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Ignorance-Oriented Instruction For Future Learning: Principles And Practices

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Abstract: *This article presents a teaching approach known as Ignorance-Oriented Instruction (IOI), which views ignorance as both the driving force and the goal of learning. IOI aims to prepare students for an uncertain future by cultivating their ability to learn by delving into their ignorance and making predictions for the unknown. Key principles underlying the practice of IOI, a course designed based on IOI, and A COPE TRAP model for formulating questions are proposed. The experiences of applying IOI in various classes show that students responded to IOI favorably, although IOI makes the course more challenging than ordinary lecture-based instruction. IOI also presents a significant challenge to instructors because some students' questions cannot be met without preparation in advance. Overall, IOI offers a promising approach to education that can help students learn how to learn, thereby enhancing their capacity to cope with the future challenges.*

Keywords: ignorance-oriented instruction, ignorance-oriented learning, COPE TRAP model, inquiry mode of learning, COPE, TRAP

Introduction

We all wish our children a smooth transition to, if not masterfully taming, the future. Education is supposed to help them to do so, and a reasonable start would be to help them see what the future is like and where their future may lie. However, what happens is that time, always speeding, is suddenly brought to a standstill in schools, which are normally silent about the future while placing a high premium on delivering knowledge from the past. Children are taught to look back to search history for answers. A proper replication of successful experiences is the best scenario one could expect. However, developing with exponentially explosive volatility and uncertainty, the future differs significantly from the past. Children would be at significant risk of being ill-equipped to adjust to the future if they relied solely on the lessons that history offers. Therefore, as Toffler (1970) argued decades ago, "education must shift into the future tense" (p. 427) and prioritizes the mission of helping students to fortify their cope-ability— the ability to adapt swiftly and adequately to the constant changes in the environment. Such adaptation hinges on two key capacities: (1) being perceptive about the problems or opportunities in today's world and (2) being inquisitive and imaginative about the possibilities that could be realized tomorrow. The former is based on the habit of exploring ignorance, and the latter involves the proclivity of predicting the future.

Every day, we march on a journey from now to the future. We can aimlessly stroll down the road without any preparation for what awaits ahead or any idea of where the road leads us. Chances are we wind up somewhere with a regrettable surprise. Or, we can set off the journey by checking our ignorance, which allows us to procure the awareness of the otherwise obliterated sights of ourselves and the world. Such newfound insight helps us adapt and advance while also allowing us to predict how the future may roll out and be prepared if such a prediction becomes reality. Exploring ignorance and conjuring up predictions do not guarantee a successful journey. Still, they can soften the blows from the capricious surroundings and reduce the risks of drifting disorientedly in the dark.

Prediction

The famous Chinese military strategist Sun Tzu (孫子) said, "Knowing yourself and your enemy wins you hundreds of battles." Just like we all try to predict our foe's moves before fighting them to avoid being caught off guard, we should not come unprepared for future shock. The futurist Toffler (1965) argued that the best way to minimize the "future shock" is to foster the ability to form better, limpid, clairvoyant ideas of what may be coming our way. It starts with the practice of predicting what is yet to be known.

Toffler (1965) argued that the value of predicting the future should not be taken lightly. Rather than ridiculing those who fantasize beyond reality, we should foster a culture where individuals, from a young age, are encouraged to engage in imaginative or extravagant speculation. This should extend beyond predicting the outlook of tomorrow and envision the prospects of the upcoming generation for human beings. The first thing to do is to dispel the widespread myth that the future is unknowable. He did not mean to underestimate the capriciousness of the future, but tried to point out the real problem being people underutilizing the power of prediction, rather than overusing it, under the self-handicapping notion that the future is too mystical to know. Surely, no method can predict the future with certainty, but the

messages emanating from patterns or trends should clue in a possible development of tomorrow (Kilpatrick, 1993). A prediction does not have to be precise or accurate to be useful. Having a vague notion of what may await in the future is better than having no idea at all.

Even a rough conjecture of what lies ahead may help us to crack open the inertia or stalemate in our thinking. The more ideas we throw in for processing, the better chance we can generate fresh or even innovative perspectives. This can lead us to approximate the feasible hypotheses that enable us to break free from the status quo. Even if it turns out wrong, a prediction always prompts us to see the differences among alternatives, pushing us to question the necessity of holding onto our reigning thoughts. Critically reflecting on such differences is the first step to push us forward into the future. In fact, as Hicks (2002) argues, it is misguided to evaluate a prediction by how accurately it matches the actual outcomes. Because the act of making the prediction itself may lead to actions that alter the expected outcome, a potentially accurate prediction may ultimately prove to be false as a result, just like a potentially false one may turn out to be true. And, from the perspective of multiple realities, the concept of making an accurate prediction is much murkier.

