Using Active Facilitation Strategies to Transfer Ownership in Teaching and Mentoring Contexts

Tamara Ball, Lisa Hunter, and Austin Barnes
Institute for Scientist & Engineer Educators, May 2017

Participants in ISEE programs are encouraged to teach and mentor in ways that transfer ownership to learners. Though learners can feel a sense of ownership over many aspects of their learning, emphasis is put on transferring and maintaining ownership over learning core concepts and practices in science, technology, engineering, and mathematics (STEM). Put simply, ISEE supports teaching and mentoring strategies in which learners feel that "I figured it out myself." This section outlines the diverse research supporting the importance of ownership as both a strategy and an outcome for improving STEM education, including an excerpt of an interaction between a mentor and a student that brings to life how active facilitation can transfer ownership to learners

There have been many calls for educational approaches that encourage a sense of ownership among learners, or that promote the transfer of ownership from those in the role of instructor or mentor to those in the role of student or apprentice. Such calls to action are based on research demonstrating that a learner's sense of ownership impacts learning outcomes, including conceptual understanding and proficiency with STEM practices, as well as affective outcomes such as motivation, engagement, and confidence. Although different terms have been used to describe a cluster of constructs related to ownership (i.e. agency, self-regulation, self-initiative, autonomy, self-determined learning), a general consensus around the benefits of promoting the transfer of ownership and greater autonomy during learning is well supported in the literature. **Moreover, there is compelling evidence that the moment-to-moment twists and turns of live interactions between educators and learners (referred to as "facilitation" in this paper) significantly impact learners' sense of ownership.**

While there is a vast literature reporting findings from observing teachers interacting with students in K-12 classrooms, studies conducted based on observations of the in-the-moment live interactions occurring in college courses are uncommon, and in mentor settings are rare. Among the few observational studies of learning in a higher education or mentor setting that do exist is a study conducted by Ball[1] that focused on interactions between mentors and undergraduate interns in a research setting, as well as in a preparatory course that used a series of inquiry labs to prepare interns for research. Ball recorded hundreds of hours of interactions between nine sets of mentors and interns; she segmented the recorded footage into discrete "episodes" (~1-3 minutes in duration). Using methods from Systemic Functional Linguistics,[2,3] she devised a coding system to identify and quantify instances of interns' reasoning and self-initiating "moves" (verbal and physical actions). Drawing on the principles of *Cultural Historical Activity Theory*[4,5] her analysis was attentive to multiple aspects of the interaction or the "activity system," including not only what mentors were doing or saying to interns but also pertinent features of the material, social, and cultural context of the situation. Consequently, Ball was able to correlate particular conditions of the immediate context with instances of the interns' displays of self-initiative. Ball's results included:

- Self-initiative varied for all interns over their program experience – indicating that initiative was not an innate trait, but rather a **product of mentoring and teaching interactions**.
- **Four kinds of conditions resulting from facilitation** were identified and correlated with interns showing self-initiative or self-expression. For example, the prevalence of one type of discourse pattern over another: *when "monologic" or one-sided discourse with mentors positioned as the expert knower prevailed, intern initiative was constrained, whereas "dialogic" or two-sided discourse patterns with mentors positioned as co-investigators promoted intern initiative.*

Among the different contextual conditions identified in Ball's study the facilitating actions of the mentor were some of the most influential. The vignette in Box 1 represents one of many episodes identified as an instance when it was evident that the mentor's facilitation affected intern's self-initiative or ownership.

Box 1. Facilitating the transfer of ownership to an intern engaged in applied problem solving

Anna is a summer intern who has been tasked with characterizing a set of optical lenslet arrays. At this particular juncture Anna was puzzled about some of the results she had been getting and initiated a discussion with her mentor, Omar:

Anna: Can you explain to me what the -what this thing does?

Omar: What was that?

Anna: I can't explain what…

In response to Anna's request for help, Omar draws a diagram on a whiteboard, offers some initial explanation and then sits back down handing the drawing tools over to Anna. It is important to convey that Omar's demeanor and tone throughout this exchange was friendly and supportive. Anna understood he was inviting her to explore and query further rather than testing her.

