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LEARNING TO ENGAGE WITH WICKED PROBLEMS IN TEAMS

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Abstract

Complex, societal problems can be overwhelming. Maybe better avoid them. This contribution shows how a cloud-based learning technology—the Reflect! platform—can be used to practice a particular strategy for dealing with so-called wicked problems. By providing a learning experience that is close to collaborative problem-solving in real life, students can gain the self-confidence needed to engage constructively with wicked problems. The approach presented is an example of how philosophy can contribute to general education. After discussing the notion of wicked problems and what is required to cope with them, this article provides information that should be useful for readers who want to include a focus on wicked problems in their teaching: first, a discussion of how the work of learners can be assessed—with examples that demonstrate what is expected—and, second, the results of a survey-based assessment of the Reflect! learning experience from learners' points of view.

Keywords: Complexity, ethics, learning technology, philosophical methods, pragmatism, wicked problems

1. Introduction

Life in modern societies requires the ability to solve problems. But there are many kinds of problems, among them very complex ones. Are we, as teachers, preparing future generations to cope with those problems whose complexity is becoming more and more a signature of our times? Here is an example of a problem that a team of four students formulated and dealt with in a class project over five team meetings, working on the Reflect! platform in 2020:[1]

> Micro-targeting, the practice of collecting large amounts of information about individuals to utilize in precise advertisement, enhances the effect of any messaging by allowing the author to tailor a specific message to a specific group of people. First utilized in the private sector for ads, political campaigns and foreign nations have begun to use micro-targeting as well. The Spread of political propaganda in the United States uses Micro-targeting in Social Media. When micro-targeting limits the abundance of knowledge and information one easily encounters on the internet, serious problems arise.
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> When the information is given through micro-targeting, rather than sought out, extreme amounts of information asymmetry can ensue, especially when it is coming from just one political

[1] Published here with their permission. This problem formulation has been created in one of the classes in which data for the assessment described in section 5 have been collected.

> direction. Online users are no longer freely choosing or intentionally analyzing what social media platforms, news articles, or political ads appear in front of them. Instead ads are chosen for them and the idea of researching or gaining knowledge from differing sources is essentially eliminated as your feed becomes micro-targeted towards "one side." Information producers are choosing their audience, rather than vice-versa. By controlling what the audience sees, they can effectively control how they think about an issue.
>
> The essential problem is not only when micro-targeting leads to a more narrow worldview of information, but when it spreads falsehoods as well. Many assume all ads and information on the internet are true. When that is the assumption, micro-targeting becomes a brilliant agent for spreading false information that online users believe they picked out themselves and think is true. The spread of political falsehoods and misinformation online, specifically in the 2016 election, had a substantial impact on how online users perceived candidates.
>
> What policies and regulations should be established to affect either federal political organizations or social media companies to help stop the spread of political misinformation and the homogenization of sources due to micro-targeting in social media? How can we ensure people are seeing information from a variety of sources, and not just from one political point of view?
>
> We imagine to be a task force within the Federal Election Commission tasked with reducing the effects of micro-targeting on misinformation in federal elections.

A challenge like this one can be described as a "wicked problem," a term introduced by Horst Rittel and Melvin Webber about fifty years ago (Rittel and Webber 1973). They introduced the notion of "wicked problems" in contrast to "tame" problems:

> The problems that scientists and engineers have usually focused upon are mostly "tame" or "benign" ones. As an example, consider a problem of mathematics, such as solving an equation; or the task of an organic chemist in analyzing the structure of some unknown compound; or that of the chessplayer attempting to accomplish checkmate in five moves. For each the mission is clear. It is clear, in turn, whether or not the problems have been solved.
>
> Wicked problems, in contrast, have neither of these clarifying traits; and they include nearly all public policy issues—whether the question concerns the location of a freeway, the adjustment of a tax rate, the modification of school curricula, or the confrontation of crime. (Rittel and Webber 1973: 160)

Over the course of their formal education from kindergarten to college, students might be confronted with tens of thousands of tame problems. But what they learn when dealing with tame problems might be outright dangerous when they encounter—without preparation—a wicked problem. Developing the ability to solve tame problems creates habits that allow the learner to approach any new problem quickly and efficiently, but usually without much reflection (Kahneman 2011). The reaction will often be habit-driven. The harm that can be done when not recognizing the wickedness of a problem results mainly from the possibility that we might overlook people who are affected by the consequences of decisions if the problem is too complex. Dealing in an ethically responsible manner with wicked problems requires preparation and training.

Wicked problems are all around us. How can the energy transition be carried out without harming people? How should technologies be designed, especially emerging technologies with

far reaching consequences such as artificial intelligence or genetic engineering? How should we deal with immigration? How with right-wing extremism, societal polarization, or the decreasing trust in democratic institutions? How to determine the focus of a research project, especially in interdisciplinary teams? Besides societal problems like these, people are increasingly facing wicked problems in their professional life when they are asked to solve problems collaboratively in teams (Graesser et al. 2018).

Wicked problems are everywhere, but educational approaches that are designed to prepare future generations for dealing with them are only slowly being developed. Many of them have been designed for environmental and sustainability studies, and interdisciplinary studies in general,[2] others for general education,[3] science studies and science education,[4] engineering and design education,[5] and learning through applied community-based research.[6] Efforts related to philosophy seem to be limited to teaching engineering ethics.[7]

In contrast to most of what has been proposed in these publications, the approach realized with the Reflect! platform focuses on a particular pedagogical challenge. On one hand, the skills and habits that are required to cope with wicked problems can only be acquired and practiced if there is a real experience of the wickedness of a problem. It is neither sufficient to lecture about wicked problems and how to deal with them, nor to guide students through the process in the form of a Socratic dialogue. As I will show in the next section based on a deeper analysis of the concept of wicked problem, addressing the wickedness of a problem requires a series of steps—starting with *formulating* the problem, first of all, and then performing a stakeholder analysis—that should be done in collaboration with others. For learning to happen, learners need to experience both the intellectual and cognitive challenges of this process and the social and emotional challenges of working with others. But this experience is only possible if teams work autonomously. This means that learning environments are required as they are described in theories of problem-based learning (PBL).

On the other hand, there is a need for guidance and support. Based on our responsibility as educators, we need to prevent harm that might result from the failure to deal successfully with confusion, cognitive overload, frustration, and conflicts when teams work over longer periods of time on a problem. (Between four and fourteen team meetings are required for the approach presented here, depending on the work plan chosen by the instructor.) Learners often feel "overwhelmed and hopeless when the status of the world seems too wicked to be overcome, and solutions are out of their hands" (Sharp et al. 2021: 622). Even though there are quite a few publications that discuss components of PBL that focuses on wicked problems,[8] I am aware of

[2] Parker 2012; Sadowski et al. 2013; Augsburg et al. 2013; Kew 2013; Wiek et al. 2014; Bosque-Pérez et al. 2016; Bruun 2019; Nair and Suryan 2020; Falls 2020; Hoffman et al. 2021; Sharp et al. 2021; Block et al. 2022 (this list, and those in the following footnotes, include references to publications in which also concepts related to wicked problems are used).

