibly to meet each situation's specific needs).

Competencies: Emphasis, given AI

In *Four-Dimensional Education*, CCR made a detailed case for Competencies. Based on the AI-related analysis above, and a world of rapid changes, one needs to be even more specific about the attributes to *emphasize* further, and their justification, per this Table below:

	Competency	Emphasis	Justification
SKILLS	**Creativity**	**Imagination**	As AI is increasingly capable of incremental creativity, the focus for humans moves on to imagination, especially the emotional and experiential depth that fuel inspiration and originality
	Critical Thinking	**Decision-Making**	Harnessing A, humans need to become more adept at ***reasoned*** decision-making - not abdicating decisions to AI.

	Communication	**Dialogue**	While active listening and convincing argumentation matter, dialogue is more needed than ever in a fractured world.
	Collaboration	**Leadership**	Cooperation/teamwork are essential to collaboration, but the world needs leaders (and followers) so that initiatives do not wither away. Leadership is also key to managing a diversity of AI Agents.
CHARACTER	**Curiosity**	**Open-Mindedness**	Exploration, and a sense of wonder, are intrinsic to human evolution. Open-mindedness is increasingly important due to the polarization of social media, and extreme religiosity, among other influences.
	Courage	**Risk-Taking**	Confidence leads to risk-taking - a hallmark of human differentiation through evolution, and increasingly necessary to push back against close-mindedness.
	Resilience	**Resourcefulness**	In a world of frequent change, the ability to devise unusual solutions with one's means becomes a necessity.
	Ethics	**Fairness**	While integrity is essential and "virtue" ill-defined, fairness[412] is the most easily understood ethical concept, as even animals display these behaviors

[412] Van Damme, D. (2022). *Curriculum redesign for equity and social justice*. CCR

META-LEARNING	**Metacognition** **Metaemotion**	**Adaptability**	Reflection must lead to better self-awareness and empathy, in the service of Adaptability for a rapidly changing world, which implies Learning how to Learn continuously. ***Adaptability is the ultimate differentiator, compared to AI.***

CCR insists on the key role of Adaptability for an AI world. Human adaptability involves the capacity to deal with a number of different sources of data, and modes of reasoning, which AI cannot muster yet. Human decision-making is also deeply intertwined with emotions and social understandings, areas where AI currently lacks proficiency.[413]

How will this Emphasis be used?

Each competency has been cross-referenced with disciplines,[414] to ensure that:

- The discipline is conducive to developing the competency.
- Teachers are not overwhelmed by having to deal with all of the competencies, and can rely on their colleagues from other disciplines to get the full complement. Teachers can focus on the top 3-4 consistently, the others occasionally as the opportunity arises.

The Emphasis of a competency describes the extra attention, or "accentuation," that is given while the competency is taught; for instance:

- For Creativity: If AI can generate a lot of impressive "me too" ideas via extrapolations and analogizing, then the Emphasis should be for students to pay attention to Imagination, which is harder for AI to achieve.
- For Critical thinking: If AI can generate seemingly plausible answers, knowing how to ask questions and evaluate answers matters all the more, with an eye toward decision-making. This is analogous to, and a generalization of, Conrad Wolfram's TED talk[415] exhortation about Mathematics to focus on posing the right problem and understanding its results, while automating the rote computation in between via software. In this case, the LLM is the "language-based computer."

[413] Damasio, A. R. (1994). *Descartes' error: Emotion, reason, and the human brain*.
[414] Dunn et al. (2021). *Embedding competencies within disciplines.* CCR
[415] TED. (2010). Conrad Wolfram: Teaching kids real math with computers. Ted Talks.

Relative Gains vs Losses of AI in Education

There is always, and up to a point, wisely, a fear of the risks of technology supplanting human capacities: an over-reliance on technology that causes human capabilities to atrophy or disappear. Humans are a tool-reliant species that requires tool use to advance and thrive. For millennia, technologies have facilitated, for better and/or worse, human growth, dispersion, and capacities to (re)produce. All the while, these technologies contributed to the loss of many human cognitive and physical capacities.

But the key factor to consider is relative loss versus relative gain. The loss of memory capacity due to scripts, as bemoaned by Socrates,[416] can be considered a major factor, though the relative gain of scripts remains greater than its relative memory loss. Therefore, the relative loss of this human capacity to technological capabilities is less than its relative gain. It is fine for humans to offload tasks when the gain is greater.

On a micro, or individual level: For the individual who leverages AI tools, one can expect a tradeoff of proficiencies. Key for the individual is to have a repertoire of tools well-suited to their lifestyle and needs. It is not *necessary* for an individual to be proficient at all competencies, nor with all AI technologies. If creativity, for example, is not an individual's strength, then it is practical for that person to develop enough fluency with techniques to engage effectively with AI, in order to offload more burdensome or time-consuming tasks.

Due to AI's ability to match baseline and moderately advanced human performance, if the individual can only expect to produce at baseline levels, it makes sense for the individual to delegate to AI to enhance their capability. Furthermore, this delegation potentially frees up the individual to perform tasks in which humans are uniquely equipped to outpace even AI's performance. This might be due to the unique animus of the individual—we want our most imaginative children to continue imagining, so they can harness and deliver the most outside-the-box ideas to help our world. Or this might be due to unique contexts—each hospital would benefit from a strong communicator well-honed to the environment of the town and its constituents. This intense localization will be difficult for an AI to replicate. Even if the AI's communication is strong, one can still expect gains from a human who is stronger *in a specific context*.

On a macro, or societal level: Determining negligible vs major factors in the atrophy of human capabilities depends on historical context and available knowledge. Major technological factors that have led to loss of

[416] *"For this invention will produce forgetfulness in the minds of those who learn to use it, because they will not practice their memory."* From Plato's dialogue Phaedrus 14, 274c-275b

human capacities are technologies like calculators or GPS. Yet some losses of human memory capacities that were considered negligible are increasingly recognized as important, such as botanical medicinal and nutritional knowledge. It is impossible to predict for certain which of our ancient, or recent past, capabilities will serve us in the future, but humans have lost many technologies (e.g. Megalithic monument raising, Egyptian pyramid construction, Roman mortar, Polynesian seafaring, etc.) which only delayed their eventual advancement.

Within the CCR framework of Knowledge, Skills, Character and Meta-Learning, there seems to be a perceptible delineation between elements that are relatively easy for AI to reproduce, improve on,[417] or best (typically, Knowledge and Skills), and therefore pose a greater risk to atrophy in human capabilities, and those that are more difficult for AI to shine at (i.e. Character and Meta-Learning). This is visible in the analysis above that identifies these capabilities for each subcompetency.

One strategy for mitigating this risk in knowledge and skills is to bolster "analog" redundancy for the society, depending on the brittleness of the technology in use. Brittleness can be determined using two factors across both the individual and societal axes: 1. The fragility of the technology, 2. The quantifiability of the technology. Brittle technologies include self-driving cars, nuclear power plants and financial trading algorithms. All of these technologies are frail, as small errors can potentially trigger catastrophic consequences. Supple, or non-brittle technologies, include traditional bicycles, mechanical watches, and solar panels. These kinds of technology are simple, and therefore robust, with few mechanical parts susceptible to failure and those parts easily replaceable during failure.

Analog bolstering includes many strategies humans already use. Mechanical backup controls in systems with digital controls, like aircraft and industrial machinery, allows an analog backup in case of digital failure. Paper records continue to be crucial alongside digital data in sectors like healthcare, finance, and law. Diesel generators, and other stand-alone power sources, are common in large-scale critical infrastructure and in individual homes where power grids may fail. In aviation and maritime sectors, pilots and sailors continue to be trained in traditional navigational methods in order to provide a fail-safe against a breakdown in satellite communications. These are but a few of the methods humans employ to mitigate reliance on critical, widespread technologies.

[417] For instance, "An AI-based system succeeds in planning and carrying out real-world chemistry experiments, showing the potential to help human scientists make more discoveries, faster." (Stoughton, J. 2023. Meet 'Coscientist' , your AI lab partner. U.S. National Science Foundation. https://new.nsf.gov/science-matters/meet-coscientist-your-ai-lab-partner

An additional factor to the fragility of the technology is how quantifiable the risk of loss of the technology is. Human society is already built upon a flimsy tower of increasingly complex technologies (for instance, microprocessors), to which AI is the latest. The breakdown of any of these technologies will have a difficult-to-predict ripple effect. Further complicating the quantifiability of risk is needing to predict the *changed human-wide capability* to respond to disaster, as the capabilities of human society will be different in a world affected by AI. It thus is harder to predict societal response to disaster when the capabilities of society have amorphously shifted—consider societal pandemic response in a world with decreased information literacy due to the proliferation of social media.

With so many capabilities delegable to AI, humanity will benefit from considering new occupations that can benefit from a thoughtful resource reallocation to better bolster societal redundancy. In addition to analog failsafes for its technologies, society likely would benefit from the training of *human* failsafes—an archivist fluent in navigating the historical records for when the AI research assistant is down, for example. A team capable of recreating the semiconductor, for another.

The drawbacks of AI to education and other human pursuits are positioned on an “n-curve” - in other words, the Golden Mean, not too much, not too little. Within the realm of reliance, there is no significant potential risk. It is fine for humans to rely on technology, as they have done for millennia. However, ***overreliance*** on technology is dangerous, particularly in its potential to weaken our critical reasoning capabilities. As with most anything, moderation is key. It is likely that some people will over-rely on technology and suffer the consequences. But it is key that societies and individuals aim for the Golden Mean.

What is the greater gain for education?

The integration of AI into education presents significant gains in terms of personalization, efficiency, and accessibility. These gains enhance student engagement and learning outcomes, provide more efficient and effective learning and make education more widely available, in space, time and for those people who are differently abled.[418] These advantages must be balanced against potential losses like diminished basic academic skills, privacy concerns, and equity issues, meaning that effective integration of AI

[418] Burgstahler, S. (2003). The role of technology in preparing youth with disabilities for postsecondary education and employment. *Journal of Special Education Technology, 18*(4), 7-19); Hwang, G.-J., Spikol, D., & Li, K.-C. (2018). Guest Editorial: Trends and Research Issues of Learning Analytics and
Educational Big Data. *Educational Technology & Society, 21*(2), 134–136; Liu, L., & Hmelo-Silver, C. E. (2009). Intelligent tutoring systems for collaborative learning: Enhancements to authoring tools. *Journal of Educational Technology & Society, 12*(3), 263-275).

in education requires careful planning and consideration of these factors. It remains that the democratizing ability of AI for education is unparallelled.

Ethan Mollick of the Wharton School at UPenn posted about the HBS result cited previously, concerning the impact of AI usage by consultants, remarking notably that "The benefits of AI assistance were not evenly distributed: in the tasks on which AI was the most useful, ***it was significantly more useful to lower-skilled participants."*** *This illustrates the power of AI in education as a good "booster," which is precisely what education is supposed to be.*

A *different* type of intelligence

The question is not "will these intelligences be able to emulate us and just add a little more?" since such machines will be doing things differently. The question is: "what will their actual capabilities be?" - David Wolpert

Although CCR's research has tried to avoid anthropocentric biases, the subcompetencies were all extracted from psychology and learning sciences research, all dealing exclusively with humans. This implies an intrinsic bias, which the authors tried hard to correct for. For instance, this was done by avoiding the use of emotionally charged but vacuous arguments that often appear in descriptions of "what makes us human". Also, one needs to be humble about the various human frailties, be they physiological or mental: judges have been shown in the US to award harsher sentences depending on their breaks, or to minority defendants;[419] doctors have shown lack of empathy towards their patients;[420] parents show lack of patience towards their children;[421] and so forth. AI, with its consistency and tire-lessness, can improve on humans, or at least help humans be more aware of such frailties and improve themselves. It may well be that constantly comparing AI to humans could be detrimental to thinking more open-mindedly and open-heartedly about its capabilities. One must be careful with comparisons, as one would with octopi's intelligence for instance; the focus should be on outcomes and capabilities, not on *ab initio* debates.

AI is a new form of intelligence*:* To recap AI's UN-human capabilities:

- Scalability, Speed, Memory: AI can handle vast quantities of information, make complex calculations, and learn from large datasets in a fraction of the time it would take a human, and never forget.

[419] Danziger, S., Levav, J., & Avnaim-Pesso, L. (2011). Extraneous factors in judicial decisions. Proceedings of the National Academy of Sciences, 108(17), 6889-6892. Mustard, D. B. (2001). Racial, ethnic, and gender disparities in sentencing: Evidence from the U.S. Federal Courts. The Journal of Law and Economics, 44(1), 285-314.
[420] Halpern, J. (2003). What is clinical empathy? Journal of General Internal Medicine, 18(8), 670-674. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1494899/
[421] Deater-Deckard, K. (2004). Parenting stress. Yale University Press.

- Adaptability: AI systems optimize their algorithms to new data.
- Versatility: AI can be an expert in various fields, from healthcare and finance to transportation and entertainment.
- Customizability: AI systems can be designed for specific tasks, making them highly efficient in particular domains.
- Multiplicity: The perception of AI as a single entity is presently derived from its access via chatbots. But in reality, there will be many different AI systems, with multiple types of capabilities, the same way there are dozens of microprocessors in cars, not just a single one.
- Global Connectivity: AI can be integrated into global networks, enabling real-time data sharing and collaboration across *single* systems. This means that their rate of learning will be infinitely faster than humans: imagine that a health care family of robots would learn from any single robot's mistake, or an automated vehicle could benefit from the situational learning of all other such vehicles.
- "Syncognitism" per Azeem Azhar: "AI will emerge as a type of collective intelligence, the interactions between many *[different]* systems behaving intelligently in different ways to create a broad substrate that feels more intelligent as a whole." This will lead to *hyperbolic-scale* learning in some situations (as showcased at the end of the movie "Her",[422] when AI decides to leave humans behind because its networked sophistication has immensely exceeded human comprehension).

Humans can and should remain in control, and use these capabilities wisely to amplify positive outcomes, and mitigate negative ones.

Emergence of different human capabilities

This book considers the distinctions between artificial and human capabilities, as well as the distinctions expected to emerge between pre-AI humans (those who grew up in worlds before AI, but who will work with it in varying quantities), and post-AI humans, who will grow up with AI technology and assume its existence as normal.

The term "iGen"[423] was coined to identify the humans who grew up in the mid-90's and later, who never knew a world that did not have smartphones. This cohort, now referenced by the more ubiquitous "Gen Z," behaves differently than previous generations, as they have adapted to a world fueled by the internet, and have no concept of a world without it.

It is possible that an even greater gap will emerge between members of an "AI Generation" and those who grew up, and were trained in their careers, in

[422] Spike Jonze, 2013. Warner Bros.
[423] Twenge, J.M. (2017). *iGen: Why today's super-connected kids…*Atria Books.

a world without it. For adults who have experienced a world without AI, there is significant skepticism (even fear) toward AI and its capabilities. A general distrust in AI is natural, as the pre-AI generation is exposed to early bugs, weaknesses, and limitations. When it comes to the affective domain, no matter how effective an AI is at mimicking human levels of empathy, the mere awareness that the AI is not human will likely hinder its effectiveness for pre-AI, and possibly post-AI, generations.

Consider a text-based therapy dialogue, in which an individual (to use therapeutic terms, the "client") wants to introspect about a situation and develop a plan of action. An AI agent and a therapist agent can generate the same content to help the client reflect, and both can suggest ideas for plans of action for the client. The communicated messages can be verbatim. Still, a client may react to the content differently based on whether they know that the information came from an AI, a therapist, or if they are unsure of the content's origin.

In the Character and Meta-Learning Dimensions specifically, AI is likely to catch up to humanity in its ability to execute "moves" that are capable, for example, of communicating sound counsel and emotional support. However, the effectiveness of these moves remains measured on human ability to receive and ingest these behaviors. Nonetheless, even when humans are fully receptive to AI it may still feel a lot better (more 'normal,') to receive the affirmations of a human whose abilities to empathize are based in personal experience, rather than algorithms (even though the algorithms are also based in human experiences and knowledge and may be more accurate at times!). On the other hand, human strong penchant for anthropomorphization might win over; so, one may witness the same divergence, based on suggestibility, as happens with social media…

This is another, great transitional period for humanity, and it is the responsibility of those who knew a world without AI to effectively capture and preserve the knowledge that may be lost, while remaining open-minded as to how AI can point out flaws in long-standing human logic. Ethics is an immediate and valid concern during this, and any, transition. Humans have relied for centuries upon human-centric heuristics in ethics and decision-making. The proliferation of AI, and post-AI humans, can be expected to challenge a variety of these heuristics. For example, the proximity of a human to the act of "killing" often produces visceral reactions that affect decision-making—hence the inherent dilemma at the heart of the Trolley Problem,[424] or the affective distinction between a drone attack versus hand-to-hand combat. These gut reactions are found in everyday human life, from financial decisions, to food selection, to political opinions and healthcare

[424] "The trolley problem is a series of thought experiments involving stylized ethical dilemmas of whether to sacrifice one person to save a larger number" Trolley problem. 2024. *Wikipedia*.

choices. These kinds of almost instinctive reactions are typically immediate, powerful emotional responses to a situation or information, and they can bypass more deliberate and rational thought processes. AI, without these sometimes beneficial, but often flawed heuristics, may be capable of more consistent decision-making within a well-defined moral framework or code, helping curb human gut instinct, and contributing to a more ethical society.

Humanity has visceral but unfair reactions when, for example, an AI driverless car kills a single pedestrian, in contrast with the tragic but accepted "mistake" of reckless human driving harming 1.3 *million* people worldwide,[425] *each year.* AI is frequently held to much higher standards than humans, who have already established socially acceptable levels of risk in interacting with each other. That said, AIs have key blind spots, and demand a remarkable amount of processing power to make what humans would consider common sense determinations. A layer of risk remains in any AI-executed decision - a blind spot unique to the issue's context. And even if AI gets 99% of its decisions right, it will inevitably make mistakes on high-stakes decisions, so society will need to accept these factors.