According to Lincoln and Guba (1985), there are at least four levels of reality:

1. Objective reality (based on naïve realism)—assumes a tangible and objectively existing reality.

2. Perceived reality (based on post-positivism)—argues that reality can only be perceived but never reached.

3. Constructed reality (based on constructivism)—argues for multiple realities people construct.

4. Created reality (based on quantum mechanics)—argues that there is no reality, only the consequences created by observers' behaviors.

In other words, reality can be the ultimate truth to be found, the truth to be approximated but unreachable, versions of construction, or outcomes of human behaviors. When predictions try to reflect realities, different definitions of realities cast different lights on the meaning of predictions. That is, making predictions can mean a guess for what the future is like, a viewpoint that represents the future, a construction for a version of the future, or an action that brings about the future. In other words, besides static speculation, a prediction can theorize, orchestrate, or create the development of the future. Just as historians predict the trajectory of humanity's future, it's not about whether or not they can fortune-telling the future, but rather about highlighting today's problems to fuel the discussions on how we can change the outlook of tomorrow (Harari, 2017). Therefore, the accuracy of a forecast is just one aspect of a prediction, which also includes hypothesizing about the development of the future, envisioning the multifarity of the future, and activating the formation of the future.

Moreover, according to quantum mechanics, when an observation "pops the quiff," it collapses waves of possibilities into a tangible particle (Wolf, 1981). A prediction can also collapse a variety of possibilities into one speculation. However, once a prediction is said out loud, it invites scrutiny of its validity and calls for alternative ideas (Harari, 2017), thereby sparking a wave of thoughts and imaginations that refresh the diverse possibilities for the future. In other words, while the ability to make a prediction

is important, what is equally, if not more, important is the ability to critically examine the validity of the prediction and spin off more ideas out of it.

From the perspective of human development, this is particularly important because children's sense of self hinges on the feedback they receive from the environment as they grow toward the person they envision themselves to be in the future (Matrahah, 2018; Singer, 1974). Educators should guide children to see beyond the routine duties that confine their visions and catch a glimpse of their possible selves. This can begin by fostering the "habit of anticipation" (Toffler, 1970, p. 408), which involves practicing making predictions about everything, including their own future. They should then critically analyze and refine these predictions to build a better sense of the future, which will serve as the foundation for their preparation for future shocks.

Nowadays, in Taiwan, as well as in many areas in the world, education prioritizes preparing students for the challenges of the future. Instructional strategies such as PBLs are particularly designed to foster students' core competencies, such as problem-solving ability, critical thinking, creativity, etc. These strategies emphasize engaging students in authentic problems, projects, or phenomena. Students actively construct meaning based on their prior experiences when they grapple with complex and ill-structured tasks. This process helps them gain deep understanding and practical knowledge, and as a result, they develop core competencies (Krajcik & Shin, 2022). Although emphasizing the "authenticity" or "real-worldness" of learning scenarios is to avert learning problems in a contrived or detached situation, it can also devalue the importance of learning in hypothetical situations. Being authentic or "real-world" suggests something happened at the moment or in the past. The question is, the world of tomorrow will be very different from today's world.

Especially in an era where paradigm shifts and disruptions are occurring increasingly rapidly (Satell, 2016), the competencies developed to solve today's problems will be difficult to transfer and thus rendered irrelevant to tomorrow's. If the learning tasks do not include the practice of making predictions and building the habit of anticipation, then education will never catch up with the change of the world, and the competencies we build from solving today's problems will never be sufficient for future challenges.

Ignorance

In a time when the body of knowledge explodes exponentially, aimlessly accumulating knowledge serves little purpose when "Today's "fact" becomes tomorrow's "misinformation" (Toffler, 1970. P. 405). When the half-life period decelerates, and the value of knowledge depreciates at an accelerating pace, the power of knowledge no longer lies in possession but in its contribution to exploring the greater or more inspiring unknown. The great dramatist Dumas (circa 1865) once said, "Human genius has its limits while human stupidity does not." The ability to see one's ignorance makes Socrates (one of) the most influential philosopher in history. The renowned mathematician Pascal once likened knowledge to a sphere, stating that as its volume increases, so does its contact with the unknown (Witte & Witte, 1995, p. 511). This suggests that the more we learn and expand our knowledge, the greater ignorance we encounter. We are thus challenged to pursue more knowledge to address the ignorance, thereby perpetuating the cycle of knowledge generation that drives humanity forward. That is why Harai (2017) contends that the defining

characteristic that sets modern science apart from previous knowledge traditions is "the willingness to admit ignorance." Such a change of attitude liberates modern science to become more versatile, dynamic, and eager to challenge. Consequently, it is the "revolution of ignorance," rather than a revolution of knowledge that fuels the scientific revolution.