[3] Munneke et al. 2007; Jordan et al. 2014; Ravankar et al. 2018; Hanstedt 2018.

[4] Agustian 2023.

[5] Beckman and Barry 2012; Kolko 2012; Melles et al. 2015; Orthel 2015.

[6] Cantor et al. 2015.

[7] Berry 2007; Berry et al. 2013; Berry et al. 2016; Jonassen and Cho 2011; van de Poel and Royakkers 2011; Dempsey et al. 2017; Hoffmann and Borenstein 2014; Hoffmann 2020; Urquhart and Craigon 2020; York and Conley 2020.

[8] Thomassen and Stentoft 2020; Hatchuel et al. 2011; Melles et al. 2015; Ravankar et al. 2018.

only a few fully developed PBL interventions.[9]

We know from research on PBL that the right balance between team autonomy, guidance, and support requires facilitators or tutors who support teams by monitoring team dynamics and answering questions without teaching.[10] Facilitators, however, need to be trained, supervised, and usually also paid so that PBL requires substantial resources. The approach presented in this contribution is unique in providing specifically designed *learning software* to balance autonomy and guidance without the need of facilitators. The Reflect! platform provides a learning environment that guides small teams of students through a "work plan" composed of individual and team activities (https://reflect.gatech.edu/). Reflect! is a cloud-based learning technology, a workflow management system, that guides teams of learners through a structured process of coping with a wicked problem.

The present contribution continues work that presented the Reflect! platform in more detail (Hoffmann 2020). The focus here is, first, on a deeper understanding of wicked problems (section 2) and, second, on how the pedagogical challenges of wicked problems are addressed by "work plans" on the Reflect! platform (section 3). In section 4, I will discuss the assessment criteria that I developed to grade the results of teams working on a wicked problem. With examples that show why certain project components failed to achieve what is expected, it should become clear what I consider success regarding learning to cope with wicked problems. The last section, finally, presents the results of an assessment of learning with the Reflect! platform that focuses on (1.) the question whether students saw an acceptable balance between autonomy and guidance realized in their project work, (2.) what stimulated reflection and self-correcting reasoning, and (3.) how they perceived working on particular project components.

The approach presented is an example of how a particular understanding of philosophy can contribute to general education. It is rooted in *pragmatism* in the sense of the five "interrelated substantive themes" that Richard Bernstein identified to characterize "the pragmatic ethos" in American pragmatism: (1) It rejects the idea that empirical knowledge can be built on firm foundations and replaces it with that of science as "a self-correcting enterprise"; (2) it acknowledges human fallibility and reacts to it with the assumption that all philosophy is "interpretative, tentative, always subject to correction"; (3) it accepts "the need to nurture a critical community of inquirers"; (4) it is aware of, and sensitive to "radical contingency and chance that mark the universe, our inquiries, our lives"; and it (5) takes for granted that "there can be no escape from plurality—a plurality of traditions, perspectives, philosophic orientations" (Bernstein 1997 <1988>: 385-389).

Pragmatists do not assume that philosophy provides any special competence to get to the truth of things or that there is a specific kind of problems for which philosophers are experts (as claimed by Barz 2019). But they are convinced that philosophy can provide useful *methods* that are needed to cope with problems. Charles Peirce's extensive contributions to logic and semiotics, among many other fields, can serve as evidence. When it comes to wicked problems as a challenge for education, the pragmatist orientation of this article will become visible (1.)

[9] Berry 2007; Berry et al. 2013; Berry et al. 2016; Urquhart and Craigon 2020; Parker 2012; Ravankar et al. 2018; Hoffmann 2020.

[10] de Jong and van Joolingen 1998; Gijlers and de Jong 2009; Hmelo-Silver and Barrows 2008; Newstetter 2005, 2006.

in taking seriously the plurality of opinions and knowledge claims in disputes and (2.) in its focus on two educational goals: that learners should acquire, first, certain skills and, second, that they learn how to develop knowledge "in a critical community of inquirers."

The Reflect! platform does not provide any philosophical content nor does its use require philosophical expertise. Working under the guidance of a "work plan" on a project over at least four or five team meetings, students are getting familiarized with a specific strategy to approach wicked problems. But what they learn about these problems depends on which problems an instructor selects. Thus, disciplinary expertise—be it in philosophy or any other discipline—comes with the expertise of the teacher.

It should be noted that I am using "student" here in the American sense that refers to any learner, from primary (elementary) school and secondary education to tertiary education (college or university) and adult learning (e.g., workforce development). Also, talk about "undergraduates" refers to young adults who are about 17 to 20 years old; their educational level is often equivalent to those who finish secondary education in other countries.

The user interface of the platform is written in English but we are currently in the process of rewriting the code so that the interface language can be switched to other languages. Whoever is willing to provide a translation to another language would make the platform available to another culture. Also, since the platform is in the "cloud," it can be developed in all sorts of further directions without requiring any "updates" on the user's side. Our understanding is that the platform is an evolving community tool; whoever brings in further funding can support the realization of additional features or the tailoring of the platform to more specific purposes (for examples see Hoffmann 2020 and Hoffmann 2021).

It should also be noted that the platform has been used mainly in face-to-face settings: in the classroom where teams of four or five students sit around a table and talk, guided by Reflect! and entering material on the team space provided on the platform via their laptops. Only in the spring of 2020—after COVID policies moved all education online in the middle of the semester—Zoom-like videoconferencing had been used for the talking. This was the semester in which the survey data have been collected that are analyzed in section 5.

2. Learning how to grapple with wicked problems

Before we talk about the skills that are needed to cope with wicked problems, it is necessary to develop a better understanding of what is meant by this concept that Rittel and Webber introduced in their seminal paper "Dilemmas in a general theory of planning" (Rittel and Webber 1973). They write that there are "at least ten distinguishing properties" of wicked problems (p. 160):

1. "There is no definitive formulation of a wicked problem." In contrast to tame problems, it is not possible to provide "an exhaustive formulation" of the problem as it is needed for understanding and solving it. The reason is, according to the authors, that the "information needed to understand the problem depends on one's idea for solving it." The essential point seems to be that a "definitive" formulation of the problem is impossible because ideas about possible solutions differ. In pluralist societies, "diverse values are held by different groups of individuals" (p. 169). Since different groups will often have very different ideas about possible solutions, wicked problems will be

perceived and specified differently as a function of varying knowledge, methods, information, conflicting interests, world-views, or values. Different people frame the problem differently.