Legal codes are another excellent example of human leniency with outdated moral and ethical codes and the laws that enforce them. Many laws still exist on the books that are so antiquated that it would be downright silly to enforce them. However, AI has the capability to ingest entire legal codes (already a feat beyond any individual human capability) and could potentially enforce ***all*** of these laws indiscriminately.[426] This example again demonstrates a balancing between flexibility vs intransigeance in AI. On the one hand, the inflexibility of AI can seem nightmarish (though if, in this case, it encouraged humans to revise obsolete legal code, that may not be the worst outcome). On the other hand, human flexibility when interpreting laws often leads to corruption, inequality, and cherry-picking by judges. AI could help keep judges on their toes in terms of consistency in legal decisions.

It is this layer of random mistakes, quirks and unforeseen outcomes that hinder the potential value AIs can have as a "neutral" mediator, judge, therapist, or other interactive agent. Like the adoption of Wikipedia as a valid source of information, validity of AI outputs will require the systems to be battle-tested over time, with trust gradually increasing as they pass more impressive, and more human-like, tests. When the validity of their responses increases, and human distrust of these responses wanes and human practice generalizes the use of AI, additional utility will open and new roles for AI agents will become acceptable and normalized.

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[425] Ahmed, S. K. et al. (2023). Road traffic accidental injuries and deaths: A neglected global health issue. *Health Science Reports*, *6*(5). https://doi.org/10.1002/hsr2.1240

[426] Al-Sibai, N. (2023). AI might actually enforce all of our stupid laws, expert warns. *Futurism.*

Chapter Seven
The Need for Personalization

"Education must be increasingly concerned about the fullest development of all children and youth, and it will be the responsibility of the schools to seek learning conditions which will enable each individual to reach the highest level of learning possible".
- Benjamin Bloom

Why has personalization always been important in Education?

Note: Although "differentiation" would be the more adequate word to use, CCR will use the more widespread "personalization", while keeping in mind its negative connotations as to the importance of social and collaborative learning.

Tailoring approaches to teaching and learning to address students' individual needs, preferences, and rhythms is crucial to education for several compelling reasons. Most importantly, students are not homogenous; they come with varied backgrounds, abilities, and learning styles. Traditional "one-size-fits-all" instructional methods are insufficient because they fail to engage all students equally, potentially leading to disengagement or underachievement for some.[427] For example, a student who struggles with reading might feel left behind in a standard classroom but can thrive when given resources that cater to their specific needs. These kinds of persistent issues and how personalized educational practices can mitigate them are well-documented by the work of educational psychologist Benjamin Bloom. Bloom identified an educational phenomenon he dubbed the "Two Sigma Problem" after observing that students who tutored one-on-one using mastery learning techniques performed two standard deviations (or 'sigmas') better than students who learned through conventional group instruction.[428] In other words, a student receiving personalized instruction could outperform 98% of the students in the traditional group setting. This finding presented a challenge that AI can now address uniquely: how can the educational system be restructured to provide the benefits of one-on-one tutoring to a broader range of students without the associated high costs and resource demands?

[427] Tomlinson, C. A. (2001). How to differentiate instruction in mixed-ability classrooms. ASCD.
[428] Bloom, B. S. (1984). The 2-sigma problem: The search for methods of group instruction as effective as one-to-one tutoring. *Educational Researcher*, *13*(6), 4-16. Nintil. (2020). On Bloom's two sigma problem: A systematic review of the effectiveness of mastery learning, tutoring, and direct instruction. *Nintil Blog.*

In addition to the phenomenal performance advantages of personalized educational practices, personalization can also contribute to developing deeper connections to learning. When education resonates with a student's interests and aspirations, it can ignite passion and intrinsic motivation, leading to more profound, lasting understanding and a greater likelihood of long-term success.[429]

Choices at different levels

It is customary to view choice for students as an all-or-nothing proposition, generally at the track level of STEM or Humanities or Arts. But there are plenty of layers that can be exercised, even as some disciplines become mandatory. The table below shows the various layers of possibilities:

Level	Example of Choices
Macro	Track chosen (e.g. STEM, Humanities, Arts) Discipline chosen within tracks (e.g. economics vs psychology)
Meso	Project type (e.g. swimming vs flying robot)
Micro	Grouped pathways (e.g. whole word vs phonetic language acquisition)
Nano	Individualized pathways (with multiple possibilities: “Flat” or Adaptive, without or with AI)

Do students always know best?

In a key critical paper, Kirshner et al debunk three pervasive and tenacious urban legends:[430]

1. “Learners as “digital natives” who form a generation of students knowing by learners often choose what they prefer, but what they prefer is not always what is best for them.
2. Naturally knows how to learn from new media, and for whom “old” media and methods used in teaching/learning no longer work.

[429] Deci, E. L., Vallerand, R. J., Pelletier, L. G., & Ryan, R. M. (1991). Motivation and education: The self-determination perspective. *Educational Psychologist, 26*(3-4), 325–346. https://doi.org/10.1207/s15326985ep2603&4_6

[430] Paul A. Kirschner & Jeroen J.G. van Merrinboer (2013) Do Learners Really Know Best? Urban Legends in Education, Educational Psychologist, 48:3, 169-183, DOI: 10.1080/00461520.2013.804395

3. The widespread belief that learners have specific learning styles and that education should be individualized to the extent that the pedagogy of teaching/learning is matched to the preferred style of the learner.
4. Learners ought to be seen as self-educators who should be given maximum control over what they are learning and their learning trajectory.

It is true for all legends that they are primarily based on beliefs and convictions, not on scientific theories supported by empirical findings."

For the sake of this book, CCR's views echo Kirshner, based on Learning Sciences:

- "Digital natives" are often more familiar with the use of technology, but that does not make them technologists, nor does that mean that using technology is always the best mechanism to learn. And with AI, they risk being "Digital nAIves," if not taught the appropriate digital literacy and computational thinking, and for some, computer science.
- Learning styles have been widely debunked, and for instance, Howard Gardner has been careful to say that he has proposed a scientific theory that should not be mistaken for a prescription for schooling.
- As for students as self-educators, there are several reasons why this aspect has to be built up carefully: per Kirshner et al.,"…learners are not always successful controlling their own learning, especially in computer-based learning environments, and not all learners prefer, nor profit, from controlling the tasks…; …learners often choose what they prefer, but what they prefer is not always what is best for them…; ...People appreciate having the opportunity to make some choices, but the more options that they have to choose from, the more frustrating it is to make the choice…". **This book delves into how to provide the *right amount* of choice, with the *right scaffoldings* for the students.**

Why is AI making personalization even more important?

Youth expectations: When algorithms tailor content recommendations on platforms like Netflix, Spotify, YouTube, Instagram and TikTok, students increasingly expect a similar level of customization in their other experiences, including those in the classroom. The pervasive nature of personalized content in entertainment and online platforms has conditioned students to seek and value individualized experiences. A "one-size-fits-all" education feels outdated and less engaging in comparison. Furthermore, today's students, being digital natives, are used to rapid responses to queries, immediate gratification, and personalized, interactive digital platforms (often to the extent that they become "filter bubbles" of personal interest and intellectual and emotional isolation).[431] Personalization helps

[431] Rouse, M. (2018). Filter bubble. *Technopedia.*

bring educational systems into the 21st century, helping them better align with the habits and attention spans of digital natives, making learning more intuitive and efficient.

Social & Emotional*:* By analyzing vast amounts of data on individual learning patterns, preferences, and emotional responses, AI systems can tailor educational experiences that not only address academic needs but also resonate with students' social and emotional contexts.[432] For example, a personalized learning platform might adjust its content and delivery based on a student's emotional state, ensuring that the material is presented in a way that is most receptive to that student at any given moment.

Competencies: As AI takes over many tasks, there's a rising importance for human-centric competencies like critical thinking. Personalized education can better cater to developing these skills based on each student's strengths and weaknesses. For instance, in the realm of meta-learning, which includes skills like adapting flexibly and reflecting on processes, learning and identity, AI tools can provide students with adaptive feedback, helping them recognize patterns of thought and behavior and encouraging them to refine their metacognitive abilities. In the skills domain, AI can simulate real-world challenges, allowing students to apply their communication or collaboration skills in diverse scenarios. Over time, AI can track their progress, adapt scenarios based on individual performance, and promote mastery in these competencies. By facilitating personalized learning experiences tailored to the specific needs and progress levels of each student, AI elevates the importance of educational personalization tools, ensuring that every learner can attain proficiency in vital competencies.

Motivation: Integrating AI-powered tools into classrooms permits new potential for personalizing learning experiences, thereby enhancing student engagement and motivation. AI-driven platforms can analyze students' interactions, progress, and feedback in real-time to tailor content and resources specifically for them. Adaptive learning platforms, for example, identify areas where a student is struggling and provide customized resources or exercises to address those gaps. Targeted approaches such as these address individual learning needs and encourage engagement by presenting material at the right level of difficulty. This enhances student motivation as students experience more consistent success and receive immediate, personalized feedback, making their learning experiences more relevant and rewarding.

[432] Calvo, R.A., & D'Mello, S.K. (2010). *IEEE Transactions on Affective Computing, 1*, 18-37.

Identity: By recognizing and adapting to individual cultural, socio-economic, or personal backgrounds, AI tools can provide content that is contextually relevant, fostering a deep sense of identity validation and belonging.[433] This level of personalization can enhance a student's emotional connection to the learning material, facilitating deeper engagement, understanding, and self-awareness. In a diverse classroom, such tailored approaches ensure that learning is not just a cognitive exercise but also a process of self-exploration and affirmation.

Agency: Agency is a vital component for deep, intrinsic motivation and effective learning. Traditional education models often place students in passive roles, but AI tools can transform them into active participants by tailoring learning experiences according to their needs, preferences, and pace. For instance, an AI-driven learning platform can offer students choices in how they want to approach a topic, which resources they'd like to explore, or even which assessments they'd like to tackle, based on their past performances and future goals. This personalization empowers students to take charge of their learning, making decisions that suit their needs and interests, increasing their sense of agency. As they interact with AI systems that adapt and respond to their inputs, students begin to recognize the value of their choices and actions in shaping their educational outcomes.

Purpose: As students embark on their educational journeys, they often have specific goals, or ambitions to which they aspire. AI tools can curate resources, tasks, and experiences that directly align with these goals. For instance, a student passionate about environmental conservation could receive AI-recommended readings, virtual field trips, and project ideas tailored to that interest, allowing them to dive deeper into the subject while also relating it to broader educational standards and objectives. Such tailored experiences not only enhance academic growth but also foster a stronger sense of purpose in learners, as they see the direct relationship between their studies and their aspirations. By dynamically aligning educational content with students' evolving purposes, AI facilitates a deeper, more meaningful engagement with learning.[434]

How can AI help solve the challenge of mass Personalization?

[433] Warschauer, M., & Matuchniak, T. (2010). New technology and digital worlds: Analyzing evidence of equity in access, use, and outcomes. *Review of Research in Education*, *34*(1), 179-225. https://doi.org/10.3102/0091732X09349791

[434] Yeager, D. S., & Dweck, C. S. (2012). Mindsets that promote resilience: When students believe that personal characteristics can be developed. *Educational Psychologist, 47*(4), 302–314. https://doi.org/10.1080/00461520.2012.722805

AI is beginning to pave the way for groundbreaking transformations in the field of education, making goals for personalized learning more attainable than ever before. AI-powered educational platforms can analyze vast amounts of data on a student's learning behaviors, preferences, and performance in real time. This enables the system to continuously adapt instructional content to fit each student's unique needs and pace.[435] For example, if an AI-driven learning tool detects that a student struggles with a particular math concept, it can provide additional resources or different instructional approaches tailored to that student, ensuring they grasp the concept before moving on. Conversely, for students who excel, the system can offer more challenging tasks to keep them engaged and promote deeper exploration of subjects. Beyond just adaptive content, AI tools can also forecast areas where a student might face challenges in the future, allowing for preemptive intervention and support.[436]

The following is a non-exhaustive list of examples of currently available AI tools and techniques for student personalization:

- **Data-Driven Insights:** AI can analyze vast amounts of data from students' interactions with learning platforms. This allows educators to understand which teaching methods are most effective, which topics are most challenging, and even predict which students might be at risk of falling behind.
- **Adaptive Learning:** AI can continuously adapt content based on a learner's interactions. If a student struggles with a specific topic, the AI can provide more resources or different types of content (e.g., videos, quizzes, or interactive exercises) to help them understand better**.**[437]
- **Individual Learning Paths:** Everyone learns differently. Some students grasp concepts quickly, while others need more time. AI can identify these patterns and tailor learning experiences to match individual students' paces, ensuring that everyone receives an education tailored to their strengths and weaknesses.
- **Personalized Learning Resources**: AI can curate resources from the internet tailored to a student's current learning level and interests. For example, if a student is passionate about space, an AI could provide math problems framed around space exploration.
- **Learning Style Adaptation**: AI can adjust teaching methods based on whether a student is a visual, auditory, or kinesthetic learner. For

[435] Pane, J. F., Steiner, E. D., et al. (2015). Continued progress: Promised developments of personalized learning. RAND Corporation. https://www.rand.org/pubs/research_reports/RR1365.html

[436] Baker, R. S., & Siemens, G. (2014). Educational data mining and learning analytics. In R. K. Sawyer (Ed.), The Cambridge handbook of the learning sciences (2nd ed., pp. 253-274). Cambridge U. Press.

[437] Koedinger, K. R., Corbett, A. T., & Perfetti, C. (2012). The Knowledge-Learning-Instruction framework. *Learning Research and Development Center* .https://pubmed.ncbi.nlm.nih.gov/22486653/

instance, visual learners might be presented with more diagrams and videos, while auditory learners get podcasts or spoken lectures.[438]

- **Engagement and Motivation:** Personalized learning experiences can be more engaging, as they cater to a student's interests and needs. This can lead to increased motivation and better learning outcomes.
- **Instant Feedback**: Traditional classroom settings don't always allow for instant feedback. AI can provide immediate responses to student inputs, letting them know where they went wrong, providing hints, or suggesting resources to reinforce their understanding.
- **Voice Assistants in Learning**: Virtual AI-driven tutors like Siri, Alexa, or specific educational variants can answer questions, offer explanations, or guide students through complex topics at any time, supplementing traditional teaching.[439]
- **Smart Content Creation**: AI can create customized reading material tailored to a student's current knowledge level, ensuring content is neither too easy nor too challenging. This might mean generating simplified explanations for difficult concepts or offering advanced readings where students excel.[440]
- **Emotion Recognition**: Some advanced systems use facial recognition to gauge a student's emotion. If a student seems frustrated or confused, the platform can adjust the teaching method or provide additional resources.[441]
- **Predictive Analysis**: AI systems can predict which students are at risk of falling behind or failing, allowing teachers and administrators to intervene proactively.[442]
- **Meeting Diverse Needs**: Classrooms are diverse. They consist of students from various cultural, linguistic, and socio-economic backgrounds, and with a range of abilities and disabilities. AI can help tailor education to meet these diverse needs, ensuring inclusivity.
- **Interactive and Immersive Learning**: Through AI-powered virtual reality (VR) environments, students can be placed in a simulated, interactive environment tailored to their learning needs, like historical events or scientific phenomena.[443]

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[438] Lynch, G. (2017). How AI will shape the future of search. *MarTech Today*.

[439] Winkler, R., & Söllner, M. (2018). Unleashing the potential of chatbots in education. *Education and Information Technologies, 23*(6), 2531-2556.

[440] Bull, S., & Kay, J. (2007). Student models that invite the learner in: The SMILI:() Open Learner Modelling Framework. *International Journal of Artificial Intelligence in Education, 17*(2), 89-120.

[441] D'Mello, S., Picard, R., & Graesser, A. (2017). Toward an affect-sensitive AutoTutor. *IEEE Intelligent Systems, 22*(4).

[442] Bowers, A. J. (2017). Quantitative research methods training in education leadership and administration preparation programs as disciplined inquiry for building school improvement capacity. *Journal of Research on Leadership Education, 12*(1), 72-96. https://core.ac.uk/download/pdf/161456866.pdf

[443] Freina, L., & Ott, M. (2015). A literature review on immersive virtual reality in education. *12th International Conference on Remote Engineering and Virtual Instrumentation*. https://www.itd.cnr.it/download/eLSE%202015%20Freina%20Ott%20Paper.pdf

- **Lifelong Learning:** Education is not limited to formal school years. With AI, adults can continue to learn and upskill throughout their lives. AI can recommend courses, resources, and paths based on a person's current skills and future goals.

These kinds of AI-powered tools and techniques, and those to come, give educators an unprecedented opportunity to make personalized learning more attainable. Scalability and speed are key benefits to these tools. While it's challenging for human educators to provide personalized attention to every student in large classes, AI-driven platforms can scale easily, offering personalized learning experiences to vast numbers of students simultaneously. Deploying AI-powered tools and techniques in the classroom will permit the enhancement of educator roles. By automating more repetitive tasks, AI allows educators to focus on more complex aspects of teaching, such as fostering critical thinking, providing mentorship, and addressing socio-emotional needs.

The following sections provide in-depth discussions of how motivation, identity, agency and purpose are understood and deployed in current social and academic contexts and by CCR, as well as how these elements may change or could be further developed in an age of AI. Definitions and pertinent research for each of these concepts will be provided in each section; however, first - the relationship between these four concepts.

The contemporary understanding of human development recognizes the fluid and multiple nature of motivation, identity/belonging, agency/growth mindset, and purpose/passion, suggesting that individuals do not possess a single, static purpose or motivation throughout their lives. On the contrary, humans navigate and thrive within a variety of roles, experiences, and social contexts that can lead to multiple identities and purposes.[444] A person may identify as a parent, an artist, and an activist simultaneously, each aspect offering a different lens through which they see the world. Similarly, one's purpose as a caregiver might differ from their purpose as a professional. Recognizing "identities" and "purposes" in the plural form acknowledges this complexity and avoids oversimplifying the tapestry of human experience. In educational settings, embracing this plurality allows educators to nurture the diverse aspirations, roles, and self-concepts of students, ensuring a more holistic and relevant approach to their development.[445]

Individuals possess motivations, identities, and purposes in the plural; however, in many parts of the following text, the singular form of these nouns may be employed for the sake of simplicity.