Unfortunately, since the beginning of public education, school education has been predominantly designed to teach students well-known knowledge. Teachers insist on conveying the "tried and true" knowledge, allowing only very limited room for expressing the unknown, unless it is well-recognized or publicly acknowledged. Because ignorance is generally considered equivalent to inferiority, unimportance, error, danger, or even evil (Quinn, 2011), teaching typically aims at annihilating ignorance, and students are systematically discouraged, if not preempted, from tuning into their ignorance (Smithson, 1985). As a result, students are stripped of the opportunities to expand their horizons of knowledge, and teachers have the opportunities to learn with students and develop the capabilities to deal with the uncertainties of the world (Stocking, 1992). This knowledge-based model of pedagogy works on the assumption that most children lead lives similar to their parents (Perkins, 2014). Given the accelerated rate of growing volatility and uncertainty in the ever-changing world, such an assumption is no longer realistic. Einstein once said, "Do not listen to the person who has the answers; listen to the person who has the questions." Nietzche also said, "Convictions are more dangerous foes of truth than lies" (Nietzsche, 2008, p.1). If the education system continues to be driven by standardized tests, leading students to place unquestioned convictions in "accurate knowledge," then the pursuit of knowledge will merely become an exercise of copycatting the voice of authorities. The truth will remain perpetually out of our reach.

However, this by no means suggests that searching for the unknown outweighs pursuing the known. De Sousa Santos (2009) points out that every piece of knowledge is tied to a specific ignorance, and every ignorance is linked to a particular knowledge. That is, when we gain knowledge, we are aware of a certain ignorance that this knowledge seeks to address. Similarly, when we are ignorant, we are also conscious of a specific gap in our understanding. The symbiotic and mutually reinforcing relationship between knowledge and ignorance (Kerwin, 1993; Smithson, 1985) fuels the learning process. Therefore, learning aims not to eliminate ignorance, but to grow through the perpetual cycle of "discovering knowledge through ignorance" and "uncovering ignorance through knowledge."

Perkins (2014) advocates "educating for the unknown," highlighting the importance of empowering students with curiosity and responsibility that encourages them to boldly venture into the untrodden territory of knowledge. This approach helps them develop the ability to think critically and ask questions, equipping them to deftly adapt to the volatile and intricate world. Essentially, this model underscores the importance of a broad and forward-thinking pursuit of the unknown, and turning it into meaningful learning. However, it only addresses half of the impact that ignorance can have on learning.

In addition to turning the unknown into the known, there is immense learning potential in converting the known back into the unknown. This involves critically evaluating established knowledge to uncover new layers or depths of understanding. The iterative conversions between the known and the unknown constitute the cycle of knowledge development, equipping students with agile,

flexible, and adaptable insights for navigating the unpredictable and complex world of tomorrow (Paterson & Caple, 2019).

The question is, how can we weave the concept of ignorance, or the cycle of knowledge development, into the fabric of classroom teaching? In this regard, Tzeng (2018) puts forth five principles that serve as the cornerstone of ignorance-oriented instruction (IOI):

1. Personalize ignorance—allowing learners to take ownership of their ignorance by encouraging them to dig deep into their understanding of the subject matter and identify areas where their understanding may fall short in capturing the gist of the knowledge, especially when viewed under different lights.

2. Sensitize the awareness of ignorance—providing abundant opportunities for random learning in the environment, valuing intuitive speculation, allowing every flashing-by doubt a chance of reflection, and encouraging learners to stay in the mode of ignorance but look for clues for opportunities to break out of ignorance.

3. Crashing boundary to unveil ignorance—carefully examining the frames that contain learners' understanding by crashing it with knowledge from different fields or interpreting it by different methods to reveal the blind spots hidden within.

4. Reassessing the game of truth—carefully reexamining the conditions or rationales that label specific data or facts as errors or outliers, and reevaluating the legitimacy of theories otherwise ruled out by the orthodox or dominant paradigm.

5. To know is to unknow—constantly looking beyond the known to learn where the known ends, and pursuing the unknown as the means to know.

Currently, there are several instruction programs based on the concept of ignorance that have been documented in academic literature. The most prominent applications of these programs can be seen in medical education, such as those at the University of Arizona (Standen et al., 1998; Stocking, 1992). Each of these programs has unique characteristics and focuses. However, a comprehensive guide on designing and implementing a course centered around the principles of prediction and ignorance is yet to be developed.