2. "Wicked problems have no stopping rule." There are no "criteria that tell when *the* or *a* solution has been found" (p. 162).
3. "Solutions to wicked problems are not true-or-false, but good-or-bad." The reason is that there are no "conventionalized criteria for objectively deciding" whether a solution is correct or false. The judgments of those involved "are likely to differ widely to accord with their group or personal interests, their special value-sets, and their ideological predilections" (pp. 162-63).
4. "There is no immediate and no ultimate test of a solution to a wicked problem." The reason that Rittel and Webber provide for this fourth property is that "any solution, after implemented, will generate waves of consequences over an extended—virtually an unbounded—period of time." Since "we have no way of tracing *all* the waves through *all* the effected lives ahead of time or within a limited time span," there is no ultimate test of a solution (p. 163).
5. "Every solution to a wicked problem is a 'one-shot' operation; because there is no opportunity to learn by trial-and-error, every attempt counts significantly" (p. 163).
6. "Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan." And: "There are no criteria which enable one to prove that all solutions to a wicked problem have been identified and considered" (p. 164).
7. "Every wicked problem is essentially unique" (pp. 164-65).
8. "Every wicked problem can be considered to be a symptom of another problem" (p. 165).
9. The "discrepancy" between expected effects of an implemented "solution" and what is actually observed "can be explained in numerous ways" (p. 166). The complexity of the problem and a multitude of relations that might or might not be relevant makes it impossible to determine any explanatory hypothesis as either supported or refuted. What seems to falsify an explanation can always be explained by other factors.
10. "The planner has no right to be wrong." This last of the ten properties points to the ethical dimension of wicked problems: "Planners are liable for the consequences of the actions they generate; the effects can matter a great deal to those people that are touched by those actions" (p. 167). As they wrote in the introduction to their list of the ten distinguishing properties of wicked problems, this is not about "malicious intent." The decision maker's responsibility for the consequences of their decisions implies that it is "morally objectionable for the planner to treat a wicked problem as though it were a tame one, or to tame a wicked problem prematurely, or to refuse to recognize the inherent wickedness of social problems." (p. 161)

This somewhat unwieldy list of ten properties opened a space for a wide variety of interpretations. In recent years the "overuse" of the notion of wicked problems has been criticized. At the same time, it became clear, in a survey, that policy experts found it difficult to identify problems that "have all the attributes of wicked problems" (Peters and Tarpey 2019).

Turnbull and Hoppe (2019) even suggested that the notion should be rejected for philosophical and practical reasons. Leaving aside the practical reasons, their philosophical argument attempts to justify that the concept of wicked problem "has no coherent conceptual basis." First, Rittel and Webber's distinction between wicked and tame problems was "unsustainable" and, secondly, it was "unjustifiable" to define types of problems "analytically" because a problem is only a problem if it is experienced as a problem by someone. This means, they argue, that problems "are inevitably viewed from somewhere, such that bound up in their viewpoints are innumerable interpretations, perspectives and social relations with other interested actors" (p. 321). Turnbull and Hoppe criticize here an unjustified "essentializing and ontologizing" of wickedness.

The last critique, though, is based on an impoverished understanding of ontology. It is certainly true that there are no problems without someone experiencing something as problematic (Duncker 1945, p. 1). But if a child does not know how to add 8 + 5, why should we reject the idea that *there is* a problem for the child? We need language to signify that certain challenges are experienced as problematic in certain situations. Charles Peirce introduced the notion of "hypostatic abstraction" to clarify the ontological status of things like sets or multitudes in mathematics (Pietarinen and Bellucci 2014; Hoffmann 2005). A set does not exist in the way a few apples exist. But it is useful to abstract from "these are many apples," "many oranges," "many propositions" the entity "set" (creating an entity is what hypostatization or, in Latin, reification means). A problem is as real as a set is real. Hypostatic abstractions are indispensable to signify abstract entities we need to talk about. If there are problems that we experience as wicked, and if we want to talk about these problems, then we need wicked problems.

With regard to Turnbull and Hoppe's first critique it has to be acknowledged that the distinction between wicked and tame problems is troublesome if none of these terms is defined. Rittel and Webber did not provide any definition, and they did not relate their now popular terminology to already "established concepts of the policy sciences and public administration" (Turnbull and Hoppe 2019: 333). However, both these difficulties can be addressed by developing a clear definition of wicked problems. These are problems, I propose, that can be *framed* in a number of different ways, depending on who is looking at such a problem, so that all of the following can be observed: the formulation of the problem and the question on which level it should be addressed become a problem; there is no exhaustively describable set of potential solutions; and there is no agreement on the standards that should be used to assess solutions (Hoffmann 2020: 796; see also Norton 2012: 450).

Based on this definition we can establish a clear boundary between wicked and tame problems. The latter can be defined as problems for which framing and the exact formulation of the problem do not play any role. For the questions "what is 3,456 + 546?" or "how to ride a bicycle?" differences between varying perspectives are not relevant. They might be relevant for *learning* these things, but not for the problems themselves. In contrast, the particular perspectives of those looking at the problem *are* crucial when the same conflict is framed by Israelis as the problem of "how to end terrorism coming from the Gaza strip" and by Palestinians as "how to end the Israeli occupation." This is a wicked problem, the others are not.

The wickedness of problems is key in fields that deal with multiple stakeholders who frame problems differently, depending on their interests, values, and world-views, and in fields that deal—for the same reason—with conflicts. As I argued elsewhere, coping with wicked problems requires the realization of three conditions (Hoffmann 2020):

1. Wicked problems must be approached only in collaboration with others, that is: only collaborative strategies are acceptable. The reason: The greatest possible number of perspectives needs to be taken into account.
2. The goal must be to build consensus, not to solve the problem once and for all. Nothing else is possible.
3. Reflection and self-correcting reasoning are crucial. The reason: We need to be able to change our own perception of the problem and our reasoning about it. If nobody changes, people will forever be stuck in conflict.

What does this mean for educational efforts that aim at providing opportunities to develop and practice the skills needed for coping with wicked problems? What are these skills? An overview of the skills on which the Reflect! approach focuses is provided in Figure 1.

Figure 1: Skills that can be practiced with the Reflect! approach to wicked problems

3. What is the Reflect! platform?

The Reflect! platform is a workflow management system that guides teams of learners through a structured process of coping with wicked problems. The guidance is provided in the form of work plans and instructions that explain what should be done and why. Multiple teams in a class are using the same work plan—even though they work usually on different problems—so that certain activities such as giving presentations can be synchronized. Even though work plans include deadlines set by the instructor, the teams are free to determine their own pace and division of labor. Engaging in this process is supposed to practice the skills needed to deal with wicked problems more confidently and in an ethically responsible manner. Two ethical

principles are crucial:

1. Take those into account who might be harmed by a decision or may find themselves in a disadvantaged position (Hoffmann 2020; Chan 2016).
2. Engage with perspectives that differ from your own in a manner that deals with conflicts constructively.

The process of coping with a wicked problem focuses on three main questions:

1. How to frame the problem?
2. Who are the stakeholders?
3. What could be a proposal that all stakeholder find acceptable?