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[444] Erikson, E. H. (1968). *Identity: Youth and crisis*. Norton & Company

[445] Yowell, C. M. (2002). Dreams of the future: The pursuit of education and career possible selves among ninth grade Latino youth. *Applied Developmental Science, 6*(2), 62–72.

This complexity demands an increased prioritization of a learner's Motivation(s), Identity(ies) (& Belonging), Agency (& Growth Mindset), and Purpose(s) (& Passion). This additional focus is due to these human attributes becoming more important as a much higher priority in comparison to artificial intelligence becomes more powerful and ubiquitous. This does not mean that artificial intelligence does not have—or will not have—(intrinsic) Identity, (directed) Agency, or (directed) Purpose. CCR expects AI "persona" identities to become ubiquitous (and note that a single model is capable of shifting between a vast number of identities); they will work at tasks near-infinitely, and they are developed with specific purposes. The following chapters will explore how these AI versions of Identity, Agency, Motivation, and Purpose are dissimilar to those of humans, and underscore how the nurturing of the human version of these constructs will lead to more fulfilled lives.

Motivation (extrinsic and intrinsic)

"The best time to plant a tree was 20 years ago. The second-best time is now." -Chinese Proverb

What is motivation? It is why you act

Motivation is commonly understood as the driving force that instigates, directs, and sustains human behavior toward achieving particular goals.[446] Human motivation is an interplay of internal and external factors that can be *broadly categorized into intrinsic motivation*, where actions are driven by internal rewards like personal satisfaction or beliefs and values, *and extrinsic motivation*, influenced by external rewards or outcomes such as money, grades, or recognition.[447] Motivation intertwines these extrinsic and intrinsic elements, *and their variance over time*, as well as emotional, cognitive and other subconscious elements. These elements can reinforce each other or weaken resolve, depending on the situation. Researchers such as Harvard's Chris Dede argue that many situations are motivated by inherent intrinsic motivation, such as keeping a journal or diary or the natural curiosity of children, while others are motivated by extrinsic factors, such as grades in the traditional education system, monetary compensation or the gain of recognition, prestige, titles, or even simply social approval.[448]

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[446] Ryan, R. M., & Deci, E. L. (1999). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology*, *25*(1), 54-67.
[447] Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior.* New York: Plenum.
[448] Dede, C. & Cao, L. (2023). Navigating a world of generative AI: Suggestions for educators. The Next Level Lab, Harvard Graduate School of Education, pp. 5-6.

CCR agrees with GPT4's response (and appreciate its evolutionary linkage, matching our views described in the appendix section on Evolutionary Origins of Competencies):
"Definition in Humans: For humans (and many animals), motivation is a complex interplay of biological drives, emotions, cognitive processes, and environmental stimuli. It's a deeply ingrained system that has evolved over millions of years to help us survive, reproduce, and thrive."

In this sense, all motivators stem from *humanity's original fear - survival.* Biological drives, emotions, cognitive processes, and environmental stimuli interact in complex ways to guide behavior and decision-making, with the ultimate goal of ensuring survival and reproduction. Biological drives, such as hunger, thirst, and the need for shelter, are fundamental motivators that have evolved over millions of years. They push individuals to seek resources and conditions necessary for life, driven by homeostatic mechanisms and hormonal signals.[449] Emotions play a crucial role in motivation, acting as a feedback system that assigns values to different outcomes and stimuli based on past experiences and innate preferences. Positive emotions like joy and love encourage approach behavior, while negative emotions like fear and disgust promote avoidance.[450]

Cognitive processes also contribute to motivation, enabling individuals to plan, anticipate consequences, and make decisions that align with their goals and values. Humans have the capacity to take negative motivators - such as fear, and turn them into positive motivators. This capacity for foresight and deliberation allows humans to override immediate biological and emotional impulses when necessary, in service of more abstract or delayed rewards.[451] Social influences are also particularly powerful, as humans are innately social animals, and the need for social connection and approval can motivate behavior as strongly as basic biological drives.[452] Ultimately, all these motivators can be traced back to the primal fear of survival, driving individuals to seek safety, resources, and reproductive opportunities, ensuring the continuation of their genes and, by extension, the species.

Primary motivators identified

Human behavior is a complex interplay of internal desires and external stimuli. At the heart of our actions lie core motivators—fundamental forces

[449] Berridge, K. C., & Kringelbach, M. L. (2015). Pleasure systems in the brain. Neuron, 86(3),
[450] Panksepp, J. (1998). *Affective neuroscience: The foundations of human and animal emotions.* Oxford University Press.
[451] Miller E.K. & Cohen J.D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience, 24*,167-202.
[452] Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin, 117*(3), 497–529.

that drive us to move, to act, and to change. These motivators range from the most basic biological impulses to the highly abstract pursuits of morality and ethics. Understanding these motivators can illuminate why people behave the way they do and what ultimately moves them toward fulfillment and growth. Below is a brief list of core motivators, categorized according to the kinds of human needs they meet:

Biological and Physiological Needs

- Survival: Basic needs such as food, water, shelter, and sleep.
- Health and Well-being: Seeking medical care, exercise, and a balanced diet.
- Pleasure: Engaging in activities that bring pleasure and avoid pain.

Safety and Security[453]

- Physical Safety: Desire for protection from harm and threat.
- Economic Security: Stability in resources and finances.
- Health and Well-being Security: Safety in health and wellness.

Belongingness Needs[454]

- Relationships: Building and maintaining social connections.
- Community: Being part of a group or community.
- Love and Affection: Seeking and giving love, care, and affection.

Recognition[455]

- Self-Esteem: Building and maintaining a positive self-image and confidence.
- Achievement: Pursuing and accomplishing goals.
- Respect from Others: Gaining recognition and respect from peers.

Intellectual Needs[456]

- Knowledge and Understanding: Seeking to understand the world and acquire knowledge.
- Curiosity and Exploration: A desire to explore and seek new experiences.
- Creativity and Innovation: Engaging in creative and innovative thinking.

Self-Actualization and Personal Growth[457]

- Fulfilling Potential: Striving to achieve personal potential and self-fulfillment.
- Personal Growth: Engaging in activities that lead to personal development.
- Contributing to a Larger Purpose: Participating in activities that contribute to society or a cause.

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[453] Maslow, A. H. (1943). A theory of human motivation. Psychological review, 50(4), 370.

[454] Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin, 117*(3), 497–529. https://doi.org/10.1037/0033-2909.117.3.497

[455] Maslow, A. H. (1943). A theory of human motivation. Psychological review, 50(4), 370.

[456] Maslow, A. H. (1968). *Toward a psychology of being* (2nd ed.). D. Van Nostrand.

[457] Maslow, A. H. (1954). *Motivation and personality.* Harper & Row.

Emotional Needs[458]

- Emotional Expression: Expressing and managing emotions.
- Emotional Support: Seeking and providing emotional support.
- Emotional Connection: Building emotional bonds with others.

Social and Cultural Influences[459]

- Social Norms and Values: Conforming to societal expectations and values.
- Cultural Influences: Influence of cultural background and traditions.
- Social Pressure: Influence from peers and social groups.

Moral and Ethical Values[460]

- Moral and ethical values
- Religious and spiritual beliefs
- Personal life values
- Prosocial values

From the biological imperatives to sophisticated urges that push us toward self-actualization and moral fulfillment, each motivator plays a distinct role in the human (inter)action. These motivators not only guide individual actions but also shape societal trends and norms. They influence our relationships, our work, our creativity, and our openness within the broader cultural and social framework. Understanding motivators and their connection to human needs provides valuable insights into the human condition and improves our ability to empathize with others.

CCR's Synthesis of Motivation Theories (See Motivation Theories in Appendix)

CCR Term	CCR Definition	Associated Terms and Constructs
Motivation	Why you take action	Drive; incentive; self-determination; inspiration

By combining principles from three prominent theories of motivation with CCR's Framework of Competencies, one can synthesize a holistic and comprehensive synthesis of motivation theories.

In the foundational stage, Maslow's basic needs are aligned with CCR's framework, ensuring that learners have their physiological and safety needs

[458] Bradburn, N. M. (1969). *The structure of psychological well-being.* Aldine.
[459] Bandura, A. (1977). *Social learning theory.* Prentice Hall.
[460] Kohlberg, L. (1981). *Essays on moral development, Vol. I: The philosophy of moral development.* Harper & Row; Pargament, K. I. (1997). *The psychology of religion and coping: Theory, research, practice.* Guilford Press; Schwartz, S. H. (1992). Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries. In M. P. Zanna (Ed.), *Advances in experimental social psychology,* Vol. 25, pp. 1–65). Academic Press.

met, which is crucial for any form of motivation to take place. During this time, CCR's focus on developing resilience supports learners in navigating challenges, contributing to their sense of safety. Vroom's Expectancy component is also critical, as learners' beliefs in their abilities (self-efficacy) are cultivated, enhancing their competence—a key component in SDT. This is fostered by CCR's focus on developing critical thinking and problem-solving skills.

In the intermediate stage, Maslow's social needs and esteem are integrated with CCR's focus on collaboration and communication, fostering a sense of belonging and recognition. Vroom's Instrumentality can also play a role, linking effort to performance, and performance to rewards, while SDT's need for relatedness is met through positive interactions and a supportive learning environment. The development of character qualities such as leadership and curiosity (CCR) further contribute to learners' self-esteem and intrinsic motivation (SDT).

In the advanced stage, individuals strive for self-actualization (Maslow) and intrinsic motivation (SDT), guided by CCR's focus on meta-learning capabilities such as metacognition and a growth mindset. Learners are encouraged to take charge of their learning (autonomy, SDT), understand the value and relevance of their work (valence, Vroom), and strive for mastery and excellence in their pursuits (competence, SDT). The integration of character qualities such as resilience and courage (CCR) ensures that learners are equipped to face challenges and pursue their passions relentlessly over their lifetime.

Why is motivation crucial in an age of AI? Because human motivations shape AI.

Human motivation is pivotal in shaping the development and deployment of AIs, directing their applications based on human passions, objectives, and ethical considerations. As AI continues to evolve, maintaining a synergy between human motivations—imbued with emotions, ethics, and cultural nuances—and AI's capabilities is crucial to harness AI's potential responsibly and ensure its alignment with beneficial purposes, such as addressing global challenges and enhancing societal well-being. Automation can also lead to effects like laziness and overconfidence,[461] especially as human brains are "lazy" by good evolutionary design.[462] Therefore, human motivation is key to mitigating laxity and disinterest.

[461] Gent, E. (2023). Could having robot coworkers make us lazier? Yep, pretty much, study says. *Singularity Hub.* https://singularityhub.com/2023/10/22/could-having-robot-coworkers-make-us-lazier-yup-pretty-much-study-says/

[462] see online Appendix: "The Evolutionary Origins of Competencies"

The changing environment of the 21st century, with digital technologies and AI as prominent features, among other trends, needs to be answered by strengthening ***intrinsic motivation***. Current education systems have been designed to a great extent in such ways that they rely on various forms of extrinsic motivation, such as compulsory schooling, various legal measures, the disciplinary system of schools, the authority of the teacher, assessment and examination systems, the way that schooling, credentials, and jobs are linked, and so forth. These forms of extrinsic motivation have been powerful in expanding education systems after WWII and still are powerful. But the important question will increasingly become: what will happen to them when digitalization and AI become ubiquitous? If these extrinsic motivators start to fail, will formal education systems still exist as they do today? These are good questions for an AGI future, but for the time being, and per chapter two, jobs are not disappearing any time soon, so the extrinsic motivators for schooling remain.

AI will also impact intrinsic motivation, but that is a different question, that this text addresses separately. It remains that it is unwise to assume that intrinsic motivation will easily compensate for the decline of extrinsic motivators. The potential risk is that, as extrinsic motivators decay, intrinsic motivation will be insufficient to compensate.

In the long run, ideally, intrinsic motivation and autonomous learning activities will flourish in an AI world. Yet, it remains unclear in which institutional environments that will happen.

Can AI possess (internal) motivation? No, but it can have programmed goals.

According to GPT4 itself:
“The concept of "motivation" in AI is not the same as it is in humans or other biological beings. Let's unpack this a bit:

- *Definition in Humans: For humans (and many animals), motivation is a complex interplay of biological drives, emotions, cognitive processes, and environmental stimuli. It's a deeply ingrained system that has evolved over millions of years to help us survive, reproduce, and thrive.*
- *AI's "Motivation": When we say an AI has a "motivation," what we're really referring to is its programmed objective or goal. This could be as simple as a sorting algorithm trying to order numbers or as complex as a machine learning model trying to minimize prediction errors. The AI doesn't "want" to achieve these objectives in the same way humans "want" to achieve their goals; it simply processes information in a manner that aligns with its programmed objectives.*
- *No Emotions or Drives: AI doesn't have feelings, consciousness, or biological drives. It doesn't experience hunger, fatigue, joy, or*

frustration. Without these emotional and physiological states, AI lacks the intrinsic qualities that fuel human motivation.

- *Dangers of Anthropomorphizing: It's easy and sometimes intuitive for humans to ascribe human-like qualities to machines, especially as AI systems become more advanced and their outputs appear more "intelligent" or "creative." However, it's important to remember that no matter how sophisticated an AI becomes, its "actions" are always the result of algorithms and data, not genuine internal desires or feelings.*
- *Ethical Considerations: Misunderstanding or misrepresenting AI's capabilities can lead to ethical dilemmas. If we mistakenly believe that AI has desires, feelings, or motivations, we might make inappropriate or harmful decisions about its use, development, or regulation.*

In summary, while AI systems can have objectives and can "pursue" those objectives in a manner defined by their algorithms, they do not possess motivation in the way that living organisms do. ***They don't "want" or "desire" anything; they simply execute code."***

The authors could not have said so any better themselves :-)

Conclusion: Motivation towards Identity and Belonging

Motivation, identity, and a sense of belonging are intricately connected. Identity is a dynamic and evolving construct, shaped by an interplay of internal self-reflection and external social and environmental factors, tied to questions like "Who am I?" and "Where do I belong?" Identity serves as a foundational aspect of an individual's understanding of their place in the world.

Identity can therefore serve as a powerful motivational force, driving behavior and aspirations. As suggested by SDT, discussed above, behaviors aligned with one's authentic self or identity are more intrinsically motivated and are, therefore, more sustainable and fulfilling. This intrinsic motivation, derived from identity congruence, can lead to more significant commitment, effort, and resilience in the face of challenges. Motivation in various forms is key to identity formation, which will be further explored in the following section.

Identity (& Belonging)

"Know thyself," Oracle of Delphi

What is Identity? Who you are in the world, and in your relationships

Identity refers to an individual's understanding and internalization of their role, characteristics, values, and beliefs in the context of the broader social world. It encompasses how individuals see themselves and how they

believe others perceive them. Identity formation is a multifaceted process influenced by personal experiences, cultural and social contexts, and interactions with significant others. It evolves over time, often undergoing major shifts during transitional life phases, such as adolescence and midlife.

For instance, a young adult might grapple with questions like, "Who am I?" or "What do I stand for?" during college when exposed to diverse perspectives and experiences. These introspections, influenced by academic pursuits, peer interactions, and perhaps even international travels, can lead to a refined sense of self, strengthening their identity around specific values, career aspirations, or social affiliations. This process of identity exploration and consolidation continues throughout life, as individuals navigate various roles and challenges.

It is not only possible but quite common for individuals to possess multiple identities, a concept rooted in the theory of social identity.[463] These identities can be based on various factors such as ethnicity, profession, gender, religion, or social roles. For instance, a woman might identify herself as a mother, a scholar, an atheist, and an Asian American, each of these identities carrying its own set of norms, values, and expectations. Some of these identities might overlap, meaning they coexist seamlessly. For instance, her practices as a scholar might influence her values and decisions in her maternal role.

There can also be situations where alternating identities come into play, especially in contexts where it might not be possible or appropriate to manifest multiple identities simultaneously. This phenomenon is often observed in "code-switching," where bilingual individuals switch languages based on the conversational context. Similarly, someone might emphasize their professional identity in a work setting but prioritize their parental identity at home. While these identities are all integral components of the individual's self-concept, the prominence of each can shift based on context, environment, and interpersonal interactions.

Identity is often associated with personality, nonetheless, these elements serve different aspects of an individual's self-concept. Personality generally refers to enduring patterns of thinking, feeling, and behaving that distinguish one person from another, encompassing traits like extroversion, conscientiousness, or neuroticism.[464] Identity, as discussed above, concerns an individual's understanding of themselves in the world, encompassing aspects like roles, affiliations, and personal narratives. For

[463] Tajfel, H., & Turner, J. C. (2004). The Social Identity Theory of Intergroup Behavior. In J. T. Jost & J. Sidanius (Eds.), *Political psychology: Key readings* (pp. 276–293). Psychology Press.
[464] McCrae, R. R., & Costa, P. T., Jr. (1999). A Five-Factor theory of personality. In L. A. Pervin & O. P. John (Eds.), Handbook of personality: Theory and research (pp. 139–153). Guilford

instance, while being introverted might be a facet of one's personality, identifying as a "writer," "mother," or "activist" signifies parts of one's identity.[465] While personality traits can influence the roles and affiliations one gravitates towards, identity is shaped by personal choices, societal expectations, and life experiences.

While “passive” constraints such as initial conditions may have a significant role in shaping identity, CCR believes the role of education is to empower learners to proceed from those starting points, and thus takes the “active view” of the development of identity.

Research indicates that there are two schools of thought when it comes to the development of identity: either it is discovered, or it is created. While the two options may seem similar, they produce very different images of identity.

The former describes an individual waiting for their “true self,” to be found. This language depicts a passive individual depending on an external event to provide their identity. It also emphasizes a predetermined nature of self as the idea of a true self does not allow for the evolution of Identity without placing a value judgment on one Identity being *superior* to the other, instead of just *different*.[466]

Conversely, the idea that Identity is *created* imagines an individual taking an active role in the construction of their identity. This depiction provides an individual with more agency in the development of their identity as it emphasizes their role and control in the process. This language also allows for the potential to craft multifaceted identities for a variety of situations and evolve each identity across a lifetime.[467]

CCR operates with the assumption that, while identity can be both discovered and created, the latter will be more impactful from the perspective of an instructor and an individual looking to cultivate identity. The philosophical choice to favor the agency of individuals and the efficacy of the education system will help learners acquire the tools needed along the way.