Omar: Imagine the light coming down (draws a line) - some of it might go up to the lens, (draws again) you could have a big lens here (uses a gesture to circle part of the diagram) but some of it could be like here (draws another line) and shooting out (draws a line veering out) and it goes away right? So that's bad right? Because then you can only see here (draws a smaller circle). So how do you think the different focal points are going to be affected - what's that effect?

Anna: What do you mean?

Omar: Well how does your - are all your lenses the same?

Anna: Are my lenses? No.

Omar: Are they different? How are they different?

Anna: In terms of focal length? You mean curvature - curvature right? 'Cause they are all the same size.

Omar: They are all the same size, they are all 200 microns? So the curvature is different?

Anna: (gesturing towards diagram on whiteboard) In terms of the focal length right?

Omar: (doesn't respond, sits back down in a chair)

Anna: I am thinking that one would be... (...pauses to think it over) the one with the highest curvature is going to give me more errors or something –

Omar: Why do you think that?

Anna: Because it's going to be (turns to diagram on whiteboard) they are all the same size - so it's going to bend down more, so it's going to have more light going away on this axis (makes a gesture in reference to the diagram).

Omar: So we've got to figure out if we can fix that right?

Anna: So - what I am thinking is that biggest curvature corresponds to smaller focal point right?

Omar: I don't know we've got to figure it out. You've got to figure it out.

In episodes that followed, Anna could be observed making more independent observations and drawing her own conclusions. Ultimately, Anna had the confidence to challenge her primary mentor's assumption about an important characteristic of the lenslets, enabling her to make a valued contribution to the project. The above vignette captures one of the interactions that were observed as Anna began taking more self-initiative and ownership of the problem she was tasked with solving.

Box 2. Facilitation strategies used to promote ownership

This box describes some of the strategies employed by the mentor in Box 1, in relation to transferring ownership to the intern. Viewed through the lens of cultural historical activity theory (CHAT), the activity (the interaction in Box 1) was mediated by material tools, discourse, power dynamics, and the norms of the community. Though described below in isolation, these factors are highly inter-related and collectively served to transfer ownership of the problem solving from the mentor to the intern.

Control of material tools: Omar relinquished control of the material tools he was using to create the diagram (marker and whiteboard) and made space, physically and intellectually, for Anna to take the lead. By sitting back down after modeling a way to start thinking through the problem, Omar invites Anna to take the lead and shifts the burden of explanation back to her. A more typical scenario would have been for the mentor to remain at the whiteboard explaining his understanding at length, or inviting Anna to make verbal contributions but retaining control of the tools and not enabling her to contribute to the co-construction of the diagram. In either case, Anna would not have had the same opportunity to drive (have ownership of) the thinking.

Verbal cues or moves: Omar's employment of a number of verbal facilitation techniques such as his use of open-ended follow-up questions (e.g. "Are they different? How are they different?"), his re-voicing parts of Anna's utterances (e.g. "They are all the same size…So the curvature is different"), and other sorts of "pivot moves" reinforced her role in the problem solving process. It is also important to recognize the timing of these moves. Omar makes verbal facilitation moves in places that might otherwise have been occupied by more evaluative or explanatory statements. For instance, when Anna offers her partially formed idea (I am thinking… the one with the highest curvature is going to give me more errors or something") Omar could have responded by confirming or disconfirming her tentative assertion or providing his own explanation. Instead he asks Anna to elaborate ("Why do you think that?"), keeping ownership of the explanation with her.

Power dynamics of expert knowledge: Consistently Omar shows restraint from exercising his presumptive position of power as a expert or authority figure and is thus able to counter-balance the otherwise normative power dynamics that typically influence interactions between students and instructors/mentors. Rather than giving explicit directives or revealing too much of his own understanding, Omar puts Anna back into the "driver's seat" by repeatedly reinforcing the expectation that Anna actively participate in determining the validity of any assertion. Omar uses several tactics to shake up the default power dynamic including: his decision to sit back down and physically give Anna the floor, long pauses while he waits for Anna to think things through and verbal diversion tactics when Anna seeks affirmative answers. This is perhaps most clearly illustrated in their final exchange when Omar resists Anna's request for an affirmation and instead invites Anna to take responsibility for "figuring it out." Alternatively, at this juncture, Omar could have revealed what he knew or taken over at the whiteboard.