Even though any work plan – by definition – outlines steps in a linear order, many of the steps of a Reflect! work plan require teams to go back to tasks completed earlier and revise what they entered on the platform based on newly gained insights. This is the main device to stimulate and practice reflection and self-correction. For example: although every work plan starts with the task to develop a problem formulation that is followed by another one to perform a stakeholder analysis (that is, stakeholder identification and determining the proposals, reasons for these proposals, and the interests and values of stakeholders), teams are instructed in a third step to adjust problem formulation and stakeholder analysis: "At the end, check whether your stakeholder analysis fits to your problem-formulation. If there is a mismatch, revise one of them."[11]

Similarly, teams are challenged to make sure, in their final presentation or project submission, to update their problem formulation so that it fits to what we call the final "symphysis proposal." In Greek, *symphysein* means "growing together." Whereas "synthesis" refers to "something that is put together," symphysis is intended to signify an ongoing process of *growing* together, that is, the *evolution* of a proposal that is always better – i.e., more broadly acceptable – than its predecessor or predecessors. The main focus of the user guidance realized in Reflect! is on *improving proposals* for specific problems and finding consensus among people with a variety of different views. With its focus on the "growing together" and the evolution of proposals, the Reflect! approach is clearly distinguished from those deliberation platforms that allow only pro-con debates on propositions that do not change.[12]

The instructor, however, needs to be aware that all this mutual adjusting of problem formulation, stakeholder analysis, and proposal development poses a fundamental problem. In contrast to the real-life experience of being embedded—as one stakeholder among many others—in the social reality of a wicked-problem management process, students in a team are the only agents around. As the authors of everything that gets done, they have absolute power to formulate the problem, determine the stakeholders, and develop a proposal as they want. They are talking *about* the stakeholders, not *with* them.[13] This means that teams are able—at least in principle—to get rid of the wickedness of the problem. Being aware of this problem means that an instructor can intervene—for example as an advocate for certain stakeholders. Even though a teacher is not supposed to provide any instruction, because the students

[11] Quoted from https://reflect.gatech.edu/how-to-develop-a-stakeholder-analysis/.
[12] For example: https://www.reddit.com/r/changemyview/, https://consider.it/, and www.procon.org.
[13] There is one work plan that includes "listening exercises." See https://reflect.gatech.edu/how-to-listen/. But this does not amount to collaborative problem solving with stakeholders.

themselves should experience the challenges of wicked problems, offering feedback on what the teams create and being available to answer questions is important. In educational settings it is crucial to find the right balance between feasibility of a project within the constraints of a course and the risk that a team finds an easy way out of the wickedness of the problem.

4. How to assess student work on wicked problems?

To provide an understanding of what it means, from my point of view, to achieve the learning goals for project work on wicked problems, it should be helpful to discuss the criteria that I am using to assess the work submitted by teams of students, and to show with examples how to apply them.[14] This assessment focuses on the three questions regarding problem formulation, stakeholder analysis, and symphysis proposal. Note that the student materials that are quoted as "2018" have been created in two classes with an enrollment of up to 180 students in which the project work has been managed by teaching assistants. I only graded the final project results. "2019" refers to two classes with an enrollment of about 35 students each in which I managed everything. All four classes were offered as PHIL 3127 Science, Technology, and Human Values.

4.1. Criteria for assessing the problem formulation

1. *Wickedness of the problem.* Here is an example of a problem formulation where the problem is no longer a wicked problem:

> **(Probl-1) Using Brain-Computer Interfaces with stroke patients**
> Brain computer interfaces are a new, emerging technology that is used to assist patients in cognitive and physical functionality. The specific technology focus we will be addressing is brain implants for stroke patients who have speech problems.
>
> The benefits for stroke patients are helping with functionality that they no longer have full control over as a result of loss of brain functionality. This technology is designed to be read only, but there is a significant possibility that it could be hacked and taken over by outsiders if it is connected to the internet. This, in turn, would turn the technology into write-only. The data acquired by the BCI could also potentially be misused without the knowledge of the patient.
>
> What guidelines for regulation should be implemented to ensure the autonomy is preserved? What ways are there to protect the humanity of the patient to ensure self-preservation, while still providing the benefits of the technology? (2019)

The difficulty with this problem formulation is that all the stakeholders that the team distinguished – patients, doctors, and technology developers – will agree that the only acceptable solution are guidelines that prevent the misuse of data and the hacking of the BCI. This means that there are clear standards that should be used to assess solutions for this problem – which would not be the case for a wicked problem, according to the definition provided above in section 2. Other cases of problems that are not wicked include raising a question whose answer should not be controversial or purely technical questions.

[14] The research protocol that determines my use of artifacts created by students has been approved by Georgia Tech's Institutional Review Board (IRB).

2. *The context in which the problem occurs is clearly described.* I did not find any final problem formulation that failed with regard to this criterion. But here is one that a team created very early in their project:

(Probl-2) Ethical use of FRT in criminal justice
Imagine you are a part of a government agency tasked with regulating the use of facial recognition in law enforcement agencies. What kind of legislature should be implemented that takes into account implicit biases and privacy concerns from the general public while maintaining an efficient system of law enforcement? (2018)

A description of the context is missing here in so far as it needs be explained why law enforcement would want to use facial recognition technologies. This problem formulation had additionally been criticized as insufficient with regard to the following four criteria:

3. *It is clear why the problem matters; why it is important; why it is unavoidable.*
4. *The boundaries of the problem are clearly determined and the focus of the project is clear.*
5. *It is clear what the (ethical) issues are.* For a positive example that shows how the ethical issues could be addressed, see the example of a problem formulation about micro-targeting at the beginning of this article. This example satisfies all the criteria of a good problem formulation.
6. *It is clear in which setting the team locates itself (a committee with a specific task, or something like that).* Regarding team setting, (Probl-1) above from a final project submission can serve as a further example for the failure to satisfy a criterion. Describing the team setting is important for two reasons. First, it must be clear whether there might be a conflict of interest if a team is paid or established by one of the stakeholders. Second, the setting in which a project is conducted determines a particular perspective on the problem. Learners should reflect on this fact. This is important to break up the habit of assuming an absolute point of view, a point that is detached from everything.
7. *The team provides a clear goal for its work.* This is important later for assessing whether all components of the problem formulation have been addressed by the proposal to cope with the problem. Here is an example for failing to achieve this seventh criterion:

(Probl-3) Preventing and Mitigating AI Bias
Bias is inherently built into many different AI technologies. In the case of Google search, several instances of racial, gender, minority, and political biases have recently received significant attention. For example, women were less likely to receive high-paying job advertisements while using Google search. Another example is that replacing “white person” with “black person” often returns results with negative connotations. Additionally, Google has recently received a lot of criticism regarding the negative results when searching for political news. Having bias present in Google's search poses a problem because it is the main way through which billions of people obtain information. Presenting biased data to the public has the potential for perpetuating existing biases and creating new ones. Currently, there are little to no standards to which Google must follow with respect to bias in its AI products. How can Google be more transparent with biases

> that may currently exist in Google search, and how can we prevent the emergence of new bias in Google's search engine technology and mitigate the bias already present in their search engine? The ethical issue central to this problem is that Google believes that they are presenting what their users want to see the most, whereas underrepresented users believe that Google is helping to perpetuate existing biases against them. In addition, if Google were to block certain searches, this act could be seen as censorship of information that people want to know. (2018)

It is not really clear here what exactly the team attempts to achieve. This poses a problem both for the determination of stakeholders and for assessing the quality of a symphysis proposal.