While prediction is to estimate the trend and take educated guesses about what may lie ahead, it is based on our understanding of the cracks in our knowledge to see how we can leap from, instead of being confined by, what we already know. This process is fundamentally driven by ignorance. That is, prediction derives from forward-looking ignorance, combined with a vision for the future, and thus falls under the umbrella concept of ignorance.

The following describes the most recent version of IOI, which has been tried and tested in courses such as Educational Psychology, Education Issues, and Foundations of the Learning Sciences for over six years. After many iterations of revision, the principles and activities are designed to signify the idea that ignorance is not only the driving force that sparks the pursuit of learning, but also the ultimate goal that guides all learning endeavors towards the exploration of a greater unknown.

An Ignorance Oriented Course

IOI emphasizes both individual learning

and group collaboration, so an IOI based class usually divides students into groups of 3-5 members. In each class meeting, the lecture time is kept to the minimum, focusing only on clarifying the most abstruse concepts, and some easy-to-miss but essential connections between theoretical arguments within the readings or across the literature. Students come to the class with preview questions for discussion. They share their anticipations of the authors' thoughts, and pose personal questions afterward. These activities allow students to spelunk their ignorance space and pinball their ignorance against ideas from diverse sources. The practices of identifying problems, reforming problems, and honing prediction skills feature the key capacities underlying ignorance-oriented learning.

Before Class—Preview Questions

1. Students are required to preview the assigned readings before class meetings, and discuss them with their groupmates. Each group needs to raise at least one question from each assigned reading for in-class discussions. Intragroup discussions are required to rank the questions if more than one question is raised.

2. Feed the questions to generative AI (hereafter GAI), such as ChatGPT, for an answer. Try to evaluate the answers that GAI provides.

3. All groups need to submit their questions to the instructor for review a day before the class sessions. Questions assessed as high-quality will be asterisked, and the respective group will receive a bonus point.

In Class—Imaginative Conversations With the Authors

During each weekly class session, one group is responsible for helping their fellow students develop a deeper and richer understanding of the assigned reading. This group, referred to as the "epistemic agent," represents the class to engage in an imaginative conversation with the authors of the assigned reading. This conversation aims to draw out additional insights or wisdom not articulated in the article from the authors. Specifically, the epistemic agent's responsibilities include the following:

1. Briefly summarize the key points and how the authors organize their arguments.

2. Interview the authors: Imagine they are interviewing the authors and trying to tap into their wisdom through this article. They need to equip themselves with a basic understanding of the authors' background, lines of research, and positions of their theoretical arguments first.

3. Predict the authors' response: After raising questions for the authors, they also need to predict the answers that the authors might provide.

4. Share comments with the authors: They need to share their thoughts and feelings about the articles with the authors. For example, what do they like or do not like about this article? Are the arguments made in this article convincing to them? How is this article related to people's daily lives or theories or phenomena from different fields? Any suggestions for the authors?

After Class—Personal Reflective Questions

1. Following each class session, students need to reflect on the class content, formulate individual questions, and seek answers from GAI. Then share these questions and the corresponding responses from GAI on a Google document. The instructor will discuss and evaluate the quality of the questions and GAI's answers in class. However, students are

not obligated to pose questions every week to prevent the submission of forced, low-quality questions and to avoid overloading the instructor. Submitting questions for three out of ten weeks of the semester warrants a B on this assignment. To get a better grade, students need to earn bonus points, awarded when the questions they posed demonstrate deep reflective thinking on the arguments presented in the readings. The COPE TRAP model, which will be detailed later, is provided for students as a guideline to formulate such high-quality questions.

2. Problem reform: In addition to the in-class presentation, epistemic agents have another responsibility. They should utilize the students' questions as a foundation and seek a fresh perspective to reframe these questions, or use them as a springboard to formulate new questions. Then, feed the revised questions to GAI for answers and compare the new answers to the old ones. This exercise of reformulating questions allows students to refine their problem-raising skills, and expand the flexibility of analyzing knowledge and its associated problems.

The crux of these activities lies in the quality of the questions posed. Formulating high-quality questions requires a sharp questioning acumen and an inquisitive mindset, which can be cultivated through extensive practice in critically examining the essence and construction of knowledge. The COPE TRAP model provides a set of guidelines to assist students in developing a keen sense of questioning and a habit of inquiry. These guidelines encourage students to manipulate the constitution of knowledge, view it in different lights, and challenge its validity, leading to the creation of insightful questions about the knowledge.

