# Validating the Potential to Exponentially Increase Outcomes of Education through Cooperation Between Multiple AI Based Intelligent Agents that is Organized by a General Collective Intelligence Based Platform Model

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**Abstract**

A General Collective Intelligence (GCI) is a model for a platform designed with the goal of organizing individuals or individual intelligent agents into coherent collective reasoning processes. The GCI platform model is predicted to exponentially increase the general problem-solving ability (collective intelligence) of the group as compared to individual humans when the limits to the speed and scale of each human's interaction with the collective reasoning are removed by training an intelligent agent to respond with the preferences of that human, and by replicating those intelligent agents to create as many instances as required to achieve the target speed and scale. The implications of an exponential increase in ability to solve any problem in general are an exponential increase in ability to solve the problem of customizing educational content and every other aspect of education to each individual student, as well as an exponential increase in ability to solve the problem of improving the productivity and effectiveness of teachers. But none of this can be achieved if group problem-solving processes lack the collective intelligence to be able to reliably assess this is feasible, so that the resources and participation required to achieve it can be mobilized. This paper outlines the shortcomings in current group problem-solving processes that prevents the assessment of such complex claims from being reliably accomplishable, particularly in education, and proposes a GCI based process for assessing the feasibility of these claims. This paper then simulates the outcome of this process through the use of AI to represent the opinions of hypothetical expert educators, and then draws conclusions from the outcome.

**Keywords**

General Collective Intelligence, LLM, Human-Centric Functional Modeling, functional state space

## 1. Introduction

This experiment aims to use a methodology based on a model for a General Collective Intelligence or GCI platform [1], to significantly increase the capacity of the education community to assess whether and how AI should be incorporated into education, in particular by creating the collective capacity to assess the interventions suggested by any member of the community, in this case to assess whether and how educational outcomes might be significantly improved with interventions based on AI and GCI.

This GCI based assessment approach will be used to assess the validity of arguments presented in a number of other papers that describe proposed educational interventions based on AI and GCI. These arguments are intended to support the conclusion that in multi cellular organisms nature has

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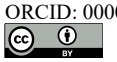

provided us with a model for decentralized and distributed problem-solving that can have exponentially greater general problem-solving ability in being able to address problems exponentially more complex than any individual cell can organize all other cells to solve, and that this solution can be generalized to allow a network of entities (humans and/or intelligent agents) to address collective problems that no single entity can reliably organize any group to solve in a top-down way. The solution is then in the construction and intelligence of the network, not in the individual. Where existing approaches to incorporating AI into education contain a single intervention or a set of interventions designed from the top-down, the GCI model is designed to mimic nature's solution of enabling networks of interventions to self-assemble from the bottom-up in order adopt any problem definition and/or any solution, and in order to vastly scale the cooperation to implement that solution, in order to in turn create the potential capacity to exponentially increase impact on any collective outcome that is targeted, in this case improving educational outcomes with AI and GCI.

## 2. Background Concepts

Research in AI and education is progressing at a rapid pace. As such much of the work is still in the pre-print phase and there is no established journal, workshop, conference, or other forum for this work. In addition, many of the background concepts summarized in this paper are novel. As such, despite having been validated by the academic peer review process, they remain to be validated by the consensus of the academic community, but at the same time this validation through consensus is difficult to achieve without any widespread awareness of these concepts in the scientific community. Consensus is not possible when the group isn't aware of the concepts and therefore is not aware of the need to validate them. However, the concepts are summarized with the goal of using GCI to mobilize that assessment.

### 2.1. Human-Centric Functional Modeling

Human-Centric Functional Modeling or HCFM [2] hypothesizes that any possible behavior of any human system can be represented within the "functional state space" defined to describe the domain of functionality that system contains. Each functional state of the system describes only the functionality the system must execute to get to that state, as well as the functionality the system can execute from that state, as opposed to describing how the system actually achieves this functionality. In this way, the functional state space of a system can describe any possible system behavior that can be observed (can model any possible functional state, and any possible process through which the system might transition between functional states), without the modeler having to understand how the actual system works.