4.2 A criterion for assessing the stakeholder analysis

The stakeholder analysis is an important part of a team's work in the earlier phase of a project because it provides a deeper understanding of who the stakeholders are and what their values and interests are. Towards the end of a project, however, teams have to focus on developing a proposal that can, potentially, satisfy all stakeholders. For this later phase of a project, there is only one question that remains relevant:

8. *Are any important stakeholders missing?*

Important stakeholders are missing when in another project on brain-computer interfaces (besides Probl-1) the government, military, software development companies, healthcare organizations, people with disabilities, and advertising/marketing firms are listed as stakeholders, but not insurance companies. These companies can be characterized as having an incentive to reduce costs for medical treatment, and this interest might be threatened by very strict privacy protections. Thus, insurance companies need to be taken into account when it comes to creating a symphysis proposal that is supposed to satisfy *all* stakeholders.

4.3 Assessing the symphysis proposal

I am using four criteria to assess the quality of symphysis proposals, that is, proposals that are supposed to "grow" and evolve over time:

9. *Its components are consistent. No contradictions.*
10. *All questions that are raised in the problem description are addressed. Nothing remains unanswered. (If not everything can be answered, then the problem should be defined more narrowly or there should be an explanation under "Considerations")*
11. *The proposal talks only about things that are needed for the problem. No superfluous material.* This criterion is supposed to direct students' attention to the expectation that there should be a good match between problem formulation and proposal. It is also important because a proposal component that is not needed to address the problem distracts attention to something that is irrelevant.
12. *It is reasonable that all stakeholders would agree with the symphysis proposal, or would at least be neutral.*

In the following, I am first providing an example of a symphysis proposal of high quality and then one that is more problematic. The first one has been submitted by the team whose problem formulation I quoted in full in the beginning of this article. To show how the components of the symphysis proposal are related to the project goals of the problem formulation, I present each

example in form of a table. All entries in both tables (besides the "goals" in the second table) are quotations of what the students wrote.

The goal of the project	***Components of the symphysis proposal***
What policies and regulations should be established to affect either federal political organizations or social media companies to help stop the spread of political misinformation?	• The government should create regulations that require social media companies to monitor the content of all political ads to prevent misinformation of any kind. • Require that a disclaimer be displayed describing who authorized and funded the advertisement. • The government should require Social Media Companies to mark ads with misinformation as being potentially dubious • Fund non-profits giving the public "media literacy" skills to help them discern between fake and real news/advertisements
How can we ensure people are seeing information from a variety of sources, and not just from one political point of view?	• Reenact an analog the [sic] FCC Fairness Doctrine under the FEC which requires social media companies give fair treatment to issues of public importance. The government should ensure that these new policies are enacted equally to all points along the political spectrum. […] • The FCC should Bring [sic] back something analog the equal time rule to ensure fair political representation in media by allowing opposing candidates to respond to misinformation in online advertisements. Political opponents would get the chance to respond to political ads to a similar audience, for a similar amount of time. […]
	• Social media companies should focus on user experience and user retention by catering to users [sic] preferences indicated by surveys.

Tab 1. *The two project goals are quoted from the longer problem formulation provided in the Introduction above.*

As the alignment between proposal components and project goals makes clear, this symphysis proposal answers all the questions raised in the problem formulation. Problematic, however, is the last proposal component at the end of the table. It violates the third criterion according to which a proposal should talk "only about things that are needed for the problem." It is not clear which part of the problem formulation is addressed by this component. Moreover, it remains unclear why the team is proposing this at all. Usually, the provision of a justification for each component (see 4.4 below) can be used to understand why a team thinks that a component is necessary, but in this case the team provided just a link to a scientific article without explaining the function of the component in question.

There is no contradiction among the components of the symphysis proposal (first criterion) so that only the fourth criterion remains for consideration: *It is reasonable that all stakeholders would agree with the symphysis proposal, or would at least be neutral.* The team distinguished five stakeholders. The instructions on the platform require that the teams, after formulating a symphysis proposal, determine for each stakeholder how much each likes the entire proposal

by entering a value between -3 (dislikes very much) and 3 (likes very much). Here are the five stakeholders with their respective level of approval as determined by the team: Social Media Companies with an interest in decreasing misinformation (3); Social Media Companies solely worried about profit (1); Political Organizations against the use of micro-targeting (3); Political Organizations who are for the use of micro-targeting (0); and Voters who use social media (2). Of course, these judgments regarding approval by the stakeholders can be questioned. But as long as they are not entirely implausible, I do not care much about them.

For the second example, let me first provide the complete problem formulation:

> **(Probl-4) Monitoring in the Workplace**
> As the prevalence of artificial intelligence increases in the workplace, companies are implementing E-Mail surveillance, call monitoring, and camera tracking to promote productivity and efficiency. As with the case of Enron, these technologies also demonstrate their value in preventing corruption and other wrongdoing, but some employees may feel their expectation of privacy is being violated. A committee of business owners, corporate employees, and government officials has been put together to propose an ethical set of rules to govern such technologies in the workplace that will satisfy all stakeholders. (2018)

The goal of the project	***Components of the symphysis proposal***
Determine an ethical set of rules to govern monitoring technologies in the workplace [my paraphrase]	
Determine rules that ensure the privacy of employees [paraphrase]	
	Committees of government officials within each state's Department of Labor will be created to oversee the use of AI in each of the companies that reside in their respective states.
	Each committee will survey each company annually to determine the level of AI implementation in each respective company. […]
	Ranges of AI situational use will correspond to a flat tax rate (i.e. a score of 20-30 results in a flat tax of $'x'.
	Any violations that are found will result in predefined fines, and the funds collected from these fines will be appropriated under government jurisdiction.
	Each committee member will hold the position every 4 years […]
	A subcommittee in Congress will be formed that oversees and decides the appropriate tax rates […]
	For the first year of enactment of this legislation, research will be conducted by the Federal Department of Labor to determine the current landscape of AI in the workplace […]
	Any activities with regards to the AI that a committee deems unethical will be recorded and brought to the attention of the board members the United States Department of Labor.
	Companies that do not use AI will not have any marginal tax levied against them that year.

Tab 2. *Analyzing (Probl-4) and assessing the alignment of proposal components to project goals*

The misalignment between components of the symphysis proposal and the central components of the problem formulation is clearly visible in this table. It seems that the team drifted towards a completely different problem, namely the effects of AI deployment on jobs. In a passage that I removed from the quotes above, the team talked about "AI is overtaking" workers' responsibilities. The problem is that it is impossible to assess the quality of a proposal without knowing what exactly the problem is that it is supposed to address.

4.4 Justification of proposal components

When students are working on a symphysis proposal, they have to provide for each component of this proposal a justification. The main purpose of such a justification is to document the reasoning process that led to a particular symphysis proposal. This is important because sometimes particular components are designed to compensate a stakeholder for a loss or disadvantage that they experience with regard to other components of the proposals. The justification is supposed to clarify considerations like this one. Another function of a justification is that it allows the teams to communicate to outsiders why the proposal is designed as it is. And thirdly, considering the "why" of a proposal component is supposed to stimulate reflection. An attempt to justify a component can reveal that there is no good reason for it. This experience should motivate a revision of the proposal.