The COPE TRAP Model

Many students, accustomed to learning by absorbing knowledge from teachers and readings without thinking twice about what they have learned, often feel lost or clueless about these problem-raising activities. In order to help them shift from the knowledge-gulping mode to the inquiry mode of learning, the COPE TRAP model serves as a scaffold for questioning, featuring eight strategies for turning the known into the unknown. The following describes the nature of each strategy, accompanied by example questions raised by students in an Educational Psychology class.

COPE-ignorance Spelunking

The acronym COPE, Clarification, Opinion, Practicality, and Evaluation, represents the first part of the model. These four strategies are designed to prompt students to delve into multiple layers of meanings associated with the knowledge presented verbally in the readings. They aim to deepen and enrich students' understanding by overlaying interpretations from various viewpoints on top of the verbally presented knowledge.

Just like adventurers spelunking an unknown cave, who try to acquaint themselves with the cave by cautiously traversing various routes and assessing the views they encountered through their knowledge and feelings, students should continually scrutinize their understanding of the meanings implied in the readings from various perspectives, and evaluate the significance of values conveyed by these meanings. In essence, the COPE model asks students to explore four layers of comprehension: (1) verbal presentation, (2) subjective interpretation, (3) practical application, and (4) value evaluation.

1. Clarification: Clarify what students have learned, which includes:

(1) Clarify the context of knowledge: The information presented in the readings is usually compressed, abstracted, single-sided, or truncated to accommodate the constraints of the presentation space. Without the context of the full narrative, the incompleteness of the meaning derived from the readings could result in fragmented, incoherent, superficial understanding — this is often the precursor to misconceptions. Therefore, the first thing that students need to do while reading is to recognize the condensed nature of the content, discerning what is being crossed out or overlooked in the text. Then, try to reconstruct the structure of time, space, and contexts in which the knowledge is situated.

Example: Does Erikson's developmental theory need new stages if applied in the modern world?

(2) Clarify the nature of knowledge: A common strategy for clarifying the nature of certain knowledge is to see whether different instances accurately embody this knowledge. By checking how the instances align with the narrative of the knowledge, people need to carefully examine the nature of the premises, conditions, or framework underlying the interpretation of the knowledge, and see whether they also apply to the interpretation of the instance. On top of this foundational structure of knowledge construction, people can further critically assess the nature of arguments, meaning, and connotations derived from the knowledge through the process of inspecting both exemplars and nonexemplars.

Example: The book "Behavioral Economics Comics" mentions a story: "A group of children liked to scribble on the outer wall of an old man's house, which troubled the old man. A neighbor who saw this told the old man that as long as he gave the children money, after a few days, he told them that there was no money to give, and they would not come to scribble again. So the old man did it, and the group of children really never came again." Does this imply that the appearance of external motivation will replace internal motivation?

2. Opinion—Subjective interpretations.

According to Polanyi (1969), all knowledge is either tacit or derived from tacit knowledge. Constructivists also argue that all knowledge is the product of personal construction. Students should be mindful of their inner voice regarding their feelings about the knowledge they are learning. Tuning into the layer of subjective interpretations on top of the verbal presentation of knowledge prompts students to contrast the learning materials against their prior knowledge and affective reactions. Externalizing tacit thoughts and attitudes, such as looming doubts, preferences, suspicion, enjoyment, confusion, or conflicting thoughts, can shape how students accept or comprehend knowledge. Students should cultivate their own viewpoint on how knowledge can be constructed. The difference between an opinion question and a clarification question is that the former proposes a personal theory, doubt, or opinion to contrast with the acquired knowledge, whereas the latter stays within the scope of the acquired knowledge.

Example: According to the Flynn effect, human IQ scores increase by 3 points every ten years. However, the human brain is unlikely to evolve so significantly in just ten years, so can this effect be seen as proof that nurture and environmental influences are the main factors changing intelligence development?

3. Practicality—Practical meanings

Most scientific and social knowledge derives from solving problems in the real world. If this knowledge is separated from the problem-solving contexts where it proves

useful, it risks becoming static, rigid, and inert. Delving into the layer of practical meaning perturbs the comprehension of knowledge established based on verbal reasoning. When such comprehension is tossed into a real-world scenario, a variety of situative factors, conditions, details, and perspectives will scrutinize its applicability and validity, inducing a greater problem space and ignorance to be addressed. Asking questions concerning the practicality of knowledge prompts students to examine the purpose of learning, the suitability of knowledge application, and the in-situ meaning of knowledge not available in its verbal form.