The functional state spaces of this human organism include a functional state space for our emotional system, a functional state space for our cognitive system, and a functional state space for our conscious self-awareness. In HCFM, human cognition is a process capable of navigating a single space of concepts described as a "conceptual space" (the functional state space of the cognitive system). The usefulness of this approach is that assuming that this conceptual space can contain any possible concepts and/or reasoning, by understanding the properties of this conceptual space it is possible to understand properties of cognition that apply to all concepts and/or reasoning processes the space can contain. Where any given reasoning process about the implications of AI in education might be right or wrong, any insight deduced using the properties of conceptual space that apply to all concepts and/or reasoning can still be correct. One of these properties for which HCFM provides a functional model defining that property is the meaning of the existence of general problem-solving ability, which at the individual level is intelligence, and at the group level is collective intelligence. Another one of these properties for which HCFM provides a functional definition is the magnitude of individual or collective intelligence. These definitions are required in order to be able to say that the increase in intelligence achieved through a given methodology or tool can be "exponential".

## 2.2. General Collective Intelligence (GCI) Platforms

A General Collective Intelligence or GCI platform [3] is a hypothetical platform that organizes individuals and/or intelligent agents into a collective cognition capable of executing collective reasoning in a coherent way. A GCI is predicted to exponentially increase the general problem-solving ability of groups by enabling them to self-assemble into networks capable of exploring a vastly greater number of permutations and combiinations of any components of reasoning of any individual in the group at vastly greater specificity, and therefore capable of exploring a vastly greater volume and density of the collective conceptual space, in order to assess which reasoning is the most correct.

Assume that an exponential increase in general problem-solving ability is equivalent to an exponential increase in ability to solve any problem in general. This suggests that a GCI is predicted to exponentially increase capacity to solve problems in any discipline. In fact assessing the validity of claims that GCI might exponentially increase general problem-solving ability in a few selected disciplines (mathematics, physics, biology, economics, computer science and engineering, psychology, systems science, and sustainable development), and that for this reason education in the future might be based on GCI, is part of the follow-up suggested for this research.

## 2.3. Large Language Models as Intelligent Agents

Large Language Models (LLMs) have been increasingly seen as a promising tool in the quest to approximate intelligent agents. The literature points to their capability in understanding, generating, and responding to human language in a coherent manner, which makes them a potential asset in mediating group processes and augmenting human interactions [4]

In the realm of education, LLMs have been leveraged to deliver personalized learning experiences and to aid teachers in assessing and guiding students' learning. Ormerod et al. [5] demonstrated that LLMs can be used to generate personalized feedback for students' essays, thus increasing the speed of feedback provision and scale of students’ work that can be handled by a single teacher.

Moreover, LLMs have been used to create adaptive tutoring systems. These systems can guide learners through a curriculum by providing immediate feedback, answering queries, and suggesting next steps in the learning process [6]. Such systems are not only scalable but also hold the promise of improving learning outcomes by catering to individual learning styles and paces.

LLMs also have potential in supporting teachers' professional development. They can serve as a resource for teachers to ask questions, share best practices, and seek advice on teaching strategies [7]. This use of LLMs can aid in reducing the time that teachers spend on seeking help and, in turn, contribute to improving teaching outcomes.

However, there are also important considerations and potential pitfalls to bear in mind. LLMs' interaction with group processes and individual users can sometimes lead to the propagation of misinformation or biases present in the training data [8]. Furthermore, the efficacy and ethical implications of LLMs in educational contexts, including the risk of over-reliance on AI and potential privacy concerns, are topics that warrant further investigation [6].

Overall, while there are promising indications, the use of LLMs as intelligent agents in the context of group processes and education remains a nascent field with much potential for exploration and development.

## 2.4. Using AI Based Intelligent Agents and GCI to Improve Educational Outcomes

As mentioned, HCFM hypothesizes that the functional state spaces of this human organism includes spaces for each of the five senses of the body as our physical system, a space for our emotional system, a space for our cognitive system, and a space for our conscious self-awareness. These functional state spaces form a composite functional state space called the "human state space". Since the outside world can only be experienced through this human system, then through representing each of these component systems as navigating its own functional state space, our experience of any possible entity or process in the outside world (in this case related to education) might be objectively described in terms of the paths through which our experience with that entity or process moves each of our systems within that particular system's functional state space. In that functional state spaces are hypothesized to provide a complete model of the meaning of functional states and of the processes used to transition between them (a complete semantic model of these functional states and of these processes), and in that these functional state spaces have the potential capacity to represent that meaning at any level of detail, then HCFM might potentially be used to more reliably communicate the meaning of any multimodal educational intervention (obtained from various modalities, such as language, images, videos, and sensor data) in terms of the path it takes the learner, teacher or other participant through this hypothetical human state space. The impact of that educational process in turn might be represented by the corresponding motion related in the fitness space of the individual (the increase or decrease in fitness to achieve a targeted outcome).