In the past, I used two criteria for assessing justifications:

13. Are all components justified?

14. Quality of argument maps

The second criterion refers to a requirement that I had established until a few years ago: that justifications had to be provided by using an argument mapping software whose use had been trained in the beginning of class. The resulting argument maps were then evaluated with criteria that are now published (Hoffmann and Catrambone 2023). Argument maps can still be used, but newer work plan versions allow learners to enter justifications as plain text.[15] At this point, I suggest to assess these justifications with the following criterion:

14. b. Is every justification of a proposal component sufficient to justify why this component is important for the overall symphysis proposal?

5. Assessing the Reflect! learning experience

What do students think about their experience of working on a wicked problem guided by the Reflect! platform? To answer this question I administered a survey at the end of two courses that I taught in the spring of 2020. This survey contained rated opinion items and open-ended questions. The opinion items asked students to indicate their agreement with a given statement using a 5-point Likert scale with the following response options: Strongly disagree, disagree, neutral, agree, and strongly agree (1-5). The items were designed to capture students' perceptions with regard to three questions: (1.) Does the Reflect! approach provide the right balance between enabling autonomous work in teams and guidance? (2.) Does it stimulate

[15] I gave up to require argument mapping because it extends the time needed to complete a project.

reflection and self-correcting reasoning and what exactly provides the stimulation? And (3.) what are the effects of working on particular project components? In addition to these rated opinion items, students were asked to provide feedback to four open-ended questions: (1.) What did you like most when working on your Reflect! project? (2.) List negative experiences and difficulties of working on your Reflect! project. (3.) What did you learn? And (4.), do you have recommendations for improvement?

A total of thirty students took the survey; twenty from a class called "Philosophical Analysis of Policy Choices" (PHIL 2025) and ten from "Ethics and Epistemology in Public Policy" (PUBP 6010). PHIL 2025 is required as part of the Bachelor Program in Public Policy at the Georgia Institute of Technology and PUBP 6010 as part of the Master's Program. Since both courses are part of the core curriculum in each program, at least 90% of all students in both pursued a public policy degree. Demographic information of the participating students is described in Table 3.

Course	*N*	*% of Class Enrollment*	*Female*	*Student Level*
PHIL 2025	20	66.6%	80%	Undergraduate
PUBP 6010	10	100%	50%	Graduate

Tab 3. *Student demographics of survey respondents per course (n=30)*

Both classes focused on argument construction and assessment, ethics, and epistemology in the first two-thirds of the semester. In the third part, wicked problems were used to deepen students' understanding of ethics and epistemology and to learn and practice strategies for dealing with wicked problems in team projects. Working on the Reflect! platform was introduced by a "walk-through." In preparation, each student had to read something about a given wicked problem and had to submit, individually, a problem formulation on the platform according to the instructions of their work plan. Over two meetings, the entire class went then, guided by the instructor, through the essential components of their work plan and entered some preliminary ideas developed in class discussions.

After this walk-through, three teams in PHIL 2025 worked over five team meetings (each 75 minutes during regular class time) on "How to formulate a right to free speech that protects us from the political damages of hate speech?"[16] Four teams worked on "Micro-targeting in Social Media."[17] In PUBP 6010, two teams worked—in the same time frame—on "Planning traffic and transportation in Metro Atlanta for the next 30 years."

All teams worked autonomously, but guided by a work plan whose main phases included developing a specific problem formulation, a stakeholder analysis, and an evolving symphysis proposal. Each of these components had to be available on the platform at certain points in time for critical feedback from the instructor. According to the work plan used in both classes, the first team meetings had to be prepared by individual homework; later homework was determined by the teams themselves to achieve the goals set by the work plan. The meetings were reserved for autonomous collaboration on the tasks at hand. "Autonomous" means that

[16] Find the assigned problem formulation at https://reflect.gatech.edu/wicked-problems/#free-speech.
[17] See https://reflect.gatech.edu/wicked-problems/#Micro-targeting.

the teams worked on their own, but: they could come to the instructor and ask for help; the instructor walked from table to table to get updates on the teams' progress and answer questions; and the instructor provided critical feedback on a weekly basis both in writing by email before class meetings and verbally during team meetings. This feedback used the assessment criteria described above in section 4. More information about how teams work through a project is provided in videos at https://reflect.gatech.edu/videos/.

The project work was concluded by the teams presenting and discussing their projects over two class meetings. Due to the COVID pandemic, only the walk-through in PHIL 2025 was done in a physical classroom; the rest online. In PUBP 6010, online work started with the fourth team meeting. It should be mentioned that all in-class group work described in this article happened in a so-called "Scale-Up Classroom." Most relevant is the fact that these classrooms provide movable chairs and tables and enough space for groups to gather around a table.

Surveys were administered anonymously and online about ten days after the last class meeting. Students received extra course-credit for the participation in the survey. The research protocol and all materials have been approved by Georgia Tech's Institutional Review Board (IRB).

5.1 Results

To determine whether the Reflect! approach provides the right balance between enabling autonomous work in teams and guidance, participants were asked about their opinions regarding both positive and negative effects of working with the Reflect! platform. Since the teams worked autonomously, the questions about positive and negative effects are supposed to capture whether the guidance provided by the platform and the instructor is sufficient to provide a satisfying learning experience.

The results presented in Figure 2 focus on possible *positive* effects of working with the Reflect! platform. Student answers indicate that especially effects on "staying focused" and feeling motivated to "think about our problem from a variety of perspectives and understand how deeply complex the issue really is" were perceived as positive. These quantitative results are supported by answers to the open-ended questions. Asked what they liked most when working on their Reflect! project, one student wrote:

> I liked how organized the work flow was and how Reflect! helped us to stay on task and work together as a team, even though we were physically separate. It was also a helpful way to think through a complex problem. The stakeholder analysis was especially helpful.

Others wrote: "The instructions were very thorough and meticulous and it was easy to get back on track if I was confused"; "it helped me visualize what we needed to be doing & helped me stay on track." More details regarding positive effects of working on the platform are provided in the following answers to this question:

> I really enjoyed the process that is laid out for this project. There was a noticeable progression in our ideas and our ha [sic] the ability to go back and change our beginning steps to create a more thematically consistent project.

I think it helped shape my understanding of what my professor was looking for and facilitated our team's ability to actually begin addressing the wicked problem.

I liked how clear everything on the Reflect! platform was. It provided guided instructions, which helped when we worked on the project. The instructions were always detailed and helpful.

I liked working in a small group with people that I hadn't worked with before. I liked that we could all view each other's work on the same website at the same time. That made collaboration a lot easier. I also thought the topic of the project was so interesting and I liked that we had a lot of freedom about what our symphysis proposal would be.

The opportunities for creativity, teamwork, and leadership afforded to everyone on my team.

Figure 3 captures the students' opinions about negative effects of working with the Reflect! platform. The fact that the averages of student agreement with the statement "I wish that we were able to talk to the professor more" lie a little bit above the perfectly neutral position of 2.5 (with 2.8 and 2.9) indicates again that the engagement of the instructor is important. However, it also indicates a certain shift in the direction of educational interaction that is indeed intended: It is a feature of problem-based learning, not a bug, that the learners want something from the instructor, not the instructor from the learners.