Example: During class, we mentioned the availability heuristic. This reminds me of a book I read, 'Thinking, Fast and Slow,' where one chapter mentions that baseball umpires can make errors in judgment due to certain cognitive biases (for example, if the first three pitches are balls, the likelihood of the next pitch being a strike significantly increases). Applying this to life, we may also make poor decisions due to these biases. I would like to ask everyone, how would you teach students to avoid this situation if you become a teacher in the future?"

4. Evaluation: Appraising the value of the knowledge

Stephen Hawking once said, "The greatest enemy of knowledge is not ignorance; it is the illusion of knowledge." People should take all knowledge with a grain of salt to avert such illusion. That is, instead of accepting the knowledge at face value, students need to delve into the layer of evaluation by critically appraising the value and the legitimacy of the knowledge they acquired. Such evaluation involves the judgment of the effectiveness of the knowledge in solving problems, the robustness of its reasoning, the magnitude of its impact, and the originality of its proposition.

Example: Kohlberg said that if logical reasoning is a necessary condition for mature moral judgment (but not a sufficient condition); then mature moral judgment is a necessary condition for mature moral behavior, so it is very important to cultivate children's ability to reason morally. However, in recent years, it can be seen that more and more crime leaders or main suspects have high academic qualifications, meticulous logical thinking abilities, and usually adhere to social norms, but they will suddenly cross the law. Does this mean that there are omissions or inaccuracies in Kohlberg's theory of moral development?

TRAP--Ignorance Pinballing

The acronym TRAP, standing for Transboundary, Remodel, Association, and Personalization, constitutes the second part of the model. They are strategies to crack the boundary of knowledge by colliding it with other ideas, thus exposing the previously unavailable ignorance. Such collisions can be made from the outside or the inside of the acquired knowledge. The outward-bound collisions contrast the acquired knowledge to knowledge from diverse fields (Transborder) or pure imagination (Association). The inward-bound collisions involve conversing the acquired knowledge with personal experiences (Personalization) or altering components within the acquired knowledge (Remodel).

1.Transborder—Making interdisciplinary dialectics between the acquired knowledge and knowledge from different fields. This strategy includes (1) same concept-different fields: discussing how the meaning of the same concept may have different connotations in different fields—for example, discussing how the meaning of "energy" means different things in fields like physics, chemistry,

biology, and psychology. (2) different concepts-same field: comparing the similarities and differences between various concepts in the same field. For example, comparing the differences between self-directed learning, self-regulated learning, and self-learning. (3) different concepts-different fields: discussing how concepts from different fields may enrich the understanding of each other. For example, how can we interpret Confucius' quote, "At seventy, I could follow the dictates of my heart and never overstepped the boundaries of right," from the perspective of Kohlberg's moral stage theory?

2. Remodel—Modifying the components of the acquired knowledge (e.g., parameters, conditions, premises, or variables) and turning such modification into questions. Students are encouraged to play with the knowledge they have acquired. By altering the constituents or the construction of the knowledge, or pushing conditions of the knowledge-embedded situation to extreme, they can create an epistemic disparity between the original and modified versions of the knowledge, leading to a new problem space for raising questioning. This remodeling process casts knowledge in different lights, guiding students to discover the multifacetedness of the knowledge. This enables students to see the diversity of ways to construct and deconstruct knowledge, and thus questions associated with it, allowing them to comprehend knowledge from a more flexible, hypothetical, or even creative perspective.

Example: During class, the teacher asked us to discuss the advantages and disadvantages of direct instruction, but only limited to the pros and cons of this teaching method itself. So, I would like to ask other classmates, what are the differences or pros and cons of using direct instruction for students of different ages, environments, subjects, or even goals?"

3. Association—"Force fit" is a widely utilized technique in creativity training that involves deliberately merging two seemingly unrelated concepts to spark innovative ideas or solutions. This approach encourages people to think outside the box. We can stimulate students to engage in mental experiments by creating forced associations between their acquired knowledge and ostensibly irrelevant information, including imaginations, hypothesized futures, fictional scenarios, or news from elsewhere. These discussions can challenge the validity of the acquired knowledge by examining its applicability in these artificially associated situations.

Example: Enhancing students' intrinsic motivation has always been a significant issue advocated by teachers. Under Taiwan's current education system, there is still a long way to go to significantly increase the intrinsic motivation of students accustomed to rote learning. However, I am curious: if one day, all students become learners with strong intrinsic motivation, what related problems might arise?"

4. Personalization: Students are encouraged to personalize their learning by integrating knowledge with their experiences, attitudes, or judgments. They can voice their subjective responses, such as their degree of appreciation, endorsement, or emotional reactions toward the assigned reading materials. Alternatively, they can interpret knowledge through the lens of their personal experiences. This approach reinforces the idea that all knowledge, even that which comes from authoritative sources, can be challenged, and that their personal feelings and viewpoints are important, regardless of how biased, individualistic, or subjective they may be.