Norms of the community: Another aspect of Omar's interaction with Anna is that he is guiding her in using norms commonly used by scientific communities. By stepping up to the white board to initiate the creation of a diagram, Omar is modeling a common practice (drawing on a whiteboard) that scientists and engineers often use when jointly working on a problem. However, after providing this conceptual tool and modeling how to make use of it, Omar quickly begins a fading process, requiring Anna to do the cognitive work using the diagram (see more on faded scaffolding below) and thinking through a problem with a peer. There are many ways that a mentor could have missed this opportunity, including overlooking that this practice may be new to the intern.

Though the elements of CHAT (e.g.. material tools, discourse, power dynamics, and community norms) are highly inter-dependent,, disentangling them to analyze and understand mentor-intern interactions proved to be very useful in this study and has broader implications. Educators approaching, or reflecting upon, an interaction with a learner can expand their view of the factors that influence the intended outcome, and by adapting can improve the outcome. For example, in considering how a student is responding to an educator's questions, the educator should think not just about the way that the question was posed, but also abou the power dynamics at play, as well as the norms that both the student and educator are used to.

Although this vignette occurred in a mentoring setting, this situation could easily have happened in a lab course or other "active learning" environment. **In general terms, this vignette represents a case where a learner is seeking guidance from an expert to make sense of something. In such moments the expert/instructor can choose to respond with their own explanation, or can employ strategic facilitation techniques to transfer ownership to the learner.**

Research on Ownership

Ball's study complements and is closely aligned with an extensive and diverse body of knowledge related to transferring ownership to learners. Following are examples of research from several disciplines within the learning sciences, emphasizing higher education and mentoring, but

including seminal work in the K-12 arena (which is vast). These summaries are brief and are not intended to be comprehensive, but rather to give readers a sense of the breadth of findings that support the construct of ownership as both a strategy and an outcome.

***Using verbal prompts and cues**:* A majority of findings about fostering learner ownership come from the work of educational researchers using sociolinguistic methods to observe and analyze teacher discourse practices such as verbal prompts, guiding cues, and follow-up questions during classroom conversations (see Erikson[6], and Schiffrin[7], for discussions of this methodology). Building on the foundational work from the late 1980's and early 1990's,[8,9,10,11] hundreds of studies have used these methods to examine the ways that teachers talk to students during instruction, and how that in turn affects a wide variety of learning objectives (for a review of discourse in science teaching see Kelly[12]). For example, studies have shown how teachers' verbal cues improve learners' content understanding, metacognitive skills,[13] and appropriation of STEM practices. McNeil[14] demonstrated the importance of teacher discourse by studying a chemistry unit focused on teaching scientific argumentation. This study compared six teachers with a range of teaching experience and background science knowledge. Lessons were recorded in each of the teachers' classrooms and combined with teacher questionnaires and pre and post student performance assessments. An analysis of variance comparing differences in student gains by teacher (with the teacher as the fixed factor, the pretest score as the covariate, and the gain score as the outcome variable) indicated that the effect of the teacher was significant. Analysis of videotaped lessons showed that **in the highest performing classroom, students were given more authority and independence through teacher discourse during guided discussions**, whereas the classroom discourse in the other five classes was primarily teacher directed.

***Supporting student autonomy**:* a distinct and substantial literature in educational psychology is concerned with how learners come to exercise "self-regulated learning."[15,16,17] Decades of research on what is now commonly referred to as *self-determination theory*.[18,19]has identified notable results and thus the importance of providing active "autonomy support" , facilitative actions that keep learners proactive and engaged rather than passive and alienated, during learning activity.[20] For example, one study focused on how discussion leaders were facilitating group work in a college level organic chemistry course and how their facilitation affected learning outcomes.[21] Students were randomly assigned to different workshops, and the researchers used surveys to measure students' perception of the degree to which their workshop leader supported their autonomy (e.g. "I feel that my instructor provides me some choices and options", or "My instructor listens to how I would like to do things"), and other aspects of their experience. **Results indicated that perceived autonomy support of the leaders correlated significantly with average course grade as well as students' perception of their competence and their interest and enjoyment in the class.**