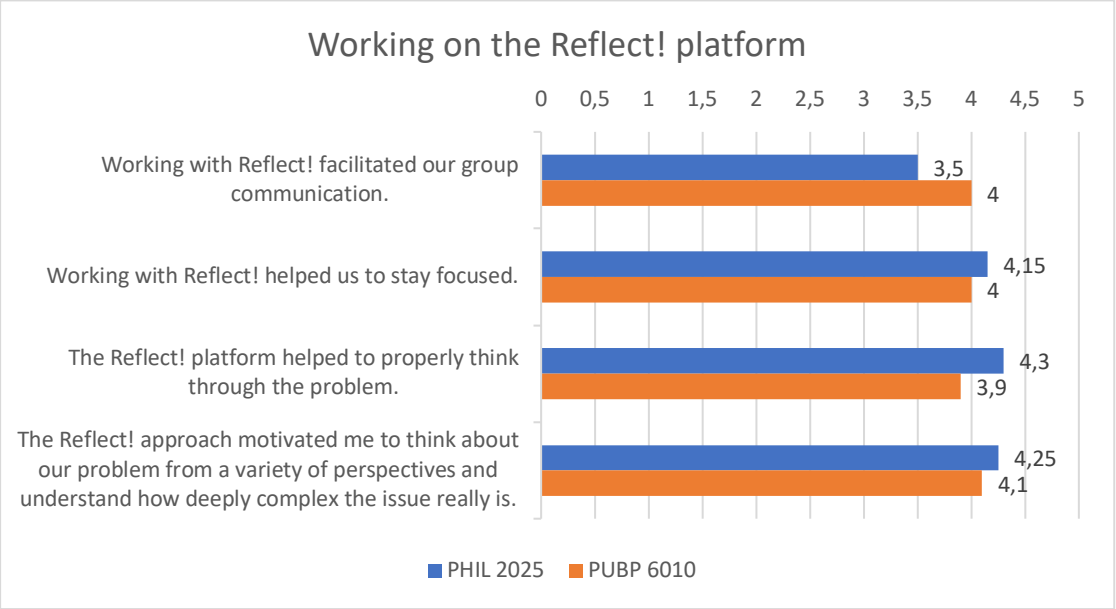

Figure 2: Positive effects of working with the platform

Even though agreement with all the other negative perceptions in Figure 3 is below the perfectly neutral position, the critical feedback provided by students is important. What they didn't like is specified in their feedback to the request: "List negative experiences and difficulties of working on your Reflect! project":

Occasionally I would be overwhelmed by the amount of text in the instructions for certain steps.

Sometimes I would get confused in the layout but that problem mostly went away after I had more time using Reflect!.

The platform seemed unnecessary for the project.

I feel like things could have been simplified on this platform. Certain assignments had too many components when I think it could have been said more straightforward.

Some of the instructions on the Reflect platform are unclear. In-class explanations and demonstrations were helpful to understanding what we were actually supposed to do, but without these explanations some of the Reflect instructions would have been confusing.

I thought that the amount of time devoted to the Reflect! group project was not a good use of our time, given the opportunity costs (i.e,. what else we could have been reading and learning that may have been focused on philosophical issues related to Public Policy). The sheer amount of class time spent on this project was not worthwhile.

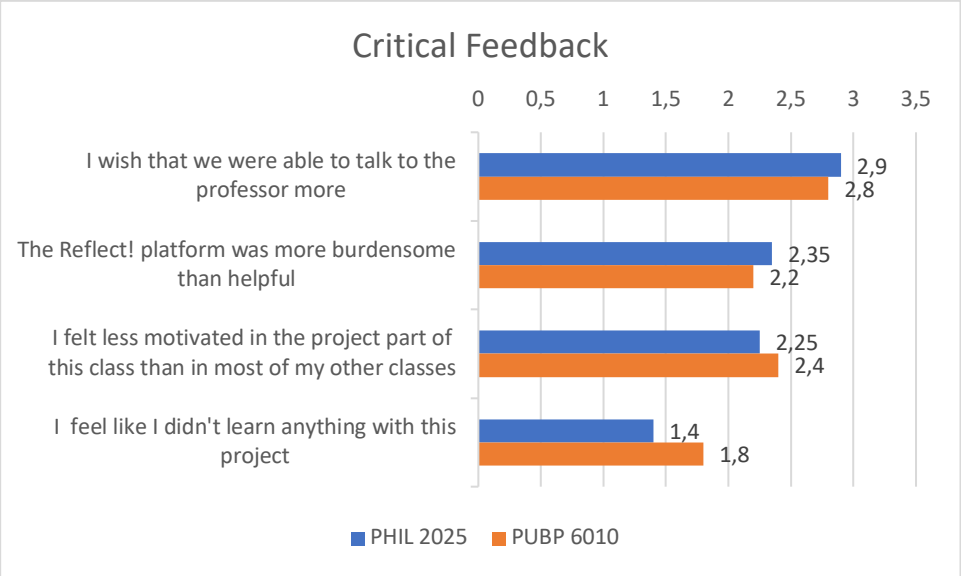

Figure 3: Negative effects of working on the Reflect! project

It should be noted that most answers to this question (17 out of 27) addressed software and user interface issues on which the developer team is working continuously. Important ones have already been addressed. Seven out of 27 students who answered this question wrote something positive such as: "I did not experience anything negative of [sic] difficult while working on my Reflect! project. Everything was pretty straight forward, and as long as my group communicated and worked together, we did not have any issues." Or: "at first we were confused about how to use the platform, but we got adjusted to it and it became easy to use so i don't really have any complaints."

Overall, a comparison of Figures 2 and 3 indicates that, according to the students' perceptions, positive effects of working with the Reflect! platform outweigh negative effects. Critical feedback to the open-ended questions shows that the guidance provided by the software can be improved, but there is no indication that it is not sufficient. The comment that the

"platform seemed unnecessary for the project" seems to underestimate the main function of the platform: that its guidance enables autonomous work on a wicked problem without requiring facilitators. We can conclude – at least with regard to this small number of participants – that the main goal of providing a tool that provides an acceptable balance between autonomy and guidance has been achieved.

The second goal of the survey was to determine the degree of reflection and self-correcting reasoning that the students experienced while working with the platform. As discussed at the end of section 2, being able to change one's perception of the problem and the reasoning about it is crucial for coping with wicked problems. Figure 4 shows the results on reflection and self-correcting reasoning. In PHIL 2025, thirteen respondents out of twenty "agreed" and seven "strongly agreed" to the statement "We frequently changed entries, even going back after some time." In PUBP 6010 the corresponding numbers are four and four out of ten, but one student disagreed and another one was neutral. One student wrote: "I liked that we had to go back multiple times and change our ideas because the first one wasn't always the best."

With regard to the question of what motivated these changes it is interesting that in both classes most of the students strongly agreed to the statement: "Changes were often motivated by feedback from the professor" (4.7 points). These responses, as well as feedback to the open-ended questions, motivated a redesign of work plan instructions to provide more reflection guidance. But they also highlight the responsibility of the teacher for promoting reflection.