[465] Erikson, E. H. (1968). *Identity: Youth and crisis*. Norton & Company.
[466] Waterman, A. S. (1984). Identity Formation: Discovery or Creation? The Journal of Early Adolescence, 4(4), 329-341.
[467] *ibid*

What is Belonging? An innate desire to be part of something larger than oneself

Belonging refers to an individual's sense of acceptance, inclusion, and within a group or community[468] and is a fundamental human need and a vital component for mental and emotional well-being. When individuals feel they belong, they perceive themselves as an integral part of a larger system, experiencing validation, support, and understanding from others.

Because of the importance of belonging, "belonging indexes" and surveys have been developed to evaluate the sense of belonging or inclusion experienced by individuals within a particular environment (e.g. workplace, community, educational institution). These indexes assess various factors (depending on their application) including:

- **Inclusivity**: How inclusive the environment is perceived to be.
- **Diversity**: The extent to which diversity is represented and valued.
- **Fair Treatment**: Whether individuals feel they are treated fairly and with respect.
- **Support and Community**: The level of support and community connection individuals experience.
- **Representation**: How well individuals feel their identity and perspectives are represented within the group.

Current examples of these are the Belonging Initiative's Belonging Survey (in English and Spanish) that aims to assess individuals' sense of belonging within their communities and the Mwah Belonging Index, a similar tool, evaluates levels of belonging within the workplace.[469] Similarly, the Valuegraphics Project has developed a Belonging Index with specific applications for education, training, and library occupations in the USA.[470] According to this index, topic indicators for belonging are:
"I feel like I belong"

- when I'm a member of a group that is important to me.
- when I have varied relationships with the people I'm around.
- I feel like I belong when I am contributing to something larger than myself."

The concept of belonging is closely intertwined with identity.[471] Identity, as an understanding of oneself in the world, is significantly influenced by the groups or communities to which one feels a sense of belonging. Inversely,

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[468] Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin, 117*(3), 497–529.
[469] Belonging Initiative. (2023) Belonging survey. https://www.surveymonkey.com/r/SVD78JN; Mwah. (2023) The belonging index. https://mwah.live/resources/belonging-index
[470] The Valuegraphics Research Project, Inc. (2022). Valuegraphics Research Company
[471] Tajfel, H., & Turner, J. C. (2004). The Social Identity Theory of Intergroup Behavior. In J. T. Jost & J. Sidanius (Eds.), *Political psychology: Key readings* (pp. 276–293). Psychology Press.

when one's identity is rejected or marginalized by a dominant group, it can result in feelings of isolation and a diminished sense of belonging, highlighting the intricate relationship between these two constructs.

Primary facets of identity and belonging

The formation of individual identity and the need for belonging that accompanies it, is a complex process influenced by a multitude of factors. These facets can be broadly categorized into psychological, social, and cultural components. For this reason, identity and belonging are extensively studied in psychology, sociology, and anthropology. This is a vast topic that cannot be completely unpacked within this text, however, major facets identified in the literature include:

- Biology:[472] Genetics play a role in determining physical characteristics as well as aspects of personality and behavior, an integral foundation of personal identity.
- Family:[473] Central to research in developmental psychology, family environment and parenting styles play a major role in the development of self-concept and identity. Family traditions, values, and dynamics are often among the first and most profound influences on identity formation.
- Society and Culture:[474] Sociocultural norms, traditions, and expectations shape identity by providing frameworks within which individuals understand themselves and are perceived by others (e.g. religion, ethnicity, national identity).
- Experience: Life experiences, such as education, relationships, and important life events - both positive and negative - contribute to shaping self-perception and identity.
- Social Interactions: Interactions with peers, friends, and broader social groups play a crucial role in identity formation, especially during adolescence.[475] This includes the influence of social roles and group membership.

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[472] Plomin, R., DeFries, J. C., Knopik, V. S., & Neiderhiser, J. M. (2016). Top 10 replicated findings from behavioral genetics. *Perspectives on Psychological Science, 11*(1), 3-23.; Polderman, T. J. C., Benyamin, B., et al. (2015). Meta-analysis of the heritability of human traits based on fifty years of twin studies. *Nature Genetics, 47*(7), 702-709.

[473] Bowlby, J. (1988). *A secure base: Parent-child attachment and healthy human development*. Basic Books; Cox, M. J., & Paley, B. (1997). Families as systems. *Annual Review of Psychology, 48,* 243–267. https://doi.org/10.1146/annurev.psych.48.1.243

[474] Giddens, A. (1991). *Modernity and self-identity: Self and society in the late modern age.* Stanford University Press. Markus, H. R., & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. *Psychological Review, 98*(2), 224–253. Tajfel, H., & Turner, J. C. (1979). An integrative theory of intergroup conflict. *The social psychology of intergroup relations* (pp. 33-47). Brooks/Cole.

[475] Brown, B. B., & Larson, J. (2009). Peer relationships in adolescence. In R. M. Lerner & L. Steinberg (Eds.), *Handbook of adolescent psychology: Contextual influences on adolescent*

- Personal Values:[476] An individual's values and belief system, which may evolve over time, are central to their identity. This includes moral, ethical, and political beliefs.
- Personal Interests:[477] Hobbies, talents, and interests are significant in shaping identity and often careers (another driver of identity). These pleasurable activities influence how individuals spend their time and often how they relate to others.
- Education and Socioeconomic Status:[478] An individual's economic background, social class and subsequent education are widely recognized in academic research as major factors that influence identity formation, as these factors influence individual opportunities, experiences, and the way people are perceived by others.
- Gender and Sexuality:[479] Gender identity and sexual orientation are fundamental aspects of an individual's overall identity and sense of belonging, influencing personal, professional, and social experiences.
- Relationships:[480] An innately social animal, humans have a fundamental need to form and maintain diverse, yet consistent, interpersonal relationships, which is why belonging is a key component of identity.

CCR's Synthesis of Identity Theories (See Identity Theories in Appendix)

development (pp. 74–103). John Wiley & Sons, Inc.. Steinberg, L., & Morris, A. S. (2001). Adolescent development. *Annual Review of Psychology, 52,* 83–110.

[476] Hitlin, S. (2003). Values as the core of personal identity: Drawing links between two theories of self. *Social Psychology Quarterly, 66*(2), 118–137. https://doi.org/10.2307/1519843

[477] Gagné, F. (2004). Transforming gifts into talents: The DMGT as a developmental theory. *High Ability Studies, 15*(2), 119–147. Holland, J. L. (1997). *Making vocational choices: A theory of vocational personalities and work environments* (3rd ed.). Psychological Assessment Resources; Iwasaki, Y. (2007). Leisure and quality of life in an international and multicultural context: What are major pathways linking leisure to quality of life? *Social Indicators Research, 82*(2), 233–264.

[478] Arnett, J. J. (2000). Emerging adulthood: A theory of development from the late teens through the twenties. *American Psychologist, 55*(5), 469–480. Lareau, A. (2003). *Unequal childhoods: Class, race, and family life*. University of California Press; McLoyd, V. C. (1998). Socioeconomic disadvantage and child development. *American Psychologist, 53*(2), 185–204.

[479] Egan, S. K., & Perry, D. G. (2001). Gender identity: A multidimensional analysis with implications for psychosocial adjustment. *Developmental Psychology, 37*(4), 451–463. Fausto-Sterling, A. (2019) Gender/Sex, sexual orientation, and identity are in the body: How did they get there? *The Journal of Sex Research, 56*:4-5, 529-555,

[480] Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin, 117*(3), 497–529. https://doi.org/10.1037/0033-2909.117.3.497; Rubin, K. H., Bukowski, W. M., & Parker, J. G. (2006). Peer Interactions, Relationships, and Groups. In N. Eisenberg, W. Damon, & R. M. Lerner (Eds.), *Handbook of child psychology: Social, emotional, and personality development* (pp. 571–645). John Wiley & Sons, Inc.

CCR Term	CCR Definition	Associated Terms and Constructs
Identity	Who you are in the world and in your relationships	Belonging; self-concept; personhood

Because identities are forged by experiences, societal contexts, stories people tell about themselves, and the intersection of various group memberships, they are fluid and change as one interacts with the world, faces challenges, and matures. CCR's synthesis of Identity theories draws upon the rich heritage of Erikson's psychosocial development, the introspective depths of narrative identity, the communal mapping of social identity theory, and the intricate patterning of intersectionality to understand this complex construct.

Why is Identity crucial in an age of AI? Because humans should not be boxed in by their own algorithms!

Identity is increasingly important due to the need for authentic human connection and understanding in a rapidly digitizing world. AI systems, which draw from large datasets, can inadvertently perpetuate stereotypes and biases embedded in the data, potentially leading to a homogenized or skewed representation of identities. For example, facial recognition technologies have faced criticism for misidentifying individuals from certain racial or ethnic groups, underscoring the challenges of ensuring AI comprehends and respects diverse identities. As AI plays a more prominent role in curating digital experiences—like content suggestions in social media—it becomes even more key, and a more active practice, for individuals to understand and assert their identities, ensuring they are not boxed in by algorithms. Emphasizing human identity in the AI era reinforces the value of individual perspectives, combats potential biases in AI systems, and stresses the importance of ethically implementing technology in ways that reinforce the nature of human identity.

Can AI possess (extrinsic) Identity? It already does.

Current and future forms of AI do and will possess Identity. These identities are fundamentally informed by three different aspects. First, the datasets on which they are trained,[481] include biases that reflect their corpora. Word "embeddings" (the multi-dimensional spaces of their relationships with each

[481] Urman, A. & Makhortykh, M. (n.d.). The silence of LLMs: Cross-lingual analysis of political bias and false information prevalence in ChatGPT, Google Bard and Bing Chat. https://www.google.com/url?q=https://link.springer.com/article/10.1007/s11127-023-01097-2&sa=D&source=docs&ust=1698958969128194&usg=AOvVaw1WveegE7xTYufvoZlB_U-3

other) often absorb societal biases in training data[482] and stereotypical or biased user prompts are almost certain to generate biased responses, even responses that amplify these biased viewpoints.[483] Second, the behavioral expressions for which they are programmed, i.e. algorithms that allow AIs to be more “friendly” or more “professional” in their tone and responses; third, traits associated with identity and personality will also be displayed through user interfaces. For example, META is currently encouraging users to create their own chatbots, which will induce the creation of a plethora of individual agents modeled on users’ desires.

Identity and personality are intertwined concepts that serve different functions. Identity being an individual's understanding and presentation of themselves in terms of values, beliefs, roles, and affiliations, often evolving in response to life events and social contexts.[484] Personality pertains to consistent patterns of thought, emotion, and behavior that characterize an individual across various situations and over time.[485] While identity speaks to "who I am" in a socio-cultural and self-reflective context, personality delineates "how I typically think, feel, and act." And while the development of AI progresses ever more rapidly, it will continue demonstrating increased capabilities to simulate certain aspects of human behavior such as identity and personality.

According to GPT4:
“The question of whether AI can possess identity is a complex and multidimensional one, blending technical, philosophical, and sociological perspectives. As of now, AI doesn't possess identity in the way humans understand and experience it. Here's a brief exploration of the topic:

From a technical standpoint, AI models, including the most advanced like GPT-4, operate based on data and algorithms. They don't have consciousness, emotions, self-awareness, or subjective experiences, all of which are key components of human identity. These models can generate responses based on their training, but they don't "know" themselves or have personal experiences (Searle, 1980).

However, from a philosophical and sociological viewpoint, things can be more nuanced. Philosophers have debated the nature of identity and

[482] Caliskan, A., Bryson, J. J., & Narayanan, A. (2016). Semantics derived automatically from language corpora contain human-like biases. *ArXiv*: Cornell University https://doi.org/10.1126/science.aal4230
[483] Bolukbasi, T., et al. (2016). Man is to computer programmer as woman is to homemaker? Debiasing word embeddings. *ArXi:* Cornell University. https://arxiv.org/abs/1607.06520
[484] Erikson, E. H. (1968). Identity: Youth and crisis. Norton & Company.
[485] McCrae, R. R., & Costa, P. T. (1987). Validation of the five-factor model of personality across instruments and observers. Journal of Personality and Social Psychology, 52(1), 81–90. https://doi.org/10.1037/0022-3514.52.1.81

consciousness for centuries. If an AI exhibits behavior indistinguishable from a conscious being, some argue it might be considered as having a form of identity, even if it's different from human identity (Dennett, 1991). Additionally, society can ascribe identities to AI. For instance, people might name their AI assistants or refer to them with pronouns, anthropomorphizing them and ascribing a form of identity, even if it's externally constructed and not inherently possessed by the AI.

That said, advancements in AI and our understanding of consciousness might reshape these views in the future. The boundary of what we consider identity may shift based on new discoveries or societal norms."

Conclusion: Identity towards Agency

Previous generations saw adolescents transition neatly from higher education to careers, to parenthood.[486] In each of these phases, identity and, to some extent, purpose, were firmly defined for individuals. Current research indicates that there has been a shift in the timing of a young person's entrance into adulthood.[487] Now, this pathway, this timing, and these roles are much more unstable and porous. As the University of Chicago's Consortium on School Research notes, "this delay into adulthood has led to greater role ambiguity and a greater focus on individuality in identity development."[488] COVID-19 further exacerbated this ambiguity, and, if the pattern holds, each generation will continue to tear down and rebuild what a meaningful life means to them as the path from adolescence to adulthood becomes increasingly more complex. Without a strong sense of identity or purpose, today's youth run the risk of feeling increasingly helpless in a volatile and unpredictable future.

It is important to note that constructs such as identity, agency and purpose are strongly tied to both an individual and to the society, culture, and surroundings in which the individual is embedded. This book addresses the subcompetencies that best enable learners to build, sustain, and express identity, agency, and purpose. It will become clear that these subcompetencies are critical for the development and stability of these constructs. The (sub)competencies likewise support and uplift various ideals of learning: from community-building, to empathy, and equity.[489]

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[486] Albeit, only for white, upper-middle class Americans.
[487] Nagaoka, J., Farrington, C. A., Ehrlich, S. B., Johnson, D. W., Dickson, S., Heath, R., & Mayo, A. (2014). A Framework for Developing Young Adult Success in the 21st Century. *University of Chicago Consortium on Chicago School Research*.
[488] Nagaoka, J., Farrington, C. A., Ehrlich, S. B., Johnson, D. W., Dickson, S., Heath, R., & Mayo, A. (2014). A Framework for Developing Young Adult Success in the 21st Century. *University of Chicago Consortium on Chicago School Research*.
[489] https://curriculumredesign.org/our-work/equity-and-social-justice-in-the-ccr-framework/

Identity, Agency, and Purpose are compelling examples of how subcompetencies can be pieced together depending on the desired goal. The subcompetencies noted here are not the *only* pieces of the 4D Framework relevant to the concept at hand. On the contrary, the 4D Framework provides a powerful inroad to these seemingly abstract and multifaceted constructs. By framing identity and purpose through the lens of specific practicable capabilities, subcompetencies can create a lever to uplift and access their development within and beyond education. As human-AI interactions become more and more frequent, the links between human identity and agency become increasingly prominent and important. Identity influences individual agency. Self-efficacy, in particular, is a facet of identity that empowers individuals to exert control over their actions and environments.[490]

As AI agents perform tasks previously accomplished by humans, there is a potential for AI to influence or reshape human identity. Examples of reliance on digital technology, such as delegating decision-making to AI, can alter individuals' sense of identity and agency.[491] Human interaction with AI thus not only reflects but potentially influences human identity and perceptions of personal agency.

A balanced relationship between identity and agency is key for humans in a world with AI agents. It is necessary to consider the potential influence of AI on human self-perception and decision-making processes to ensure that these technologies augment rather than diminish a human sense of agency. AI tools need to be leveraged to enhance human capabilities while preserving core elements of individual human identities and agency. In the next section, agency and its relationship to AI will be further explored, demonstrating how Identity and belonging inform Agency and, eventually, purpose.

Agency (& Growth Mindset)

"You have agency, and you are free to choose. But there is actually no free agency. Agency has its price. You have to pay the consequences of your choices." -Dieter F. Uchtdorf

What is agency? Your capacity to take action

Agency refers to an individual's capacity to act independently, make choices, and exert control over their actions and decisions. Rooted in both psychological and sociological discourse, agency emphasizes the proactive

[490] Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191–215. https://doi.org/10.1037/0033-295X.84.2.191
[491] Turkle, S. (2015). *Reclaiming conversation: The power of talk in a digital age.* Penguin Books.

role individuals play in shaping their lives, rather than being passive recipients of external forces.[492] Agency is closely tied to one's belief in their ability to influence events, known as self-efficacy. A person with high self-efficacy believes they can influence outcomes through their actions, thereby exhibiting a strong sense of agency. Conversely, those with low self-efficacy might feel that their actions have little impact on outcomes, resulting in diminished agency.[493]

Agency often begins with the self; in particular, with self-Agency, or the realization that an individual has control over their own actions and behaviors.[494] This process can begin even before the concept of self-awareness, developing as individuals observe casual connections between their actions and changes in the environment. Also called self-regulation, self-Agency empowers an individual to exert influence over themselves and is particularly important during early childhood development.[495] Self-Agency allows an individual to understand what they do and do not have control over and how to work within those confines. For example, while an individual perhaps cannot control that they feel an emotion, they *can* control how they express and act upon that emotion. *They* can be in control, instead of letting their emotions control them.

This is one of the primary differences between agency and autonomy. Agency is influenced by both internal and external factors, whereas, autonomy emphasizes acting based on one's own values without external compulsion, underscoring self-governance and independence from external influence. Both concepts deal with individual choice, but autonomy is more focused on independence from external influence.[496]

It is perhaps most apparent in Agency – though it is also true for motivation, identity, and purpose– that structural factors significantly impact how an individual can express their Agency. Socio-economic background, childhood, family experiences, and culture can all have a substantial impact on agentic orientation and agentic possibility.[497] All of these factors are often outside of an individual's control – particularly as an adolescent.