Example: There are many ways to classify transfer, such as positive and negative transfer. I am curious: Can these two opposite types of transfer occur at the same time? For example,

when I am learning German, I unconsciously use known English pronunciation, leading to negative transfer. However, my knowledge of English also allows me to guess the meaning of unfamiliar German words, resulting in positive transfer. However, can these opposite transfers, such as low-level transfer and high-level transfer, forward transfer and backward transfer, also occur in the same learning process?"

COPE and TRAP are not mutually exclusive. While COPE describes how people spelunk their ignorance by delving into different layers of understanding, TRAP describes how people widen their ignorance by pinballing their knowledge with thoughts from various sources. Most questions can be labeled by COPE and TRAP simultaneously. For example, one student raised the following question, which can be labeled as both Clarification and Transborder:

Freud's proposed superego acts according to moral principles. However, in his work 'Civilization and Its Discontents,' and in Zizek's works, the superego is described as strict and cruel. For example, the chaste women praised in ancient China might commit suicide at home because they were glanced at by other men outside. For such incidents, for Kohlberg, is it a punishment and obedience orientation in the pre-conventional moral period, or is it a social contract orientation in the post-conventional moral period because it is regarded by contemporary society as the highest goodness and the highest standard of morality?

Key principles of ignorance-oriented instructions

Instructors need to find balance in the following dichotomies to turn a regular lecture-based class into an ignorance-oriented one.

1. Disequilibrium vs. equilibrium: From Piaget's perspective, learning begins with solving disequilibrium and ends with restoring equilibrium (Piaget, 1964). Once the equilibrium is restored, the learning task is considered completed, and students are ready to move on to the next learning objective. In contrast, IOI begins with perturbing equilibrium and creating disequilibrium, aiming at finding greater ignorance that drives further exploration, and ends with evaluating and interpreting the identified ignorance, resulting in expanded comprehension of the acquired knowledge.

2. Cognition vs. metacognition: Understanding a concept is one thing, understanding how one understands and assesses the quality of that understanding is another. Metacognition can unveil and evaluate one's ignorance inherent in learning by anticipating learning activities in advance, scrutinizing the effectiveness of learning while it is happening, and reflecting on the results and quality of the learning process afterward (Winn & Azevedo, 2022).

3. Accident vs. planned activities: In a planned teaching activity, ignorance is usually carefully calculated and methodically crafted as the target to conquer. Such design ensures that students acquire the pre-determined knowledge and the "correct approach" to problem-solving. However, this could result in a formulated learning process and rigid knowledge comprehension. Accidents can bring about unforeseen challenges and fortuitous learning opportunities, urging students to improvise solutions for the unprepared situation. This places students in a novel ignorance space, exposing the boundaries of their understanding and testing the adaptability of their knowledge.

4. Making errors vs. pursuing correct answers: Understanding the nature of errors or aberrant ideas and their origins is valuable for learning. These instances provide learners with opportunities to confront their ignorance while also offering a glimpse into a fresh perspective of thinking, rather than being detrimental to the learning process, as some might believe from the perspective of lecture-based instruction. Motivating students to err and experiment with unconventional problem-solving approaches not only exposes students to ignorance that demands innovative thoughts but also incites them to challenge the assuredness of a certain "correct answer."

5. Raising questions vs. finding answers. Einstein once said, "The formulation of the problem is often more essential than its solution, which may be merely a matter of mathematical or experimental skill." While finding answers to the presented questions is the norm of education in schools, it should be the student's responsibility to ask questions rather than the teachers, as is often the case in schools. Students should cultivate an ignorance-driven inquisitive mindset to question everything they hear, to deliberate before deciding what to accept as truth, and proactively identify potential loopholes in the answers they formulate or those provided by others.

6. Preview vs. review: Previewing the study materials before class is an effective strategy for students to brace themselves for their ignorance of the knowledge to be addressed. This not only clues students in the parts they may struggle to comprehend, but also alerts them to the forthcoming instruction that may deal with their struggles. Reviewing the class content afterward is also important as it enables students to reflect on the status of the ignorance and whether new ignorance has arisen as a result. Identifying one's own ignorance before and after the class serves different purposes. Collectively, they help students navigate the terrain of their understanding from various directions.