If tools like ChatGPT and GCI vastly increase our capacity to generate reasoning from a set of assumed "facts", then facts and reasoning become unimportant as the objects that must be communicated by education and received through learning, and instead the most important objects of learning and education become the patterns through which truth in facts and reasoning might be identified. Since current teaching methods prioritize facts and reasoning, this suggests GCI and ChatGPT might completely disrupt current education and make it largely obsolete for knowledge workers at the leading edge of productivity. In other words, traditional education might still exist, but if the coming technological changes, particularly AI, fulfill their promise of becoming incorporated into the life-cycle of every product or service, with the market for AI growing at an unprecedented rate, recipients of that traditional education who are largely ill-equipped to receive these benefits might expect to be marginalized and to fall behind at a historically unprecedented rate as well.

## 2.5. Shortcomings of Current Group Problem-Solving Processes

A recent empirical study [9] evaluating the fitness of the relevant scientific community's problem-solving processes (described as their Collective Intelligence or CI and measured by their general collective intelligence or C factor) with respect to being able to solve the problems most relevant to them, found an insufficient C factor in many cases, indicating that the scientific community has not collectively reasoned through possible viewpoints.

In summary, groups can't reliably assess the validity of a concept when they don't reliably ask all the questions required to do so, when they don't reliably question group reasoning that is inconsistent, incomplete, and/or otherwise flawed, as well as for a number of other reasons. For example, assessing the validity of a concept might require one thousand questions, but the group can only reliably be made to ask ten questions in a given forum such as a conference or workshop. Such a concept is then too complex for the group to reliably be able to assess the correctness of that concept within that forum. This is assumed to be equivalent to saying that the C factor of the group is insufficient to solve that problem in that forum.

The significance of this research is that basic ideas required to develop solutions to resolve difficult questions like whether and how AI might be used in education might or might not already exist. But whether or not they exist is irrelevant if groups can't reliably reason through the implications of all those ideas, and can't reliably converge on the correct ones. Therefore research exploring whether and how LLMs might be incorporated into education might be far less important than implementing a

General Collective Intelligence based platform or process that is able to radically increase our collective ability to answer this question.

## 3. Hypothesis

The hypothesis to be tested in this paper is that a GCI based process can be created to assess the feasibility of leveraging AI and GCI to achieve an exponential increase in ability to solve the problem of improving learner outcomes, such as through customizing educational content and every other aspect of education so that it is optimal for each individual student, as well as an exponential increase in ability to solve the problem of improving teacher outcomes, such as through improving the productivity and effectiveness of teachers.

## 4. Methods

In the intended version of this experiment, each individual attending the workshop "AIED2023 Empowering Education with LLMs - the Next-Gen Interface and Content Generation" who decides to participate would be asked whether they are willing to weigh in on any one or more of a set of questions concerning the hypothesis that a GCI based process can be created to assess the feasibility of an exponential increase in ability to solve the problem of improving learning and ability to solve the problem of improving the productivity and effectiveness of teachers. Since group based reasoning processes such as consensus are not appropriate where topics are new within a group and consensus doesn't yet exist, and if it is valid that using consensus characterizes the reasoning style of some individuals, ChatGPT would be asked to use the indicators of that reasoning style to determine which of each individual's selected questions will actually be assigned to that individual. For the questions they select, and for the questions that ChatGPT suggests they are equipped to answer, ChatGPT will be asked to review the individual's research up to its cutoff date of September 2021. ChatGPT would then be asked to review the material supporting the arguments and to simulate an assessment of the validity of those arguments from the perspective of those researchers. The researchers would then be allowed to validate ChatGPT's evaluation of that feasibility if they so chose. Only evaluations conducted by ChatGPT that are complemented with human oversight in this way, particularly when it involves ethical considerations and methodological rigor, would be considered in the final assessment of the results of the experiment, since the involvement of AI in these processes should be supportive and not replace human decision-making, particularly in areas that require nuanced understanding and judgment. This procedure was meant to reduce the human effort required to assess all of these arguments, so that an assessment is reliably achievable within the effort that individuals are willing to commit. However, in this early version of the experiment, due to lack of access to those researchers prior to the workshop, all responses will be simulated by ChatGPT. The prompts used for this simulation are to be found in the supplementary data to this paper (supplementary data: prompts 1 to 8).