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[492] Bandura, A. (2006). Toward a psychology of human agency. *Perspectives on Psychological Science, 1*(2), 164–180. https://doi.org/10.1111/j.1745-6916.2006.00011.x
[493] Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist, 37*(2), 122–147. https://doi.org/10.1037/0003-066X.37.2.122
[494] Hansen, D. M., & Jessop, N. (2017). A Context for Self-Determination and Agency: Adolescent Developmental Theories. *Development of Self-Determination Through the Life-Course*, 27-46.
[495] Ibid.
[496] Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68
[497] Klemencic, M. (2015). What is student agency? An ontological exploration in the context of research on student engagement.

Understanding how these variables impact Agency can help an individual identify where they can most productively exert influence for positive impact.

Often associated with Agency is the concept of executive function. Executive function is an umbrella term for the different cognitive skills that are needed to behave flexibly and adaptively in new situations. Executive function refers to a set of cognitive processes that enable individuals to engage in goal-directed behavior. These processes include working memory (holding and manipulating information), cognitive flexibility (shifting between tasks or adapting to new rules), and inhibitory control (suppressing impulses or resisting distractions). These mental skills are essential for tasks such as planning, problem-solving, organizing, and managing time effectively.[498]

Agency, on the other hand, is the capacity of individuals to act independently and make free choices. While executive function provides the cognitive tools necessary for goal-directed actions, agency refers to the beliefs and motivations that drive individuals to initiate and persist in such actions. In essence, executive function is about "how" people can achieve something, while agency is about the "belief" that they can achieve it and the drive to do so.

Comparison with Growth Mindset

Agency and growth mindset are both integral concepts in educational and psychological fields as they intersect in how they influence individual behavior and learning. Growth mindset refers to the belief that abilities and intelligence can be developed through effort, training, and perseverance.[499] Individuals with a growth mindset tend to embrace challenges, persist in the face of setbacks, and see effort as a pathway to mastery.

The relationship between these two constructs is closely knit. A growth mindset can foster greater agency. When individuals believe they can develop their skills and intelligence, they are more likely to take proactive steps in their learning and lives, underscoring the essence of agency.[500] On the other hand, recognizing and exercising one's agency can lead to the cultivation of a growth mindset. When students see the results of their proactive behaviors and choices, they can develop the belief that growth is possible.

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[498] Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, 64, 135-168. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4084861/

[499] Dweck, C. S. (2006). *Mindset: The new psychology of success*. Random House

[500] Yeager, D. S., & Dweck, C. S. (2012). Mindsets that promote resilience: When students believe that personal characteristics can be developed. *Educational Psychologist, 47*(4), 302–314. https://doi.org/10.1080/00461520.2012.722805

Teachers' growth mindset supportive language (GMSL)--rhetoric emphasizing that one's skills can be improved over time--has been shown to significantly reduce disparities in academic achievement and enhance students' learning outcomes. Teachers' GMSL involves the use of phrases and feedback that encourage students to believe that their abilities and intelligence can be developed through effort, persistence, and the right strategies.[501] However, teachers often lack effective professional development in these techniques. To mitigate this problem, researchers have begun using LLMs to provide automated, personalized coaching to support teachers' use of GMSL. This AI tool revises unsupportive utterances submitted to GMSL by "developing (i) a parallel dataset containing GMSL-trained teacher reframing of unsupportive statements with an accompanying annotation guide, (ii) a GMSL prompt framework to revise teachers' unsupportive language, and (iii) an evaluation framework grounded in psychological theory for evaluating GMSL with the help of students and teachers."[502] This kind of research provides a glimpse of the exciting complementary capabilities of AI tools for the development of agency and growth mindset.

Primary facets of agency

Agency is informed by a combination of internal and external facets. These driving forces can help in comprehending how people exercise their agency at different times, in different contexts. Given the focus of this book, it is not possible to discuss all facets of agency exhaustively. Here are the primary facets of agency as identified in the literature:

- Personal Values:[503] Core principles, such as beliefs, often guide what individuals consider important, influencing their choices and actions.
- Goals:[504] Goals, both short-term and long-term, provide direction and purpose, fueling an individual's actions.
- Self-efficacy:[505] The belief in one's ability to be efficacious significantly impacts agency whereas confidence in one's skills and competence encourages individuals to take action and make decisions.

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[501] Dweck, C. S. (2006). Mindset: The new psychology of success. Random House

[502] Handa, K, Clapper, M., et al. (2023). "Mistakes help us grow": Facilitating and evaluating growth mindset supportive language in classrooms. ArXiv: Cornell University. https://arxiv.org/pdf/2310.10637.pdf

[503] Schwartz, S. H. (1992). Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries. In M. P. Zanna (Ed.), *Advances in experimental social psychology,* Vol. 25, pp. 1–65). Academic Press. https://doi.org/10.1016/S0065-2601(08)60281-6

[504] Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*(1), 109–132. https://doi.org/10.1146/annurev.psych.53.100901.135153; Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist, 57*(9), 705–717. https://doi.org/10.1037/0003-066X.57.9.705

[505] Bandura, A. (2001). "Social cognitive theory: An agentic perspective." Annual Review of Psychology, 52(1), 1-26.

- Autonomy:[506] The degree of autonomy an individual has in their personal and professional life impacts their ability to exercise agency. This includes freedom from undue external control or influence.
- Metaemotion:[507] Also known as Emotional Intelligence, it is one's ability to understand and manage emotions, and empathize with others, can influence how an individual exercises agency, especially in social contexts.
- Educational and Socioeconomic Background:[508] Education provides knowledge and critical thinking skills, while socioeconomic status can impact the range of choices available to an individual. These factors can expand or limit the extent of one's agency.
- Cultural and Social Influence:[509] Sociocultural norms and expectations shape an individual's understanding of what actions are possible or acceptable. Family, peer groups, and broader social networks all play a role in influencing decisions and actions.
- Physical and Mental Health:[510] Health can affect agency both directly and indirectly as physical and mental well-being influences an individual's capacity to act and make decisions.

CCR's synthesis of Agency theories (see Agency Theories in Appendix)

CCR Term	CCR Definition	Associated Terms and Constructs
Agency	Your capacity to take action	Autonomy; Self-efficacy; empowerment; intentionality

To create a composite theory of agency, CCR reviewed prominent and currently used theories of agency and growth mindset. CCR's framework for competencies shares many characteristics with several influential theories of agency (See Appendix) and can be used to foster agency by combining key subcompetencies.

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[506] Baltes, P. B., Lindenberger, U., & Staudinger, U. M. (2006). Life Span Theory in Developmental Psychology. In R. M. Lerner & W. Damon (Eds.), *Handbook of child psychology: Theoretical models of human development* (pp. 569–664). John Wiley & Sons, Inc.
[507] Bourdieu, P., & Passeron, J. C. (1977). *Reproduction in education, society, and culture.* Sage; Goleman, D. (1995). *Emotional intelligence.* Bantam Books.
[508] Sen, A. (1999). "Development as Freedom." Oxford: Oxford University Press.
[509] Giddens, A. (1984). *The constitution of society: Outline of the theory of structuration.* University of California Press; Markus, H. R., & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. *Psychological Review, 98*(2), 224–253.
[510] Albrecht, G. L., & Devlieger, P. J. (1999). "The disability paradox: High quality of life against all odds." Social Science & Medicine, 48(8), 977-988. Ryan, R. M., & Deci, E. L. (2001). On happiness and human potentials: A review of research on hedonic and eudemonic well-being. *Annual Review of Psychology, 52,* 141–166. https://doi.org/10.1146/annurev.psych.52.1.141

Both CCR's framework and Bandura's SCT emphasize the role of the learner in shaping their education. Bandura's concept of self-efficacy aligns with CCR's attention to mastering competencies like critical thinking. SCT's focus on observational learning—where individuals learn by watching and imitating others—resonates with CCR's Character domain, including traits like resilience and ethics. Finally, Bandura's idea of self-regulation is mirrored in CCR's "meta-learning," highlighting the importance of self-awareness in the learning process.

The Theory of Planned Behavior focuses on how individual intention, influenced by external factors, determines behavior. For instance, "attitude towards behavior" in TPB can be paralleled with CCR's attention to the Character domain, particularly traits like Courage and Ethics, which influence an individual's perspective and response to situations. The "subjective norms" from TPB, which refers to the perceived social pressure to perform (or not) a behavior, resonates both with CCR's Character and Meta-learning domains, in terms of Courage, Ethics and Metacognition The element of "perceived behavioral control" in TPB, which is the perception of the ease or difficulty of performing a behavior, aligns with Skills in CCR's framework; competencies like Critical Thinking, Communication and Collaboration which directly influence an individual's confidence in executing tasks.

Finally, Giddens' Structuration Theory shares an priority with CCR on the dynamics between individuals and the structures within which they operate. Giddens' theory posits that while social structures guide individual actions, these actions can also produce and reproduce these structures. This duality of structure emphasizes human agency's role in shaping societal constructs.

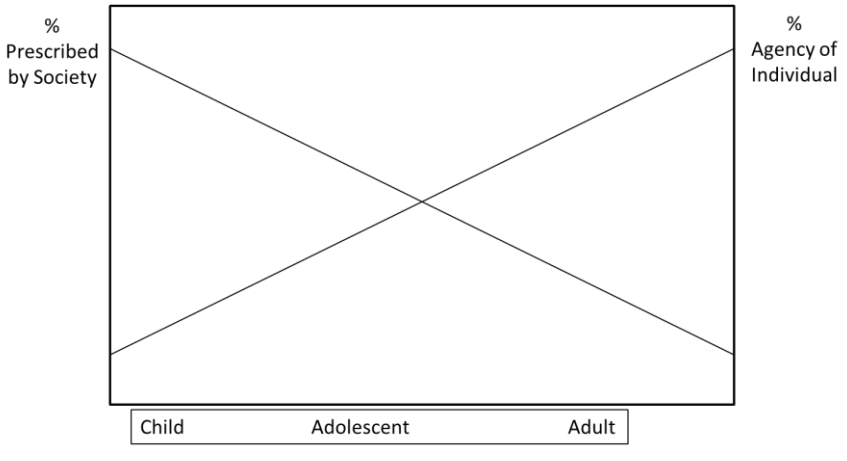
This dynamic is also present in CCR's framework. Character, which includes traits like Ethics, Resilience, and Courage, can be seen as components of individual agency that influence and are influenced by societal structures. This aligns with Giddens' focus on agency as being embedded within structures. Skills, particularly competencies like Communication, Collaboration, and Critical Thinking, mirrors Giddens' view on "modalities" – the means through which agents draw upon structural properties. Effective communication, for instance, can serve as a modality to reinforce or change existing societal norms and institutions.

Levels of Agency in Education

Agency is sometimes overblown in education as being absolute, with no constraints. Yet there are several layers of agentic choices, and a wise education needs to balance all these layers:

Agency Layer	Example	Comment
Discipline	Environmental science	Tracking choices in high school
Branch	Conservation biology	Depends on availability
Subject/Topic	Climate change impact on a specific ecosystem	Easy to implement
Implementation	Restoration projects	Often underappreciated; often naturally multidisciplinary
Purpose	Educational programs on conservation	Most impactful; often naturally multidisciplinary

Furthermore, the degree of choice starts low, as young students need to master the basics (even within a Montessori-like environment) to greater and greater Agency, per the diagram below:



(Source: CCR)

Why is agency crucial in an age of AI? Agency permits humans to use AI as a tool.

Agency has taken on paramount significance because it serves as a touchstone for human uniqueness and control amidst rapidly evolving technological landscapes. AI systems have begun to perform tasks that were traditionally within the exclusive realm of human cognition—such as diagnosing diseases, composing music, or writing prose. In this context, maintaining human agency ensures that humans remain active decision-

makers, not passive recipients or bystanders in the face of technological determinism.[511]

Agency is integral in establishing a sense of purpose and direction, allowing individuals to harness AI as a tool rather than be overshadowed by it.[512] In areas such as ethics, and emotional intelligence, human agency remains crucial, guiding how AI should be designed, integrated, and regulated in society. It is through this agency that humans ensure AI technologies align with our collective values, goals, and societal norms.[513]

Maintaining a robust sense of human agency in the age of AI not only helps maintain the intrinsic value of human individuality but also safeguards democratic processes, ethical considerations, and personal freedoms. The balance between leveraging AI's capabilities and preserving human agency will be pivotal in steering the future course of human-AI collaboration.

Can AI possess agency? Yes, in some limited forms.

This is currently a gray area as AIs *do* possess a narrow form of agency, particularly generative adversarial networks (GAN) that are programmed to independently compete against each other. The release of AutoGPT and similar autonomous AI agents, "showcases the potential for machines to handle tasks previously thought to be exclusive to humans, including content creation, problem-solving, and decision-making."[514] A compelling example is NVIDIA's release of Eureka, an AI agent that can automatically generate algorithms, using LLMs like GPT-4 and reinforcement learning, to train robots to perform complex manual tasks and rapidly acquire new skills.[515]

It remains that, beyond these examples where AI agents have been given limited agency, humans have not yet provided agency to most AIs, let alone full agency. However, John Von Neuman's concept of self-reproducing automata is the tip of the research arrow.[516] The role of humans remains, for now, to program AIs for different levels of particular agency and direct them to human purposes.

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[511] Brynjolfsson, E., & McAfee, A. (2014). *The second machine age.* W. Norton & Co.
[512] Drexler, K. E. (2019). *Reframing superintelligence: Comprehensive AI services as general intelligence*. Future of Humanity Institute, University of Oxford.
[513] Dignum, V. (2019). *Responsible artificial intelligence:* Springer Nature.
[514] Takyar, A. (2023). AutoGPT: Unleashing the power of autonomous AI agents. *LeewayHertz*. https://www.leewayhertz.com/autogpt/; Significant-Gravitas / AutoGPT. (2023). GitHub account. https://github.com/Significant-Gravitas/AutoGPT
[515] McKay, C. (2023). NVIDIA's Eureka uses GPT-4 to teach robots new skills. *Maginative*. https://www.maginative.com/article/nvidias-eureka-uses-ai-to-teach-robots-new-skills/#:~:text=Crucially%2C%20Eureka%20does%20this%20without,the%20task%20and%20robot%20morphology
[516] Se, K. (2023). FOD#23: The quest for self-reproducing automata: Old and new ideas. *Turing Post.* https://www.turingpost.com/p/fod23

According to GPT4, with which the authors agree:
"Agency is typically understood as the capacity of an entity to act independently and to make its own free choices. When discussing AI, the concept of agency is more nuanced.

AI does not have agency in the same way humans do. Human agency is rooted in consciousness, intentionality, and the ability to act based on desires, beliefs, and individual experiences. In contrast, AI systems operate based on programmed algorithms, and their "actions" are determined by code, data inputs, and specified objectives. Even when an AI system's behavior appears autonomous, it is still bounded by the parameters set by its developers.

However, AI can display a form of "functional agency." For example, a machine learning system trained to optimize stock trades might make decisions autonomously within the scope of its programming, processing vast amounts of data faster than a human could. It "acts" on the data it's provided to achieve its optimization goal. But this decision-making process lacks true intentionality or conscious understanding.

As AI systems become more advanced and their decision-making processes more opaque, it can sometimes appear as if they have a form of agency, especially when these systems operate in unpredictable ways or when the reasoning behind their decisions is not immediately transparent. This perception can lead to ethical and philosophical debates about the responsibility and accountability of AI systems and their creators".

In summary, while AI can exhibit autonomous behaviors within the boundaries of their programming, they do not possess agency in the rich, conscious sense that humans do."

Stanford's Fei Fei Li often emphasizes caution in the development of AI. She argues that AIs should always be considered as tools to augment human capabilities, rather than autonomous agents.[517] For example, in the domain of AI for healthcare, which Li has worked on considerably, AI can provide timely assistance to medical practitioners in diagnosing conditions, but the final diagnostic decisions should always be overseen by well-trained human professionals.

Granting agency to AI also further complicates ethical implications. Accountability and responsibility become ambiguous if we give AIs complete agency.[518] Li, among others, insists that, by always understanding AI as a tool, it remains clear that humans are always ultimately responsible for the

[517] Li, F.F. (2023). *The worlds I see.* Macmillan.
[518] As is happening in military applications…

actions and outputs of AI. ”It's recognizing [that] the future of AI is so profoundly impactful that the agency must remain within us. We have to make the choices of how we want to build and use this technology. If we give up agency, it would be a freefall.”

Conclusion: Agency in action

Agency is intrinsically linked to the concept of purpose. Purposes and passions provide the direction and intrinsic motivation for agency, while a high degree of agency amplifies the effects of these motivations, leading to persistent and goal-directed behavior. When individuals possess a clear sense of purpose, their agency becomes directed towards fulfilling that purpose, resulting in greater satisfaction and psychological well-being.[519] This creates a feedback loop where agency and purpose reinforce and strengthen each other.

Conversely, a lack of agency, even with strong motivation, hinders the ability to act on desires and intentions. Therefore, optimal performance and goal achievement require both strong motivation and a robust sense of agency.[520] A strong sense of identity helps individuals understand themselves and their place in various groups, both internally and externally. With agency, learners can direct their identities towards personally meaningful goals, contributing to a larger purpose that matters to themselves and others.

The relationship between agency and purpose becomes more vital in a world of AI. AI technologies can inadvertently impinge on human agency by automating decision-making processes, posing a risk to the human sense of purpose. Scholars such as Noah Harari warn of a future where AI's capabilities could overshadow human decision-making, leading to a diminished sense of purpose and agency.[521] When AI plays a substantial role in everyday tasks, it becomes crucial to actively cultivate and maintain human agency and purpose. Doing so ensures that AI’s capabilities are harnessed to augment human potential, rather than diminish human aspects of purpose and self-determination. The following sections will discuss the links between agency and purpose and focus on the importance of human purposes in an AI world.

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[519] Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227–268.
[520] Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology*, 52, 1-26. https://www.annualreviews.org/doi/abs/10.1146/annurev.psych.52.1.1
[521] Harari, Y. N. (2016). *Homo deus: A brief history of tomorrow.* Harper.