7. Framework vs. content: Before diving into the process of acquiring knowledge, it is crucial to first critically examine the underlying assumptions and foundations of the knowledge, and the perspectives that shape its interpretation. This is because these conceptual frameworks may mask ignorance or render it seemingly irrelevant. These assumptions and perspectives not only justify the construction of knowledge but also lay the groundwork for its application. The focus of school tests on content might distract students from realizing that failing to carefully scrutinize how these conceptual frameworks shape their knowledge comprehension can lead to the danger of misconception or misapplication.

8. Intuition vs. cogitation: Intuitive thinking is one of the key principles in Bruner's discovery learning. He argues that "the most valuable coin of the thinker at work" features "shrewd guess, fertile hypothesis, courageous leap to a tentative conclusion" (Bruner, 1977, p.14). Encouraging students to make educated guesses and bold assumptions before getting the answers from teachers is a great exercise to learn with ignorance. Intuitive thinking, which may sometimes seem wild or irrational, can escape the scrutiny of the dominant knowledge structure and lead to refreshed problem-solving insights. However, it is important to exercise cogitation to ensure these insights are feasible and grounded in reality. The interplay between breakout thinking and realignment of existing knowledge structures propels our understanding to higher levels.

9. Creation vs. acquisition: Turkle and Papert argue that knowledge construction should resemble the creation of bricolage art, where insights surface through the negotiation

and reorganization of the constituent elements (Turkle & Papert, 1991). In essence, creating an intellectual artifact necessitates learners to reconstruct their understanding of knowledge by meshing it with otherwise untapped thought processes. The transition from acquired knowledge to creating new artifacts is propelled by insights derived from a series of experimental trials and errors exploring the known and the unknown. Learning through creating intellectual artifacts can prevent a reductionist approach to knowledge (Paavola & Hakkarainen, 2005). Moreover, as manifestations of thought, these artifacts can unveil unique characteristics that inspire individuals to explore new ways of thinking about their prior ignorance.

10. Objective vs. subjective: Although science aims for objectivity, it is essentially shaped by human judgment and interpretation. Pursuing knowledge is not a straightforward path to an objective truth, but an intricate process driven by subjective perspectives and explanations. After all, science is a human endeavor, deeply rooted in our values, biases, and constraints in the context. Our greatest ignorance about science is not the absence of knowledge, which can be easily remedied by internet access, but rather our inability to recognize the subjectivity inherent in the hypotheses tested, the instruments employed, the judgments rendered, and the interpretation of outcomes in the production of scientific knowledge. It is vital for learners to confront their ignorance about the subjective undertones of knowledge that are often labeled as "the truth."

Conclusions

For six years, IOI has been continually tried and tested in various courses. The instructor, with over 20 years of teaching experience, has found this method effective. Students have responded positively to this teaching style, as evidenced by the consistently high evaluation scores, which typically range from 4.75 to 5 on a 5-point scale.

A quasi-experiment was recently conducted on two classes of Educational Psychology, both taught by the same instructor. Class A (30 students) was subjected to IOI, while Class B (27 students) received regular lecture-based instruction. At the end of the semester, a 10-question survey was distributed, and an ANOVA was performed to examine the differences between the two classes on each item. Four questions showed significant differences. This offers an insight into how IOI can facilitate deeper learning in students compared to regular lecture-based instruction.

1. Class A students are more likely than class B students to remind themselves to question whether different perspectives or theories have not been mentioned in the class or the textbooks ($F=7.34$, $P<.001$, $\eta 2 =.06$)

2. Class A students believe that the difficulty level of the class is significantly higher than class B students ($F=5.95$, $P<.05$, $\eta 2 =.05$).

3. Class A students want to know more knowledge beyond the class content than class B students ($F=7.32$, $P<.01$, $\eta 2 =.06$).

4. Class A students believe they are more capable of proposing amendments to the theories proposed by experts and scholars mentioned in the class, than class B students ($F=5.66$, $P<.05$, $\eta 2 =.05$).

However, students asking questions before and after class not only challenges them to critically reflect on the assigned reading, but also challenges instructors to

respond appropriately. The instructor found that he could immediately answer 47% of students' questions, but he needed some time to think before responding to other 32%. He had to prepare for other 17% of the questions by searching for information from books or the internet. The remaining 4% were questions that he was unsure whether he could provide a suitable response to, even after searching for information within the timeframe between receiving the question and the start of the class meeting. In other words, even for an experienced instructor, only less than half of the questions could be confidently answered instantly, and 21% of the questions definitely required preparation before the class. This can be daunting for instructors who adopt this approach initially. IOI is not easy, but the results can be rewarding. Students may need significantly more time to examine what they have learned critically, but they know that it is an excellent exercise for learning how to learn to cope with the future.

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