Shifting power dynamics to transfer ownership to learner: Another area of research has focused on the effects of giving students more choice during problem-solving activities[22] and how actions by teachers can counter-balance normative power and authority relationships that typically structure learning interactions in both informal and formal science education settings.[23,24] Studies have documented the benefits of instructional strategies that simultaneously provide structure, but yet give students the ability to "act autonomously," to "self-regulate," and promote "self-reliant thinking."[25] Building on self-determination theory (above), Stefanou and colleagues[26] studied different types of pedagogical strategies that can be used to disrupt normative power dynamics and foster student autonomy. They observed how instructors gave students more freedom to make organizational choices (choosing group

Box 3. Some strategies shown to promote "cognitive autonomy" include giving learners opportunities to:

- Discuss multiple approaches or strategies
- Find multiple solutions
- Justify solutions for the purpose of sharing expertise
- Be independent problem solvers with scaffolding

See Table 1 in Stefanou[33]

members) or in regards to procedural elements (handling materials but argue that these tactics alone are not sufficient for disrupting normative power dynamics. Organizational and procedural tactics may provide the initial engagement, but **long-lasting effects on engagement and motivation will more likely come from supporting "cognitive autonomy" (see Box 3).** Research distinguishing cognitive autonomy from other ways of acting autonomously aligns with ISEE's focus on fostering learner ownership over core scientific concepts and STEM practices. ISEE participants learn that giving students simple choices about procedures, tasks or roles is not sufficient; they must also support learners through the cognitive process of appropriating and mastering core knowledgeable practices into their own repertoires.

Responsiveness to learners and fading support: The implications for practice based on self-determination theory are consistent with literature on active scaffolding.[27,28,29] van de Pol & Volman[30] reviewed 66 articles on scaffolding (noting the varied use of the term) searching for studies that focused on face-to-face interactions between student and teacher (facilitation). Key characteristics of effective scaffolding emerged from the review: contingency, fading, and transfer of responsibility. "Contingency" is described as the degree of instructor responsiveness to what learners are doing or saying at any given moment, or "calibrated guidance."[31] Fading is described as the gradual withdrawal of active guidance or modeling as the learner becomes more capable and in response to visible indications of a learner's progress towards learning objectives.[32,33] Finally, scaffolding a transfer of responsibility refers to the progress students make towards taking responsibility for completing a task independently after receiving support from teacher earlier on. Studies point to improvements in students' metacognitive and cognitive activities when instructors used calibrated scaffolding strategies. For example, Hmelo-Silver has repeatedly shown that a **facilitator's ability to use faded scaffolding strategies is critical to success in establishing Problem-Based Learning (PBL) environments**.[34] One study focused on the accomplishments of five second-year medical students working on a medical problem under the guidance of a master facilitator. Hmelo-Silver[35] analyzed transcripts and video recorded during problem-solving sessions and interviewed the facilitator (while viewing the videotape) regarding his goals and strategies for particular discourse moves. The researcher identified several effective questioning strategies that use faded scaffolding to reach the goals of supporting students' a) deep engagement with conceptual knowledge b) ability to construct causal explanations c) reason effectively, and d) become critical, self-directed learners.

Box 4. General characteristics reported to support deep engagement, reasoning, self-directed learning:

- **Contingency:** responsiveness to what learner is doing or saying
- **Fading:** gradual withdrawal of guidance in response to visible indications of learner's progress
- **Transfer of responsibility:** shifting from educator to learner

Using research on autonomy and ownership to inform educators' practice

Taken together, the research described above presents a compelling case for educators (including mentors) to take seriously the impact of their moment-to-moment interactions with learners. And yet, after decades of studies, many researchers still find that this **handover to independence rarely occurs[36] and conclude that more often than not, teachers' utterances remain overly directive and act as "straight jackets"[37] on student learning**, rather than being of the kind that promote a transfer of ownership. The disconnect between what is known about effective strategies for transferring ownership to learners and what educators do in practice is not isolated to this particular area of research, but is a broader issue in efforts to improve education. Translating research findings into practice, and considering the subtleties of implementation is an ongoing challenge for professional development. The intent of this paper is to introduce educators to what is known about facilitating learner ownership as a means of stimulating discussion, and to lay a foundation for further activities that provide opportunities for practicing and reflecting on strategies in teaching and mentoring contexts.

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