Purpose (incl. Passion)

"Education is not the filling of a bucket, but the lighting of a fire." -W.B. Yeats

What is Purpose? Your sense of significance

Purpose can be described as a central, self-organizing life aim that drives an individual's thoughts, actions, and behaviors, providing a sense of direction and meaning. It often emerges from a blend of personal passions, strengths, values, and a desire to make a positive impact in the world or to contribute to something greater than oneself.[522] Purpose is not only about setting goals; it involves an enduring intent that provides coherence to one's life. The existential psychologist Viktor Frankl[523] emphasized the fundamental human need for purpose, proposing that a meaningful life is anchored in the pursuit of purpose, even in the face of adversity. Having a clear purpose has been linked with a variety of positive outcomes, from improved well-being and health to increased resilience and longevity.[524]

By and large, there are two types of purpose: self-interested and self-transcendent. The first refers to a purpose that largely benefits the self (e.g. an enjoyable task or activity), while the second is rooted in benefiting others or working towards something larger than oneself. Though both can be considered purposes, self-transcendent motivations are often more effective in motivating people.[525]

That said, the road to self-transcendent motivation can be paved by self-interest. As individuals are often interested in experiencing self-transcendent purposes, leveraging curiosity can help target both motivations simultaneously. Seeking to understand deeply is a powerful tool in helping determine interests and passions – a spark that may lead toward a self-transcendent purpose.[526]

Similar to Identity, researchers and philosophers remain split on whether individual purpose is discovered or created.[527] Researcher John Coleman

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[522] Bronk, K. C. (2014). *Purpose in life: A critical component of optimal youth development*. Springer.
[523] Frankl, V. E. (1963). *Man's search for meaning: An introduction to logotherapy*. Beacon Press.
[524] Kashdan, T. B., & McKnight, P. E. (2009). Origins of purpose in life: Refining our understanding of a life well lived. *Psi Chi Journal of Undergraduate Research*, 14(1), 22-30.
[525] Yeager, D. S., Henderson, et al (n.d.). Boring but important: A self-transcendent purpose for learning fosters academic self-regulation. Journal of Personality and Social Psychology, 107(4), 559-580.
[526] CUR4: Actively pursuing one's own interests and passions
[527] Coleman, J. (2017). You Don't Find Purpose - You Build It. *Harvard Business Review*. https://hbr.org/2017/10/you-dont-find-your-purpose-you-build-it

describes this first conception well: “On social media, I often see an inspiring quotation attributed to Mark Twain: ‘The two most important days in your life are the day you are born and the day you find out why.’ It neatly articulates what I’ll call the ‘Hollywood version’ of purpose. Like Neo in The Matrix or Rey in Star Wars, we’re all just moving through life waiting until fate delivers a higher calling to us.”[528] Coleman accurately describes the pervasive perception that individuals play a passive role in the development of their purpose—that purpose finds *them*, not the other way around. It is therefore crucial that individuals explore interests and eventual purposes to contribute to the creation of their purpose.

The depiction that individuals *create* purpose places them in an active role. Coleman stresses that purpose is actively constructed through our actions and choices, and research and popular wisdom such as the Ikigai model (in Appendix), echo this priority. People who frame their lives as a “hero’s journey” lead more meaningful and satisfying lives. Contrary to popular belief, there isn't just one overarching purpose to be found; rather, people draw meaning from various aspects of our lives such as work, family, faith, and community. This approach to purpose allows for a richer, more diverse experience of life where different sources of meaning take precedence at different times. Our sense of purpose can evolve, reflecting the different stages of our lives and professional paths. Thus, as with identity, this discussion will proceed under the assumption that agency allows purpose to be both created and multifaceted.

What is passion? Your enthusiasm for your actions

“Choose a job you love and you'll never have to work a day in your life” – Confucius.

Passion, in psychological and sociological contexts, is often understood as a strong inclination or desire toward an activity or object that individuals deeply value, find personally meaningful, and in which they invest significant time and energy.[529] It is a driving, or enthusiastic, feeling or sentiment. Passion can serve as a motivating force, guiding individuals towards pursuits that provide them with a sense of purpose and meaning in life.

The relationship between passion and purpose is intricate. While purpose relates to a broader life goal that provides direction and meaning to one's actions,[530] passion can be seen as the fuel that drives individuals towards the realization of this purpose. A person may have a purpose to contribute

[528]Coleman, J. (2017). You Don’t Find Purpose - You Build It. *Harvard Business Review*. https://hbr.org/2017/10/you-dont-find-your-purpose-you-build-it

[529] Vallerand, R. J., Blanchard, C., et al. (2003). Les passions de l'âme: On obsessive and harmonious passion. *Journal of Personality and Social Psychology, 85*(4), 756–767.

[530] Damon, W., Menon, J., & Bronk, K. C. (2003). The development of purpose during adolescence. *Applied Developmental Science, 7*(3), 119–128.

to environmental sustainability, and their passion for gardening or wildlife conservation can be the avenue through which they actualize this purpose. In essence, while purpose offers the "why" behind our actions, passion provides the vigor and enthusiasm for the "how" of pursuing it.

Major facets of purpose and passion

The concepts of purpose and passion are widely studied in psychology, particularly in the fields of positive psychology and developmental psychology. This is a vast and nuanced topic, for which this section will not provide an exhaustive list of facets. However, it is important to note that many of the facets of purpose and passion overlap with those for identity and agency and are often issued from motivations:

- Enjoyment:[531] When an individual finds something they inherently enjoy, they are more likely to be motivated and develop a passion for that activity, project, or cause. These Intrinsic interests, when nurtured, can become passions and purposes.
- Values:[532] Because values and beliefs often guide people's choices and behaviors, when activities align with one's values or beliefs, a person is more likely to feel a strong(er) sense of purpose and passion.
- Self-Efficacy and Competence:[533] A key topic in psychological research, individual belief in the ability to succeed and in their competence in the skills needed to succeed can feed passions and purposes. When a person feels competent, they are more engaged and enthusiastic about activities and projects.
- Autonomy:[534] The freedom to choose and control one's actions is critical to passions and purposes. Autonomy permits people to pursue personally meaningful interests and goals.

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[531] Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior.* Plenum; Silvia, P. J. (2006). *Exploring the psychology of interes*t. Oxford University Press Vallerand, R. J. (2008). On the psychology of passion: In search of what makes people's lives most worth living. *Canadian Psychology / Psychologie canadienne, 49*(1), 1–13.

[532] Dweck, C. S. (2006). *Mindset: The new psychology of success.* Random House; Steger, M. F., Kashdan, T. B., Sullivan, B. A. et al. (2008). Understanding the search for meaning in life: Personality, cognitive style, and the dynamic between seeking and experiencing meaning. *Journal of Personality, 76*(2), 199–228. https://doi.org/10.1111/j.1467-6494.2007.00484.x

[533] Pajares, F., & Schunk, D. H. (2001). Self-beliefs and school success: Self-efficacy, self-concept, and school achievement. In R. Riding & S. Rayner (Eds.), *Perception* (pp. 239-266). Ablex Publishing; Stajkovic, A. D., & Luthans, F. (1998). Self-efficacy and work-related performance: A meta-analysis. *Psychological Bulletin, 124*(2), 240–261. https://doi.org/10.1037/0033-2909.124.2.240

[534] Deci, E. L., & Ryan, R. M. (2008). Self-determination theory: A macrotheory of human motivation, development, and health. *Canadian Psychology / Psychologie canadienne, 49*(3), 182–185. https://doi.org/10.1037/a0012801; Gagné, M., & Deci, E. L. (2005). Self-determination theory and work motivation. *Journal of Organizational Behavior, 26*(4), 331–362.

- Belonging:[535] Relationships and social interactions inspire and nurture passion. Support from others can affirm and encourage pursuits, contributing to a sense of purpose.
- Experiences:[536] Exposure to different activities and experiences can spark interest, passions, and purposes, as people often discover passions by trying new things and exploring different places, communities, or fields. This idea is explored in several fields, including developmental psychology, educational psychology, and career counseling.
- Self-Discovery:[537] Reflecting on life experiences, strengths, and interests can lead to a clearer understanding of what drives personal passion and purpose.
- Ambition:[538] The role of ambition and achievements as drivers of purposes and passion is well-established, particularly in the fields of motivation, personality psychology, and organizational behavior. Setting and working towards goals can foster a sense of purpose and the process of striving for and achieving goals can be a powerful driver of passion.
- Inspiration:[539] Inspiration from others, such as mentors, role models, or influential figures, can play a significant role in igniting passion and shaping a sense of purpose.

CCR's synthesis of Purpose theories (see Purpose Theories in Appendix)

CCR Term	CCR Definition	Associated Terms and Constructs
Purpose	Your sense of significance	Passion; interests; intentions; ambition

[535] Cohen, S. (2004). Social Relationships and Health. *American Psychologist, 59*(8), 676–684. https://doi.org/10.1037/0003-066X.59.8.676; Helliwell, J. F., & Putnam, R. D. (2004). The social context of well-being. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 359(*1449), 1435-1446.

[536] Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development.* Prentice-Hall.

[537] Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84*(4), 822–848. https://doi.org/10.1037/0022-3514.84.4.822; Marcia, J. E. (1966). Development and validation of ego-identity status. *Journal of Personality and Social Psychology, 3*(5), 551–558. https://doi.org/10.1037/h0023281

[538] Duckworth, A. L., Peterson, C., Matthews, M. D., & Kelly, D. R. (2007). Grit: Perseverance and passion for long-term goals. *Journal of Personality and Social Psychology, 92*(6), 1087–1101. https://doi.org/10.1037/0022-3514.92.6.1087; Judge, T. A., & Kammeyer-Mueller, J. D. (2012). On the value of aiming high: The causes and consequences of ambition. *Journal of Applied Psychology, 97*(4), 758–775. https://doi.org/10.1037/a0028084

[539] Morgenroth, T., Ryan, M. K., & Peters, K. (2015). The motivational theory of role modeling: How role models influence role aspirants' goals. *Review of General Psychology, 19*(4), 465–483. https://doi.org/10.1037/gpr0000059; Thrash, T. M., & Elliot, A. J. (2003). Inspiration as a psychological construct. *Journal of Personality and Social Psychology, 84*(4), 871–889.

Because purposes are evolving constructs that are cultivated over time, driven by individual competencies and societal contexts, they are not static end-goals but reshaped as individuals interact with the world, accumulate experiences, and gain knowledge. Drawing from the strengths of major research frameworks addressing purpose (see Appendix), and supplementing them with the CCR framework, one can define a composite theory of purpose consisting of:

Foundational Layer (0-12 years): Aligning with Erikson's early stages, purpose here is tied to basic trust, autonomy, and initiative. Children's initial sense of purpose comes from safety, exploration, and basic task accomplishments. Within the CCR framework, this aligns with the competencies of Curiosity, Communication and Courage and as children question the world and construct their understanding of its responses. This can be considered the pre-full consciousness stage.

The following stages are all full-consciousness:

Identity Formation Layer (13-24 years): Aligning with Erikson's adolescence stage and insights from PIL, purpose during these years is about exploration, seeking identity, and understanding one's role in the larger societal context. This corresponds with CCR's attention to Meta-Learning (particularly MET2: Reflecting on processes, learning, and identity) and competencies such as Creativity, Curiosity and Ethics. Here, students should be encouraged to ask big questions about life, reflect on their values, and develop a sense of direction.

Societal Interaction Layer (25-50 years): Aligning with Erikson's young and middle adulthood stages, purpose here is about deep connections, contributions, and legacy creation. People start to seek meaning in their jobs, relationships, and societal roles. CCR's competencies of Collaboration, Communication and Ethics play pivotal roles. Additionally, the Meaning Maintenance Model asserts that when people perceive anomalies in their worldviews, they strive to resolve them. Therefore, when adults face challenges to their sense of purpose, competencies such as Resilience, Courage and Curiosity will encourage them to seek new avenues or adapt their views to restore meaning.

Reflective Layer (50+ years): Rooted in Erikson's late adulthood stage, purpose revolves around reflection, life review, and acceptance. People ask: Did I live a meaningful life? Did I contribute positively? CCR's Meta-Learning is crucial here, allowing individuals to learn from their experiences, adjust their sense of purpose, and impart wisdom to younger generations.

Why is purpose (or purposes) crucial in an age of AI? Because AI cannot think for itself (yet…)

Human purpose is becoming increasingly essential for several reasons. As automation and AI systems take over routine tasks and jobs, individuals need to find meaning and direction in activities that machines cannot easily replicate. Human qualities such as empathy, ethics, and a sense of purpose differentiate us from machines. While AI tools can surpass human doctors in analyzing data and often in generating diagnoses, for example, a human doctor's purpose lies in empathetic care, understanding a patient's unique situation, and making decisions that resonate with ethical and humanistic values.[540] Similarly, educators whose purpose is to inspire and foster growth in students can adapt to using AI tools in classrooms, not as replacements, but as enhancements to their teaching methods, ensuring that the human touch remains central.

Clear purpose also provides a compass with which individuals can navigate uncertainties and challenges. When people possess well-defined purpose(s), they are more likely to be resilient, adapt to change, and find satisfaction, even when facing disruptions. Finally, with the ethical implications of AI coming to the fore, a collective sense of purpose is vital in guiding the development and application of AI technologies. Purpose-driven objectives ensure that AI advances are directed toward the greater good, benefiting humanity at large rather than a select few. AI used in sustainable energy solutions demonstrates how purpose-driven tech can address global challenges like climate change.[541]

Does AI have purpose? Intrinsically, no!

Purpose remains human, for the time being. Current forms of AI cannot be argued to possess purpose, as their processing and actions depend on a human taskmaster. Were AI to be given agency, it might be possible - yet quite debatable - that advanced forms of AI would define their purposes.[542]

Speculation aside, it is not improbable to imagine future AIs with the capacity to independently define their purposes, even if only within particular programmed frameworks. AI agents such as AutoGPT are already capable of defining objectives within the parameters of their programming.

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[540] Davenport, T. H., & Kirby, J. (2016). *Only humans need apply.* Harper Business.
[541] Russell, S., Dewey, D., & Tegmark, M. (2015). Research priorities for robust and beneficial artificial intelligence. *AI Magazine*, 36(4), 105-114. https://arxiv.org/abs/1602.03506
[542] Anderson, M., & Anderson, S. L. (Eds.). (2011). *Machine ethics.* Cambridge University Press; Tegmark, M. (2017). *Life 3.0: Being human in the age of artificial intelligence.* Knopf; Tononi, et al. (2016). Integrated information theory: from consciousness to its physical substrate. *Nature Reviews Neuroscience, 17(*7), 450–461.

Purpose and objectives, though related concepts remain distinct. Purpose provides the "why" behind an endeavor, while objectives provide the "what" and "how" to achieve it. Objectives are specific, measurable, and (often) time-bound goals that delineate the steps necessary to achieve or move towards a purpose.[543] Therefore, though AI can currently define objectives, it is not possible, yet, to attribute purpose to their actions.

According to GPT4 itself, which we fully agree with:
"AI does not possess purpose in the same intrinsic and deeply personal way that humans do. Humans derive purpose based on a complex interplay of experiences, emotions, values, beliefs, and sociocultural influences. In contrast, AI operates based on programmed objectives, instructions, or goals set by its developers or users.

However, AI can be designed to have a "purpose" in a functional sense. For example, a self-driving car's AI is designed with the purpose of navigating the road safely and efficiently. A chatbot might have the purpose of answering user questions or providing information. But it's important to distinguish between this kind of operational directive and the rich, multifaceted sense of purpose that humans can experience. AI doesn't have emotions, consciousness, or self-awareness, so while it can perform tasks aligned with a specified goal, it doesn't "feel" or "understand" purpose in a human sense.

In the age of advanced AI, questions about machine purpose, autonomy, and rights have been brought up in philosophical discussions.[544] As AI systems become more integrated into human society and exhibit behaviors that mimic human-like intelligence, it becomes increasingly important to define and understand the bounds of AI "purpose."

Conclusion: Purpose + Motivation, Identity and Agency - core to the human experience

Human motivation, identity, agency, and purpose are deeply interconnected and form the core of the human experience. Motivation drives us to act, influenced by our identities, which in turn inform agency. In turn, our purpose gives direction to our agency, guiding our actions toward meaningful goals. These elements are key to psychological well-being, as they enable individuals to lead autonomous, self-regulated lives.

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[543] Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist, 57*(9), 705–717.
[544] Bryson, J. J. (2010). Robots should be slaves. In Y. Wilks (Ed.), *Close engagements with artificial companions: Key social, psychological, ethical and design issues* (pp. 63-74). John Benjamins Publishing Company.

In an AI-driven world, these constructs gain greater significance. As AI systems become more integrated into daily life, they influence how decisions are made, often with efficiency and logic as primary drivers. This integration risks marginalizing human aspects like motivation, identity, agency, and purpose. In a world increasingly influenced by AI, it is crucial to actively cultivate these human constructs.

What can educators do to ensure that these constructs are central to their teaching and being fostered in their classrooms? The following chapters (and appendix) will discuss strategies and frameworks for fostering motivation, identity, agency, and purpose in the classroom, featuring the use of AI tools to make these experiences more relevant to learners' futures.

Subcompetencies Supporting Motivation, Identity, Agency, and Purpose

The Drivers (Motivation, Identity, Agency, and Purpose) are not competencies in themselves, as these are personal positionings that cannot be taught as content. Nonetheless, CCR competencies and subcompetencies encourage the discovery, development, appreciation, and maintenance of these drivers in a variety of ways. Below are examples, but not a comprehensive list, of specific subcompetencies than can be employed to foster each of these drivers. Again, this is not an exhaustive list, but a series of suggestions to demonstrate the ways the Competencies and Subcompetencies can be deployed to foster other traits in learners.