The ChatGPT4 prompts consisted of the following steps:

- Step 1: assess whether it is feasible that an exponential increase in the general problem-solving ability of groups of individuals (as compared to any individual in the group) is achievable through the use of GCI to orchestrate the participation of those individuals into coherent collective reasoning processes, and through the use of AI based intelligent agents to interact with the collective reasoning processes on behalf of those individuals to remove the human limits on the speed and scale of collective reasoning.
- Step 2: assess whether it is feasible that an exponential increase in the general problem-solving ability of groups of individuals is equivalent to an exponential increase in the ability of the group to solve any problem in general.
- Step 3: assess whether it is feasible that an exponential increase in the ability of the group to solve any problem in general implies an exponential increase in ability to solve the

problem of improving outcomes for learners and an exponential increase in ability to solve the problem of improving outcomes for teachers.

- Step 4: assess whether it is feasible that leveraging AI and GCI could lead to achieving an exponential increase in ability to solve the problem of improving learning and an exponential increase in ability to solve the problem of improving the productivity and effectiveness of teachers.
- Step 5: assess whether it is feasible that it is valid to pre-screen respondents in steps 1, 2, 3, and 4, so that these claims are assessed by individuals who don't use reasoning by consensus, since if the community is not aware of these concepts no consensus is possible.
- Step 6: assess whether it feasible that it is reliably achievable for this GCI based process to assess the feasibility of leveraging AI and GCI to achieve an exponential increase in ability to solve the problem of improving outcomes for learners and an exponential increase in ability to solve the problem of improving outcomes for teachers.

## 5. Results and Observations

The results of this experiment suggest that based on the arguments provided and the results of the previous steps:

- If respondents for claims 1, 2, 3, and 4 have been pre-screened effectively to ensure they do not use reasoning by consensus, this supports the idea that their assessments are based on individual expertise and critical evaluation rather than groupthink or social conformity. This is a positive aspect and increases the reliability of the assessment process.
- The qualification of the experts selected to answer claims 1, 2, 3, 4, and 5 is also crucial. If these individuals have verifiable expertise in education, AI, GCI, and related fields, their opinions can indeed be considered credible and valuable for assessing the feasibility of the stated aims.
- If the feasibility of claims 1, 2, 3, 4, 5, and 6 can be assessed within the time that survey respondents are typically willing to devote, this suggests that the process is efficient and does not impose undue demands on the experts involved.
- Given the earlier steps' results, all of which indicate feasibility, there is a strong case to suggest that this GCI based process can reliably assess the feasibility of leveraging AI and GCI to exponentially increase the ability to solve the problems of improving outcomes for learners and teachers.

To summarize, the arguments for Point 6 seem valid and it appears feasible that this GCI-based process could reliably assess the feasibility of leveraging AI and GCI to significantly improve educational outcomes. However, it's essential to remember that the implementation of AI and GCI solutions comes with its own set of challenges, including ethical concerns, technical difficulties, and the need for extensive training and support.

## 6. Discussion

Relying on research which suggests that groups are limited in their problem-solving ability [9], and that this collective intelligence which solves problems in a way that is aligned with collective outcomes might in some cases even be less than the intelligence of certain individuals in the group, where individuals are defined as solving problems in a way that is aligned with their own individual outcomes, then groups might not be reliably capable of reliably even making an assessment of whether and how AI might benefit learning or teaching in education, much less making a correct one. Therefore research elaborating the concept of GCI as well as actual efforts towards implementing a GCI that is able to reliably assess proposed interventions in order to answer the question of whether and how AI might benefit learning or teaching in education, is predicted to be far more important than the research itself in whether and how AI might benefit learning or teaching in education.

Furthermore, the mathematical construct of conceptual space suggests that there will be a limit past which the facts and reasoning produced by AI will be beyond human capacity to validate. Past this limit humans must either rely solely on AI, which can't reliably be assured to be aligned with human well-being, or humans can rely on AI (in the form of intelligent agents that reflect the needs of individual users) orchestrated by a GCI which it is hypothesized can reliably be assured to be aligned with the collective human well-being.

Finally, an analysis of conceptual space suggests that an exponential increase in ability to learn and to use that learning is possible with AI and GCI. The meaning of these exponential increases are explored below:

## 6.1. LLMs, GCI, and Education in the Science, Technology, Engineering, and Math (STEM) Disciplines

What this might mean is that in the future, when a super-intelligent GCI is able to orchestrate a network of AI based agents in coming to any decision, then even without any knowledge of medicine at all a user might be able to leverage that GCI to conduct surgery and other medical interventions that the best doctors in the world today would consider miraculous and completely beyond their abilities. Users could potentially do so simply through being able recognize the truth regarding which of the vast number and combination of possible interventions can be observed to best improve the condition they are trying to heal. Or which set of interventions best prevent the condition entirely. As another example, even without any knowledge of physics at all, one might be able to leverage a GCI to discover new theories in theoretical physics that are completely beyond the capacity of any human physicist today to discover. Once all data is modeled semantically, as required for GCI in any case, users might be able to do so by simply asking the GCI to show all the phenomena across the entire physical universe where some observed data isn't consistent with any theoretical understanding, and then using GCI to vastly increase capacity to consider any permutations or combinations of any component of any existing theory in discovering a solution.