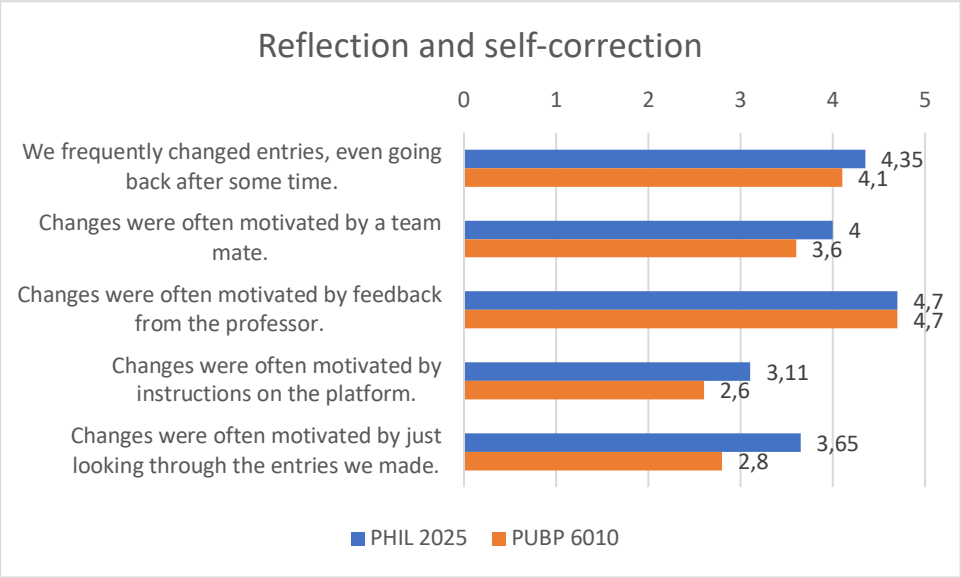

Figure 4: What motivated reflection?

Figure 5 shows feedback on the three core components of a Reflect! project on wicked problems: problem formulation, stakeholder analysis, and proposal development. It is interesting to note that opinions on the latter two items are the only ones in the survey where we find a stark difference between the two classes. It can only be speculated that the discrepancy in perceptions results from the two very different kinds of wicked problems that were used in both classes. Considering traffic and transportation in a big city (PUBP 6010) differs from politically more contentious discussions about free speech and micro-targeting in social media. The results from PHIL 2025 show a high level of agreement regarding the support provided by

the platform for crucial challenges of wicked problems, those from PUBP 6010 less so. Here are a few answers to the open-ended questions that provide more detail:

> I liked how the project had a clear outline, examples, and a problem formulation that we could read through and mirror the format of. I appreciated how we could compare interests and values when going further into stakeholder analysis, and feel like the platform aided the timeline of our project.
>
> The process of thinking through a complex problem and trying to figure out the many layers that occur with it.
>
> I found the stakeholder map very helpful. Being able to visually distinguish the stakeholders and add reasons to each was very helpful when thinking through the differing interests.
>
> The stakeholder analysis was a useful tool for mapping proposals, reasons, and interests.
>
> I liked that I could see the team analysis and that the whole team could work on the Reflect! platform at the same time. I also liked how the symphysis portion of the project moved quickly after having put in lots of time on the stakeholder and problem portions.

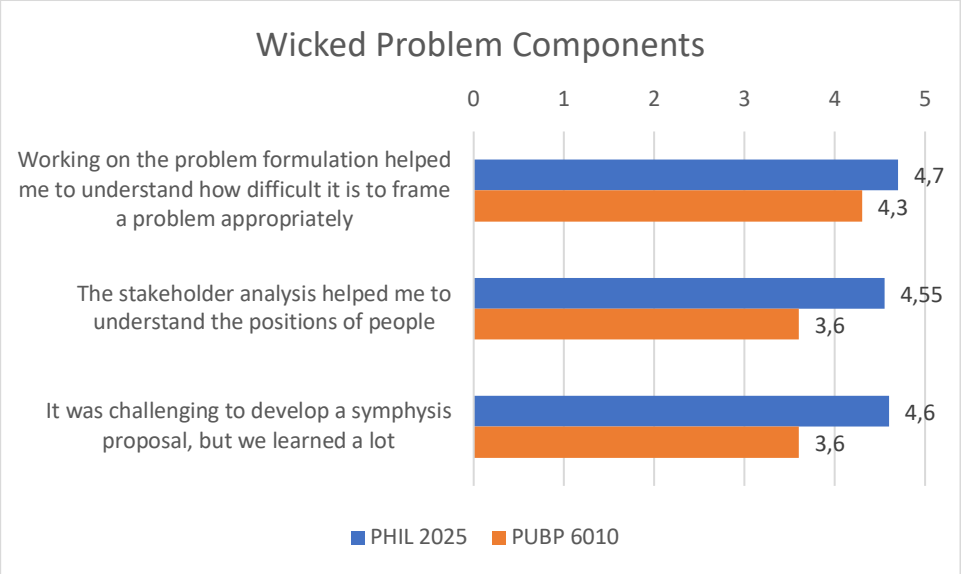

Figure 5: Problem formulation, stakeholder analysis, and what is called a "symphysis proposal" (from the Greek word for "growing together") are at the center of every Reflect! project

In summary, Figure 2 shows that the overwhelming majority of participants indicated that the Reflect! approach motivated them to think “from a variety of perspectives” about the wicked problem they had to deal with and that they came to “understand how deeply complex the issue really is”; Figure 4 that they “frequently engaged” in reflection and self-correction; and Figure 5 that working on the problem formulation helped them “to understand how difficult it is to frame a problem appropriately.” These results should be a good starting point for more work in this direction.

6. Conclusion

Wicked problems are an important challenge in modern life. Especially in democracies people need to understand, first, that simple solutions to wicked problems usually come with a high price for those who are harmed by decisions that do not take all stakeholders sufficiently into account. Second, they need to understand that wicked problems should not be avoided or left to others. Since harm can result from not addressing wicked problems adequately, it is a question of ethical responsibility to deal with these problems – and to approach them with the best strategies available.

It should be a central task of education to provide opportunities to develop the skills, dispositions, and confidence needed to deal with wicked problems. I tried to show how those opportunities can be created with team projects that are guided by the Reflect! platform. The platform has been designed to address a crucial challenge that educational efforts are facing when they aim at promoting and practicing wicked problem skills: how to find the right balance between team autonomy and guidance? How can students be exposed to experiencing the wickedness of problems on their own without getting lost in confusion, frustration, or conflict? The Reflect! platform is a tool that enables us to teach coping with wicked problems in a responsible manner.[18]

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[18] It is easy to set up a user account at https://reflect.gatech.edu/ to play with Reflect! in a "sandbox." Please contact me if you want to create a class project. We are still working on an interface to do this without support.

[19] Award 1623419: https://www.nsf.gov/awardsearch/showAward?AWD_ID=1623419&HistoricalAwards=false.

[20] See https://reflect.gatech.edu/about-us/.

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