Subcompetencies Supporting Motivation

CUR4: Envisioning and prioritizing one's interests and passions
Envisioning and prioritizing interests and passions serve as foundational elements in fueling motivation. By visualizing personal passions and placing them at the forefront of one's goals, individuals can cultivate intrinsic motivation.[545] Envisioning a future where one's passions play a central role can act as a motivational compass, guiding efforts and fostering perseverance in the face of challenges. When individuals imagine a clear path between their present actions and a desired future that aligns with their core interests, research demonstrates that they are more likely to remain motivated and committed to their pursuits.[546]

[545] Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227–268.
[546] Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist, 57*(9), 705–717. https://doi.org/10.1037/0003-066X.57.9.705

COU5: Believing in oneself and one's agency and self-efficacy
Self-efficacy, or belief in one's own capabilities, is crucial for maintaining motivation and taking action. Research shows that individuals with high self-efficacy are more likely to engage in challenging tasks, put in greater effort in the face of adversity.[547] For instance, a student who believes they can master a complex math problem is more likely to invest time and effort into solving it compared to a peer who doubts their own abilities. Confidence in one's skills not only drives initial motivation but also enhances resilience in the face of setbacks. Additionally, recognizing and trusting one's agency to act independently and make choices can greatly boost motivation. When individuals view themselves as the masters of their own destiny, they are more inclined to set meaningful goals and pursue them vigorously, knowing that their actions can shape outcomes.[548] Ultimately, believing in oneself acts as a powerful source of motivation, driving individuals to take on challenges, overcome obstacles, and achieve their goals.

MET5 Determining goals, plans to achieve those goals, and reviewing one's progress
Setting clear goals and crafting actionable plans to achieve them serves as a roadmap for motivation. According to Goal Setting Theory, explicit, challenging goals paired with appropriate feedback motivate individuals more effectively than vague or easy objectives.[549] For instance, a student aiming to achieve an "A" in a course, rather than just "doing well," is likely to be more motivated because the goal is both specific and challenging. Delineating a detailed plan reinforces the perception of a clear path toward achieving a set objective, breaking it into manageable steps and further boosting motivation. As the individual progresses, periodic reviews of their progress allow for adjustments and recalibrations. Such reviews can offer positive reinforcement when goals are being met or can serve as a nudge, indicating areas needing more focus, thereby continually fueling motivational drive.

Subcompetencies Supporting Identity and Belonging

CRE1: Developing personal tastes, aesthetics, and style
The process of developing one's tastes, aesthetics, and style is crucial in shaping an individual's sense of self. Research emphasizes the importance of an exploration phase, which allows individuals to expand their exposure

[547] Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191–215. https://doi.org/10.1037/0033-295X.84.2.191
[548] Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology, 25*(1), 82–91. https://doi.org/10.1006/ceps.1999.1016
[549] Locke, E. A., & Latham, G. P. (1990). *A theory of goal setting & task performance.* Prentice-Hall, Inc.

to different influences and experiences.[550] This exposure broadens their choices and informs their personal identity. Additionally, the desire to belong is deeply ingrained in human nature, leading individuals to seek out and shift between various group affiliations throughout their lives. Through exploration, both in terms of personal style and group belonging, individuals can continuously adapt and grow in response to changing contexts and new opportunities.[551]

COU4: Acknowledging one's strengths and weaknesses

It takes courage to express some facets of identity, and to commit to that expression even in spaces that are uncomfortable – or even violent – towards that expression.[552] Recognizing personal strengths and weaknesses can contribute towards developing an authentic lens through which individuals can evaluate and integrate various aspects of their identity and helps individuals navigate a related tripwire of identity: the feeling of *too many* possible identities.[553] An honest self-assessment acts as a compass, guiding individuals towards roles or environments where their strengths can flourish, and away from contexts where their weaknesses may be exacerbated. With time, this self-awareness helps individuals prioritize and integrate identities that resonate with them, allowing them to craft a cohesive sense of self amidst a sea of potential personas.[554]

MET2: Reflecting on processes, learning, and identity

Unsurprisingly, metacognition provides an effective inroad to the creation of identity by helping individuals navigate the multifaceted aspects of self-presentation, often known as performativity.[555] This concept underscores how individuals adapt their identity based on the audience, such as code-switching between family and friends or between professional and personal settings. Through introspection and understanding of one's thought processes and learning, individuals can adeptly modulate their identities across various contexts,[556] ensuring they align with internal beliefs while also fitting the demands of specific environments.[557]

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[550] Quinn, B. P., Heckes, S. L., & Shea, M. L. (2019). Classroom Practices that Support the Development of Purpose. *Journal of Character Education*, *15*(2), 71+.
[551] CUR2: Seeking out novelty and trying new things
[552] COU1: Pursuing ambitious goals despite social, financial, physical or emotional risk to self
[553] Waterman, A. S. (1984). Identity Formation: Discovery or Creation? The Journal of Early Adolescence, 4(4), 329-341.
[554] Schwartz, S. J., Côté, J. E., & Arnett, J. J. (2005). Identity and Agency in Emerging Adulthood: Two Developmental Routes in the Individualization Process. *Youth & Society, 37*(2), 201–229. https://doi.org/10.1177/0044118X05275965
[555] Greenhow, C., & Robelia, B. (2009). Informal learning and identity formation in online social networks. *Learning, Media and Technology*, (34), 119-140.
[556] MET7: Thinking and adapting flexibly
[557] MET6: Practicing awareness and regulation of internal state; MET1: Reflecting on processes, achievements, learning and/or identity

Subcompetencies Supporting Agency

RES1: Persevering through challenges but seeking help when needed
Resilience and agency are closely intertwined, with perseverance serving as a key component of individual agency. By persisting in the face of challenges, individuals can reinforce their belief in their ability to effect change and achieve their goals, leading to personal growth and self-reliance.[558] However, recognizing the importance of seeking help when needed is also crucial, demonstrating a mature understanding of limitations and utilizing available resources. Engaging with others fosters collective intelligence and collaborative competencies necessary in an interconnected world.[559]

COL1: Taking and sharing responsibility with others
Taking responsibility and sharing it with others can strengthen individual agency. Assuming responsibility demonstrates commitment and boosts self-confidence. It also fosters a sense of ownership and encourages active engagement. Sharing responsibility promotes collaboration, teaching individuals the value of interdependence and collective effort. It also exposes them to diverse perspectives, enhancing problem-solving and decision-making. Through mutual collaboration, success becomes more likely, and participants feel more included, motivated, and empowered.[560]

COU1: Believing in oneself and one's agency and self-efficacy
The possession of agency does not guarantee its use; it requires courage. When individuals perceive themselves as competent and capable, they are more likely to be courageous and take on challenging tasks. This self-belief drives action and enables individuals to persevere in the face of obstacles. Over time, this recursive relationship between self-belief and action strengthens an individual's sense of agency, as past achievements reinforce the belief in one's ability to influence outcomes.[561] A case study on the development of agency in the classroom found that students' growing confidence and bravery in expressing their beliefs enabled them to speak up without fear.[562] This demonstrates the importance of courage as a necessary tool,[563] although resilience is also needed to sustain agency.

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[558] Bandura, A. (1997). *Self-efficacy: The exercise of control.* W H Freeman/Times Books/ Henry Holt & Co.
[559] Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology, 25*(1), 82–91. https://doi.org/10.1006/ceps.1999.1016
[560] Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227–268.
[561] Bandura, A., & National Inst of Mental Health. (1986). *Social foundations of thought and action: A social cognitive theory.* Prentice-Hall, Inc.
[562] Mitra, D. (2004). The Significance of Students: Can Increasing "Student Voice" in Schools Lead to Gains in Youth Development? *Teachers College Record - TEACH COLL REC*, *106*,
[563] COU2: Standing up for one's values

Subcompetencies Supporting Purpose and Passion

CUR1: Seeking to understand deeply
Deep understanding, a pursuit fueled by intense curiosity, serves as a bridge to purpose. When individuals dive deeply into subjects or concepts, driven by a desire to understand them thoroughly, they can uncover or crystallize a sense of purpose. This comprehension, born out of genuine curiosity, enables individuals to discern what aligns with their values and passions. By seeking a deep understanding of the world around them, people are led to discover their purpose, embedding their lives with richer meaning and direction.[564]

RES5: Motivating oneself via meaning or purpose
While having a purpose can increase the effectiveness of an activity or pursuit, it does not necessarily increase an individual's enjoyment of that pursuit.[565] It is a common misconception that a purpose in life will make every aspect of their work or life enjoyable – and if it is *not* enjoyable, it must not be their purpose. Unfortunately, this is not always the case. Instead, a purpose – particularly one that transcends the individual – serves only to make those less enjoyable tasks more effective and/or bearable.[566] In this way, resilience is crucial to the sustainability of a purpose – whether that be persevering through the less enjoyable parts of life to reap the rewards later,[567] or finding that guiding star to look to when times are tough (or boring!).[568]

MET5: Determining goals, plans to achieve those goals, and reviewing one's progress
Our purpose(s) evolve and expand over a lifetime.[569] Metacognition allows an individual to recognize shifting priorities and assess their permanence or impermanence (e.g. is this an interest to me because of its novelty, or does it have the potential to drive my life?). Making plans and reviewing progress also equip an individual with the skills to adapt to ever-evolving and pivotal purposes.[570]

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[564] Bronk, K. C. (2012). A grounded theory of the development of noble youth purpose. *Journal of Adolescent Research, 27*(1), 78–109. https://doi.org/10.1177/0743558411412958; Kashdan, T. B., & Steger, M. F. (2007). Curiosity and pathways to well-being and meaning in life: Traits, states, and everyday behaviors. *Motivation and Emotion, 31*(3), 159–173.
[565] Yeager, D. S., Henderson, M. D., et al (n.d.). Boring but important: A self-transcendent purpose for learning fosters academic self-regulation. *Journal of Personality and Social Psychology*, *107*(4), 559-580.
[566] Yeager, D. S., Henderson, M. D., Paunesku, D., Walton, G. M., D'Mello, S., Spitzer, B. J., & Duckworth, A. L. (n.d.). Boring but important: A self-transcendent purpose for learning fosters academic self-regulation. *Journal of Personality and Social Psychology*, *107*(4), 559-580.
[567] RES5: Preserving through challenges but seeking help when needed
[568] RES4: Orienting to a meaning or purpose
[569] Coleman, J. (2017). You Don't Find Purpose - You Build It. *Harvard Business Review*.
[570] MET7: Thinking and adapting flexibly

Chapter Eight
The How

"I want to emphasize that a lot of AI is also going to automate really bad ways of teaching. So [we need to] think about it as a way of creating new types of teaching." - Dr. Daniel Schwartz, Dean of Stanford Graduate School of Education, at the AI+Education Summit.[571]

"AI will enhance—but never replace—the work that students and teachers do together in the classroom" - Bill Gates, Philanthropist, in his newsletter.[572]

As stated in Chapter Four, "Chapter Eight will thus **focus on the Design** aspect first and foremost, showcasing how all the recommendations can be designed together cohesively. Given the extremely dynamic and fluid situations at play, which will decant only over time, this book will not cover the various Delivery aspects except for a short section on Prompts, and on Adaptive Learning and ITS." **For those interested in a comprehensive overview of the very many possible uses of AI in Education, the "AI in Education Map"[573] should serve them well.**

Redesigning Curricula and Courseware

The preceding chapters have made the case that Modern Curriculum = Essential Content + Interdisciplinary Themes + Core Concepts + Competencies + Identity/Agency/Purpose + Pedagogical considerations (projects, assessments, techniques, etc.). The example below shows how all such parameters can come together. This is a real case of a school in Ontario, Canada, that must abide by the Ontario language standards for English, but this example is, of course, transposable to other disciplines.

1) Essential Content and jurisdictional standards: Ideally, those would have been updated via the process described in Chapter Five, and the Appendix, to be modernized (for Essentiality, Produce/Interpret/Appreciate, Given/Asked/Can, etc.). Regardless, they always contain enough leeway for the school/teacher to continue with the process that follows.
2) Core Concepts: extraction and mapping: ideally, this complex process will have been done in advance, and mapped to the standards,[574] at both discipline-level and branch-level.

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[571] Stanford University HAI (2023).
[572] Gates (2023).
[573] Holt, L. (2023). A map of generative AI for education. *Medium.* https://medium.com/@LaurenceHolt/map-of-ai-for-education-cd6863fecf87
[574] CCR has extracted Core Concepts and created such mappings for a number of entities, such as the Gates Foundation, for four entry-level college courses: Chemistry, Psychology, Sociology, and Statistics & Probabilities: https://curriculumredesign.org/higher-education-learning-outcomes/. In K-12, it has done so for Mathematics, History, Technology & Engineering, and is continuing on with other disciplines.

Grade Level	Mandatory standards	Map Core Concepts
Grade 9	Modernized	Discipline & Branch
Grade 10	Modernized	Discipline & Branch
Grade 11	Modernized	Discipline & Branch
Grade 12	Modernized	Discipline & Branch

3) Next, Interdisciplinary Themes are chosen: for instance: Information, and Environmental, Literacy for grades 9 and 10; Global, and Civic, literacies for grades 11 and 12.
4) Next, the inclusion of a broader, global literacy (which is part of the CCR Interdisciplinary Themes as well): Texts will be chosen[575] to correspond to the interdisciplinary themes.

Map Core Concepts	Cover Interdisciplinary Themes	World Literature
Discipline & Branch	Info + Environmental Literacy	Choices
Discipline & Branch	Info + Environmental Literacy	Choices
Discipline & Branch	Global + Civic Literacy	Choices
Discipline & Branch	Global + Civic Literacy	Choices

5) Drivers of Personalization are introduced: the students are encouraged to choose a subset of the texts to explore their Identity/Agency/Purpose, to generate motivation.

6) Pedagogies: various modern pedagogies are introduced, in the form of modes of expression. The final year allows for a larger project matching a UN SDG goal or equivalent.[576]

7) Digital Humanities are then applied during the teaching, for expanded digital literacy (another CCR interdisciplinary theme).

[575] CCR has created a database of 275 curated works from a variety of cultures: https://worldliterature.curriculumredesign.org/browse?searchQuery=
[576] CCR has created a database of 240 Projects aligned with the UN SDG's: https://passionprojects.curriculumredesign.org/

Drivers I/A/P (M)	Apply Modern Pedagogies	Use Digital Humanities Technologies
I, A	Digital communications (social media, etc.)	Word frequency; language analysis; Sentiment Analysis; Text-to-image; Text-to-video; Concept extraction; Knowledge graphs; Pattern recognition; longitudinal dynamics; databasing
I, A	Public Speaking, Debate, Negotiation	
A, P	Journalism, Poetry	
A, P	Projects on SDGs	

8) Finally, Competencies: the competencies will have been selected for this particular discipline, based on CCR's research of which competency is best served by which discipline.[577] The result for Native language is Creativity, Critical Thinking, Communication, Metacognition and Ethics.

Embed Competencies
CRE, CRI, COM, MET + ETH
CRE, CRI, COM, MET + ETH
CRE, CRI, COM, MET + ETH
CRE, CRI, COM, MET + ETH

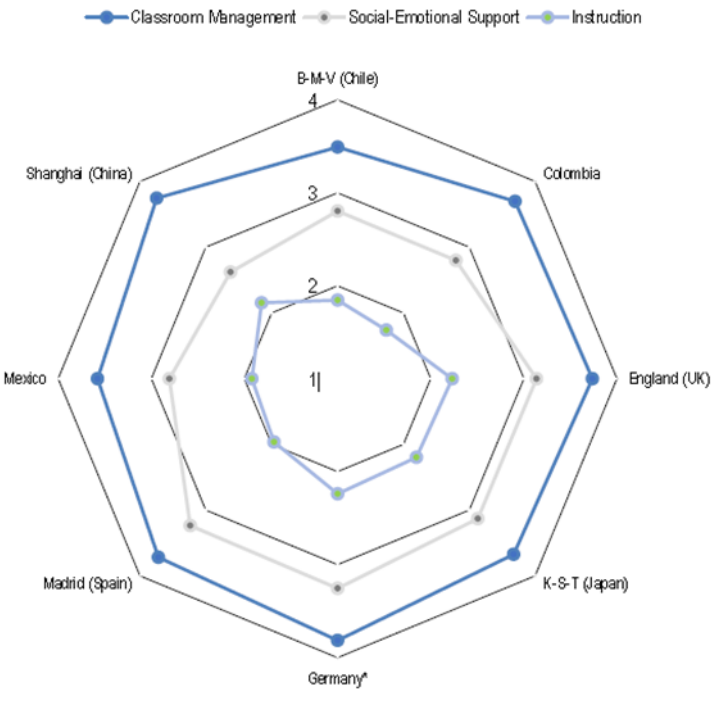
This example demonstrates that with careful design, all the required parameters can be intertwined together like a rope, each one bringing more solidity to the complete construct.

Consequences for the role of teachers

From the design complexity outlined above, it seems clear that the already overburdened teacher will be extremely challenged to do, *solo*, what takes CCR a team of experts to design, over several months, for a *single* course! The OECD's Global Video Study of Teaching[578] has highlighted how teachers are already stretched to become sufficiently proficient at Instruction itself, *even with the **past** requirements*.

[577] Dunn, K. et al. (2021). Embedding competencies within disciplines. Center for Curriculum Redesign. https://curriculumredesign.org/wp-content/uploads/Embedding-Competencies-within-Disciplines-aka-Top4-CCR-June-2021.pdf

[578] OECD (2020), Global Teaching InSights: A Video Study of Teaching, OECD Publishing, Paris, https://doi.org/10.1787/20d6f36b-en



(Source: OECD Global Video Study, 2019)

Education systems are asking too much of teachers: to be superhumans and to go beyond the breaking point. The modern curricular requirements will force a welcome, different focus on their role, from being historically both a content designer AND delivery agent in the classroom, to a much greater focus on classroom delivery (and being offloaded of the courseware design). Content creation will rely increasingly on well-resourced teams assisted with AI tools, as has historically been of book publishers.

This adaptation will, of course, be attacked by some as a de-professionalizing of their role, or having to blindly follow procedures, but it is neither: Their professional development to handle this pedagogical complexity needs to be vastly increased,[579] *and the curricula/courseware are important guidelines to draw from as they personalize education in the classroom.*
A modern, pre-designed curriculum and courseware and their tools thus need to be seen as a "force multiplier" (an "exoskeleton for teachers"), allowing them to focus on:

- Local adaptations of the curriculum, and classroom strategies
- Personalized student learning, with various degrees of AI assistance
- Student social-emotional support
- Collaboration with other teachers and outside experts
- Working with parents and administrators
- Professional and personal growth

[579] Via, for instance, professional certifications like NBPTS in the USA: https://www.nbpts.org/

The first, but likely transitory phase, will witness the emergence of AI-assistants to teachers for course design, and for lesson plan augmentation. But over time, it seems unlikely that this situation will perdure, as it still places the course design burden on the teacher.