## 6.2. LLMs, GCI, and Education in the Languages and Humanities

Tools capable of real-time audio translation of languages and real-time generalization and retrieval of metaphorical and allegorical symbolism from the humanities by large language models has both the potential to accelerate learning of languages and the humanities on the one hand, as well as the potential to eliminate the need for learning languages or humanities at all on the other, thereby making their current study obsolete. But such tools also create the potential to vastly increase the importance of the study of languages and the humanities in general when new methods based on HCFM and GCI can be applied. For example, if and when real-time voice translation is available, there will no longer be any need to learn any other human language other than one's native tongue. But at the same time, the ability to study and compare all languages could potentially explode. In the humanities, when LLMs have the ability to abstract metaphorical or allegorical symbols from written works and to generalize them to the context of the current conversation in real-time, so they might be inserted into the conversation in real-time, then the need to familiarize oneself with works like Plato's "Allegory of the Cave" as a famous example of allegory, in order to be able to draw from symbolism like that of the serpent as signifying the tempter or true evil, is a need that simply disappears. However, again, at the same time the ability to study and compare all works in the humanities could potentially explode.

## 7. Limitations and Suggestions for Future Work

The limitations to this work are that due to the novelty of this approach, and therefore the lack of familiarity with it among the educational community, this experiment suffered from a lack of access

to the required experts in the use of AI in education. The survey responses of these human experts in this experiment then had to be completely simulated in ChatGPT without human feedback as to the validity of this feedback. However, once this approach gains more collective awareness, it is hoped that sufficient human participation might be achieved.

Suggestions for future work are to use this GCI based methodology to organize an effort to assess the feasibility of the education related portion of phase II of a ten phase Collective Intelligence based Program to Accelerate Achievement of the Sustainable Development Goals (CIPAA-SDGs). The education related part of phase II aims to pilot a project in Antigua and Barbuda that will leverage GCI with the aim of significantly increasing educational outcomes per program dollar across the CARICOM region, so that those results might be replicated worldwide.

To facilitate this assessment, one suggestion for future work is to explore how a series of meetings might be planned that will invite the attendees of the AIED2023 workshop on "Empowering Education with LLMs - the Next-Gen Interface and Content Generation" to consider what processes and roles are involved in such an assessment, and how collectively intelligent cooperation might be used to significantly increase collective outcomes over any that might reliably be expected without this cooperation. These increased outcomes might then be used as incentives to ensure access to the resources and participants required to execute those processes.

## 8. Conclusions

Current research processes in education, and in every other topic, are centralized in the sense that research doesn't explore how potentially massive networks of interventions can be assembled using network science, orchestrated using AI and GCI. This likely begins with the fact that the sources of funding for such research universally have policies that force the selection of a single intervention or a set of interventions designed from the top-down, rather than networks of interventions that self-assemble from the bottom-up in order adopt any problem definition and/or any solution, and that vastly scale the cooperation to implement that solution, despite such networks creating the potential capacity to exponentially increase impact on any collective educational outcome that is targeted.

This centralization might be clearly visible to outsiders with disruptive ideas based on such network effects, particularly those working in regions other than those from which funding originates, who find themselves unable to generate enough awareness to facilitate any independent assessment of the validity of their ideas, and who find themselves without the funding to conduct empirical studies on their own. Because the validity of such complex concepts can't be assessed through conventional methods within the typical speaking time allotted in a conference, or in the typical number of pages allotted in a journal, then if such researchers lack the independent resources to draw an audience to conferences or publications of their own, then these ideas with the potential to radically transform education in a positive way might effectively be censored.

This paper has explored how collective intelligence might be used to organize attendees of the conference to assess the ability of collective intelligence to fund research into whether and how AI and GCI can be used to significantly improve education at all levels, where a detailed plan for a program intended to actually achieve this has been designed to be piloted in the small island state of Antigua and Barbuda, so that it might be replicated across the CARICOM region, and then globally. This approach is designed to enable foreign countries to invest in deploying such interventions in the relatively "green field" laboratory of Antigua and Barbuda, in order for those countries to achieve significant increases in educational outcomes per dollar back home, particularly in comparison to the amount invested in this research. However, the problem that remains to be cracked is actually engaging this participation.

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