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An Interplay of Problem-Solving Modes and Authority: Framework for Equitable Collaboration in Undergraduate Physics Labs

Sophia Jeon, Cornell University, mj398@cornell.edu
N. G. Holmes, Cornell University, ngholmes@cornell.edu
Eleanor C. Sayre, Kansas State University, esayre@gmail.com
Scott Franklin, Rochester Institute of Technology, svfsps@rit.edu

Abstract: We use the Adaptor-Innovator Theory and the Influence framework to interpret undergraduate physics laboratory students' approaches to – and bids for – intellectual and directive authority. Students display behaviors that utilize structure and work within a defined system (adaptor) and, separately, behaviors that work outside the system (innovator), the latter often by engaging directly with equipment. Adaptors exhibit high authority by asserting experimental understanding, whereas innovators are attributed with high authority through their frequent, direct handling of the equipment. We interpret equitable collaborations as those in which students 1) have full access to the experimental or conversational floor adaptively or innovatively while being 2) acknowledged in their authority by their group.

Keywords: problem-solving, equity, collaboration, Adaptation-Innovation Theory, authority

Theoretical framework

Although group work is an important form of learning for undergraduate STEM students, improving problem-solving skills and content understanding, identity-based performance gaps persist (Heller & Hollabaugh, 1992; Madsen et al., 2013). We examine undergraduate physics lab students' group dynamics, integrating the Adaptor-Innovator Theory (AI Theory) and the Influence Framework to interpret problem-solving behavior and frame a definition for equitable collaborations (Kirton, 2011; Langer-Osuna, 2016).

In AI theory, *adaptors* approach problems methodically, using given structures (Simpson, 2019). We observe three adaptor mode behavioral markers: i) seeking instruction, ii) defining the system, and iii) adhering to a manual. Conversely, *innovators* "problem solve by working outside of the system, sometimes creating radical changes" (Simpson, 2019). Innovator mode behavioral markers include: i) frequently handling equipment, ii) generating new ideas, and iii) exploring with curiosity. Individuals can exhibit both modes, and behaviors exist on a continuum, with the degree depending on context (Kirton, 2011; Kirton, 1980).

Students negotiate problem-solving modes through authority, and seek acknowledgment in their preferential approaches. The Influence Framework defines two types of authority: *intellectual authority* is perceived "as credible sources of information pertinent to the particular task at hand", while *directive authority* makes commands or suggestions to steer a course of action (Langer-Osuna, 2016). We find that acknowledgement in authority differs with the AI mode accessed: innovators are *attributed* with authority as they handle the equipment, whereas adaptors *claim* authority by asserting experimental understanding.

Table 1: Behavioral markers of adaptor and innovator modes and authority.

Adaptor-Innovator Theory		**Influence Framework**	
Modes	**Behavioral Markers**	**Authority**	**Behavioral Markers**
Adaptor	•Asks for and seeks instruction •Defines the system at hand •Appeals to lab manual	**Intellectual Authority**	•Perceived as an important source of information, asked questions by peers •Makes claims about experiment
Innovator	•Frequently handles equipment, not afraid to make changes. •Generates ideas outside of manual •Expresses curiosity in equipment	**Directive Authority**	•Makes directives to peers •Prompts actions on the equipment •Perceived as one that confirms bids

Methods

In this study, one researcher observed videos of students collaborating on advanced physics lab experiments at a public research university in the midwestern United States. The course is populated by second- and third-year

physics majors and minors. After transcribing student discourse, the researcher coded for moments of high or low levels of intellectual and directive authority and when students approached problems adaptively or innovatively. Codes were confirmed with another researcher, who separately analyzed the videos, and organized into the codebook shown in Table 1, which describes the various behavioral markers.

Manifestation of problem-solving modes and authority and frame of equity

Students demonstrated behavioral markers of adaptors and innovators, moving fluidly between the two. For example, we observed a student to initially access the innovator mode, saying, "I kind of want to just start trying things" (unafraid to make changes on equipment), and later access the adaptor mode, saying, "We have to be really careful because of the cord in the back…that's what the manual was talking about" (appeals to lab manual). When a group attempts to access different problem-solving modes simultaneously, they express a preference through bids for authority. Their level of authority depends on how their peers respond to their ideas, and does not necessarily correlate with confidence or AI modes. For example, one innovator says, "I'm gonna start flipping these knobs…I don't know." Though he is unsure of his actions, the group affords him intellectual authority, perceiving him as a source of important information. In another group, an adaptor claims directive authority by proposing tasks and responsibilities: "Someone should be the ring measurer, someone should keep an eye on voltage." She opens up the conversational floor—indicating influence—by asking "Who wants to be the ring measurer?" Her partners acknowledge her directive authority by taking on various roles and asking clarifying questions. Students with high intellectual authority are acknowledged by their peers; students with low intellectual authority, in contrast, are often unheard by the group even after expressing their thoughts.

We observe low authority when students are not given access to the conversational nor experimental floor, despite explicit bids. For instance, when one student suggests that the group ask the professor for confirmation, a partner rejects this bid for directive authority and instead asks the third member: "Should we turn it to, like, 500 and plug it in just to see?" The second student nevertheless persists, interjecting "Yeah, I would just say. Test it first and then we can actually start taking data." Bids for authority may be rejected when students have differing problem-solving modes. In this example, we observed an adaptor reading from the lab manual in a bid for directive authority, which is rejected by the innovators directly handling the equipment.

We interpret equity as the ability to access the experimental or conversational floor and be acknowledged in one's authority to approach problems adaptively or innovatively. For example, a student adjacent to a monitor may be unable to see the lab equipment, and thus have limited access to the experimental floor. Participation would therefore require explicit interjection into ongoing discussions, which are often ignored. When one student asks, "Do you know how to use an oscilloscope?", the other responds with "Kind of," ignoring the marginalized third member's response of "Yes." Here we see the inequity of access to the conversational and, thus, experimental floors to decrease group productivity, as the member with knowledge has been denied intellectual authority. When student authority is acknowledged, students can participate fully and thus equitably in their problem-solving collaboration. Inequities, however, are produced when students are marginalized by peers that dominate in authority or do not recognize bids because of a different problem-solving mode. The balance fluctuates throughout a lab, with moments of inequity interspersed with moments of equity.

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