Lastly, as mentioned in Chapter Four, all this presupposes the availability of competent teachers, which is not a given in many areas of both developed and developing worlds.

Prompts and their Engineering - here to stay?

"Prompts" are the queries sent to the LLMs, which, hopefully, readers of this book will have experienced firsthand. The explicitness of Prompts is increasingly being recognized as determinant in the success of a query: in a sense, *a Prompt is coding without a computer language*. It requires the prompters to carefully think through their questions in detail, and describe all the attributes they seek in the LLM's answer.

This means that good prompts require significant upfront cognitive investment, which must be constantly weighed against the return on that investment. "Prompt Engineering" has thus emerged as a serious field, with high salaries offered to those who master the art/science of prompt writing, and the emergence of prompt compilations that sell their wares on websites. It is noteworthy that some prompts are pages long!

One added complexity is the partially stochastic nature of the algorithms, and the changing nature of the LLMs datasets and such algorithms, which means that a given prompt can provide different answers, even within the same LLM, just seconds later; and responses will differ all the more among different LLMs. Furthermore, several papers have described how AI can be better at prompt generation than humans,[580] and how AI can be effectively employed to refine and optimize its own prompts! [581] "Last year, in a paper presented at NeurIPS, the field's flagship meeting, researchers at Google Brain showed how a model prompted to explain itself (a capacity called

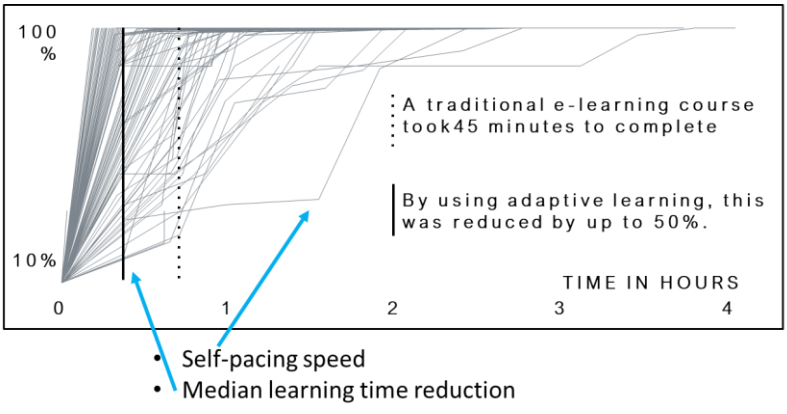
[580] LLMs are human-level Prompt Engineers -Arxiv 2211.01910. And: Zamfirescu-Pereira, J.D.,Wong, R.Y. et al. (2023). Why Johnny can't prompt: How non-AI experts try (and fail) to design LLM prompts. CHI '23: Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems. Article No. 437, 1–21 https://doi.org/10.1145/3544548.3581388; Burger Doug, "AutoGen: Enabling next-generation large language model applications." Microsoft Research Blog, 25 Sep. 2023, https://www.microsoft.com/en-us/research/blog/autogen-enabling-next-generation-large-language-model-applications/ and Fernando, Chrisantha, et al. "Promptbreeder: Self-Referential Self-Improvement Via Prompt Evolution." arXiv, 28 Sept 2023

[581] Yang, C., Wang, X. et al. (2023). Large Language Models as Optimizers. *ArXiv*: Cornell University. https://arxiv.org/abs/2309.03409; Diao, S., Wang, P., Lin, Y., & Zhang, T. (2023). Active Prompting with Chain-of-Thought for Large Language Models. *ArXiv*: Cornell University. https://arxiv.org/abs/2302.12246; Guo, Q., Wang, R. et al. (2023). Connecting large language models with evolutionary algorithms yields powerful prompt optimizers. *ArXiv:* Cornell University. https://arxiv.org/abs/2309.08532

chain-of-thought reasoning) could correctly solve a math word problem, while the same model without that prompt could not."[582] Advances will continue at a rapid pace, but the authors of this book do not believe, at this stage, that prompts will mostly be dispensed with - that would imply divination (!) on the part of the LLM: for a precise answer, the LLM will likely need precise questions, as even a cogent human would. *This also implies continued Prompt design proficiency will still be required from teachers.*

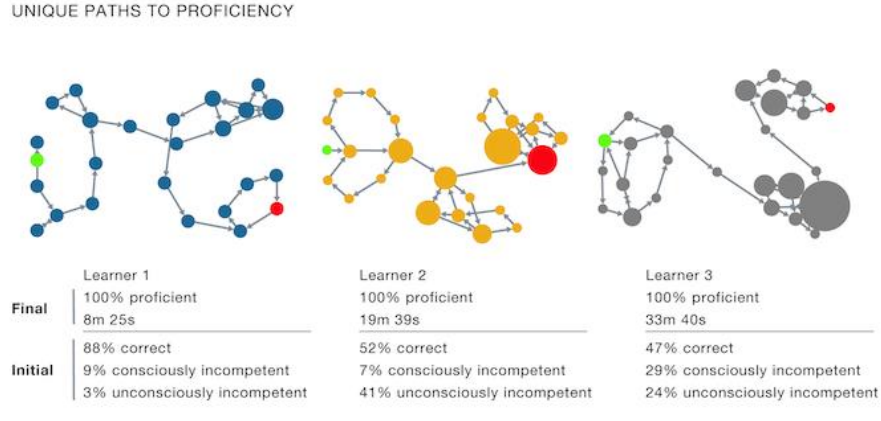
From Adaptive Learning to Intelligent Tutoring Systems[583]

The case for adaptive learning can be made at two levels: Learning time reduction for the median, and self-pacing, as shown in the diagram below:



(Source: Area9 Lyceum)

The self-pacing aspect is better served by technology, given its ability to track every student independently:

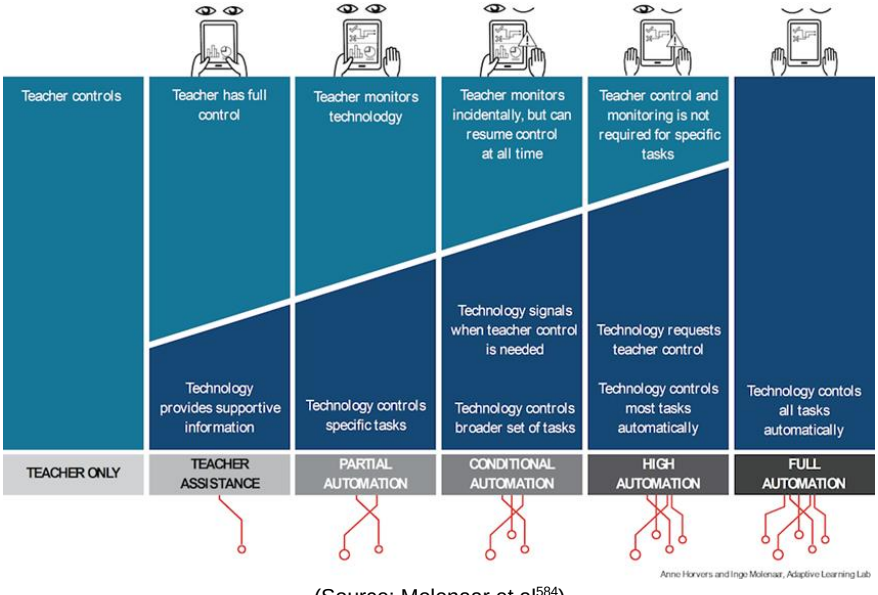


(Source: Area9 Lyceum)

[582] Quanta Magazine, March 16, 2023 by Stephen Ornes, https://www.quantamagazine.org/the-unpredictable-abilities-emerging-from-large-ai-models-20230316/

[583] For a technical overview, the reader is referred to CCR's "Artificial Intelligence in Education"

But it is not yet clear the extent to which such systems will be driven completely vs partially, by teacher vs student. It will take numerous experiments to understand all the variables that drive each scenario and their interplay (for instance: verticality of the discipline; proficiency of the teacher; level of the student; etc.). The following diagram shows the various scenarios yet to be understood (per discipline, per age group, etc.):



(Source: Molenaar et al[584])

A possible solution to teacher shortages?

Notably, the world needs 44 million more teachers to educate every child, according to UNESCO,[585] and yet half the OECD countries face teacher shortages:[586] it is highly unlikely they will be recruited and trained fast enough, particularly given the increased requirements of the What. Using a healthcare analogy, CCR predicts the growing acceptance of “nurse-equivalents” assisted by AI, rather than the sole reliance on “general practitioners”. As in Health Care, it would of course be much better to have better-trained general practitioners, but that may, sadly, simply not be economically or politically feasible in many countries or even individual districts or schools…

[584] Molenaar, I. (2021), "Personalisation of learning: Towards hybrid human-AI learning technologies", in OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots, OECD Publishing, Paris,

[585] UNESCO, International Task Force on Teachers for Education 2030. (2023). The teachers we need for the education we want: the global imperative to reverse the teacher shortage; factsheet. *UNESCO Digital Library.* https://unesdoc.unesco.org/ark:/48223/pf0000387001

[586] OECD. (2023). Latest PISA results. OECD.org. https://www.oecd.org/pisa/

In Summary

AI holds significant promise in education by offering high potential in two critical and interdependent facets of teaching: Design, and Delivery. In the realm of Design, AI can assist educators in crafting innovative and tailored curricula and lesson plans, ensuring that educational content is learning-sciences-based, engaging, and effective. In the area of Delivery, AI can power ITS'es that provide personalized learning for students, addressing their individual strengths and weaknesses. Through data analysis and predictive algorithms, AI can also help educators make informed decisions to meet the diverse needs of their students.

Conclusion

PISA 2022 results[587]:

Just as this book was being completed, the OECD published its PISA 2022 results, which are sobering to many. It makes the following recommendations to the question: **What can we learn from resilient education systems?**

1. "Keep schools open longer for more students": this is in line with CCR's views about modern knowledge, and schools as a hub of stability.
2. "Prepare students for autonomous learning": similarly, this is much in line with Meta-Learning, and Motivation/Identity/Agency/Purpose, coupled with AI-helped learning.
3. "Build strong foundations for learning and well-being for all students": this is related to poverty and insecurity, not addressed in this book.
4. "Limit the distractions caused by using digital devices in class": not addressed in this book, deliberately.
5. "Strengthen school-family partnerships and keep parents involved in student learning": not addressed in this book, deliberately.
6. "Delay the age at selection into different education programmes": tackled as the choice between Produce/Interpret Appreciate while still providing a broad foundation for all.
7. "Provide additional support to struggling students instead of requiring them to repeat a grade": Adaptive Learning and ITS should help this issue.
8. "Ensure adequate, high-quality education staff and materials": Not addressed in this book, deliberately.
9. "Establish schools as hubs for social interaction": this is in line with CCR's views about schools as a hub of stability.
10. "Combine school autonomy and quality assurance mechanisms": Not addressed in this book, deliberately.

Focus of this book, vs OECD recommendations above

Education is a large field, and CCR did not try to address many policy issues highlighted by the OECD. This book attempted to clarify the complexities induced by AI, and help foster thorough conversation leading to action. CCR has tried to showcase that all these complexities can be designed into standards, curricula, courseware, and assessments; and require significantly enhanced professional development. This is not magic*; it is explicitly deliberate, systematic, comprehensive, and demonstrable hard work* - CCR's mantra.

[587] OECD. (2022). PISA 2022 results. OECD.org. https://www.oecd.org/publication/pisa-2022-results/#recommendations

Training for Curriculum teams: Clearly, this increased complexity requires significant training for the education departments/ministries involved. CCR recommends a "gradual release of responsibility approach" also known as "you watch, I do; we co-design; I watch, you do." CCR could design one grade, co-design a second one, and then a jurisdiction would design the third one with CCR's advice. CCR also recommends starting with the "Significant Rework" approach, and then once mastered, move to the "Deepest Redesign" approach. CCR looks forward to continuing to assist jurisdictions and school systems in their change process info@curriculumredesign.org

The Real Culprit, unmasked: University entrance requirements

This book has voiced an increased sense of urgency, to respond to life and employability requirements of this century, and of AI. Yet public sector systems, and in particular education, are among the slowest to change. On one hand, "do no harm" is a wise mindset. On the other hand, what if immobilism becomes more harmful than acting? This book contends that **not** acting is indeed more harmful.

Beyond all the philosophical debates of education, CCR's root-cause analysis[588] finds the Gordian knot, ***the unwitting culprit in freezing all changes: university entrance requirements***. Whether called Gao Kao or Baccalaureat or SAT/GPA, these summative, end-of-studies tests enshrine what gets taught, and are highly resistant to improvement. CCR's efforts in the coming years, in concert with the OECD, will act at loosening the stranglehold.

[588] Bialik, M. & Fadel, C. (2017). Overcoming system inertia in education reform. Center for Curriculum Redesign. https://curriculumredesign.org/wp-content/uploads/Inertia-in-Education-CCR-Final.pdf

Epilogue

By Dr. Michael Fullan, OC, Professor Emeritus, OISE/University of Toronto

"What an honor it is to be connected to this book!

The previous chapters you have just read paint a picture of excitement, concern, and unknown opportunity. Our advice is first getting a sense of the scope and depth of events that are likely to occur. By definition you won't be able to get a clear view of what is likely to transpire. No one can. But an overview will be helpful. Then delve into a component that is most relevant to your interests. Maybe you are a teacher, an entrepreneur, or policymaker – or a parent concerned about their children's future, or a young person wondering what the next 20 years will be like. A good exercise for almost everyone is to delve into the future of occupations by examining occupations that members of family are involved in; or what could be the future of work if you, or people you know, do not currently have work right now.

Our best advice is to take a dual lens. Consider the big picture --what is likely to happen to the world and the universe no matter how fantastic the possibilities – good or bad. At the other end examine your own situations and that of your family or friends. What is happening now? What could happen in the short run (within a year or two). What could you do, or how should you approach it? Apply the lens of yourself, family and friends and the world at large.

We doubt if humans at any time in our history have been so aware of the bigger context; or has there been an era where the very young have witnessed such turmoil in their early lifetimes, or seen such spectacular innovations. When all is said and done, we are in an era where living, and being aware of living, have ever been so palpable for better and/or for worse.

In short, read and apply the ideas, thinking and questions that occur to you as you go through the chapters of the book. Wonder about the future of humanity, your place in it, and how to affect positive change."

Final Words

Tipping our hat to A.C. Clarke

SAL-9000 : "Dr Chandra, will I dream?"
Dr. Chandra : "Of course SAL, you will. All intelligent beings dream."
(Movie: 2010 - *The Year We Make Contact*[589]; sequel to *2001 - A Space Odyssey*)

Biographies

Charles Fadel
Charles is a global education thought leader and author, futurist and inventor, founder and chairman of the Center for Curriculum Redesign, chair of the education committee at BIAC/OECD, member of OECD Expert Group on AI Futures, co-author of *Education for the Age of AI* (2024), *Artificial Intelligence in Education* (2019), *Four-Dimensional Education* (framework in 23 languages), and *21st Century Skills* (Wiley, 2009). "21st Century Skills" has become a moniker used worldwide.

He has worked with education systems and institutions in more than 30 countries and spent 25 years in technology management (M/A-COM, NeurodyneAI [founder], Analog Devices, Cisco Systems).

Formerly, he was founder and president of Fondation Helvetica Educatio (Geneva, Switzerland), Global Education Lead at Cisco Systems, visiting scholar at MIT ESG and Wharton/Penn CLO, project director Harvard GSE, member of the President's Council at Olin College of Engineering, and angel investor with Beacon Angels. He holds a BSEE, an MBA, and seven patents (plus one pending).

Full Bio at: http://curriculumredesign.org/about/team/#charles

Alexis Black (Dr.)
Alexis is a PhD (2019) in Anthropology whose research focuses on the relationship between language, imagination, and human reality. Her work primarily studies language use as speakers "make sense" of their experiences in novel situations and unknown or future scenarios. Her postdoctoral research (2020-2021, generously funded by the Fyssen

[589] Wikipedia. (2023). The year we make contact. https://en.wikipedia.org/wiki/2010:_The_Year_We_Make_Contact

Foundation) addressed health storytelling and comprehension of crisis during the COVID-19 pandemic. Currently a Senior Researcher at the Center for Curriculum Redesign, her expertise in sense-making practices and extensive research experience align with CCR's goals to design pertinent curricula and tools for a future-facing world.

Robbie Taylor
Robbie is a Distinguished Senior Advisor at CCR, where they lead and collaborate on projects which include development of the 4-Dimensional Framework, global measurement of competencies[590], and consulting and professional development for schools and teachers. Previously they were the Curriculum Coordinator and the Art & Design Teacher at Austin Preparatory School. They earned a M.Ed. in School Leadership from Harvard Graduate School of Education and a B.A. in Communication Studies from Northeastern University.

Janet Slesinski
Janet is an educational consultant working with CCR. She coaches teachers globally to develop stronger content, pedagogy, and assessment knowledge. She contributes to the development of modern mathematics curricula, competency research, and courseware development. Previously, she was Director of Mathematics at Regional School District 19, in Mansfield, CT, and has taught high school mathematics in Vermont, Tennessee, and Connecticut. She earned an M.S. in Curriculum from Saint Michael's College, a B.S. in Secondary Education, a B.S. in Mathematics, and a B.A. in Physics from the University of Vermont.

Katie Dunn
Katie is an education researcher and project manager at CCR. Previously, she was a Science and Mathematics Teacher at Boston Latin School. She earned a M.Ed. from High Meadows Graduate School of Teaching and Learning (Formerly Woodrow Wilson Institute, in collaboration with MIT) and a B.S. in Physics and Planetary Science from the Massachusetts Institute of Technology (MIT).

A. M. E. G.

[590] Taylor, R. et al. (2020). Competencies for the 21st century: jurisdictional progress. Brookings Institute. https://www.brookings.edu/articles/competencies-for-the-21st-century-jurisdictional-progress/

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