RESEARCH IN PROGRESS

BEHAVIORAL TECHNOLOGIES OF TEACHING AT 50: NEW OPPORTUNITIES AND NEW CHALLENGES

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This paper concerns an ongoing effort at the University of Massachusetts Medical School to develop computer-supported instructional procedures that may contribute to national efforts to address high-priority public health challenges. Recent efforts have yielded publications aimed at supporting practitioners responding to the increasing prevalence of autism spectrum disorders (e.g., McIlvane et al., 2018). Very recently, this effort has taken a new direction – supporting practitioners who provide services to people with co-occurring mental health and substance use disorders (CODs). In describing this new initiative, we hope to call attention to currently neglected research opportunities for behavior analysts.

As background on behavior analytic instructional science, two seminal works were published in 1968. The first was Skinner's *The Technology of Teaching* in which he summarized an emerging behavioral science relevant to teaching. He contrasted its methods and findings with longstanding educational methods used from the primary grades through graduate education. The second seminal work was Keller's Goodbye Teacher, in which he outlined the Personalized System of Instruction (PSI). Keller summarized its main features as follows: (1) learners go at their own pace; (2) learners master one unit's information before advancing to the next; (3) lectures and demonstrations motivate rather than provide critical information; (4) written word is emphasized in teacher-student communication; (5) proctors conduct repeated testing, immediate scoring, and tutoring.

Via these two works, Skinner and Keller helped launch the field of programmed instruction. One revolutionary perspective was foundational: the teacher's responsibility is to arrange conditions under which students truly learn the material. Instead of merely grading students against whatever standard they preferred, teachers would become responsible for "grading" themselves against the standard of student achievement. If teaching proved ineffective or inefficient, then it was the teachers' responsibility to improve it. In doing that, Skinner and Keller expected that teachers would apply the best information available to refine their teaching, to incorporate new methods that promised improved outcomes, and over time perfect their teaching to the extent possible.

Behavior analysis has many successful, sustained applications in education and training of normally capable children and people with developmental disabilities. For example, The Journal of Behavioral Education publishes many such reports. In a review of its offerings overall, we found relatively few projects with normally capable adults. Concerning behavior analytic programmed instruction as a whole, many studies with normally capable adults were published prior to 1990. In this century, however, examples are also relatively few. Literature relating to PSI implementation is similar.

One is led to ask why methods with a substantial basis in empirical evidence have made so little recent impact on education and training programs for college students and normally capable adults in general. This situation seems

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especially puzzling given the explosion of distance learning programs that are excellent vehicles for programmed instruction. Concerning PSI specifically, social medial platforms could be used to implement its cooperative learning features, but such projects seem virtually nonexistent (cf. Eyre, 2007; see Svenningsen, Bottomley & Pear [2018] for an example of computer-assisted instruction with PSI features).

To account for neglect of such opportunities, systems inertia and intellectual and/or emotional opposition come to mind. However, there is the highly plausible alternative that programmed instruction and PSI are perceived as dated approaches. Most foundational work on these topics was accomplished decades ago. Moreover, much of the technology employed back then was primitive by today's technological standards. Developers today might be excused for evaluating such technology as obsolete.

In one effort to correct this misperception, our project on CODs was inspired by the Sidman and Sidman (1965) Neuroanatomy programmed text, the result of a partnership between a neurologist and a behavior analyst. Our project partners an expert on health care services with a behavior analyst and a computer scientist. As background, CODs are common. They challenge providers to provide effective treatments, especially for individuals who are homeless and/or involved in the criminal justice system. Research has shown that integrated, coordinated community-based services have the potential to improve client outcomes. However, there is a clear gap in training the health care workforce on such treatment techniques – a gap we hope to begin closing.

Our project is focused on developing a programmed distance-learning course called MISSION U. Its purpose is to teach practitioners about an evidence-based, transdisciplinary case management model called Maintaining Independence and Sobriety through Systems Integration, Outreach and Networking (MISSION). Listed in the Substance Abuse and Mental Health Service Administration-Registry for Evidence Based Practices (NREPP), MISSION has had substantial impact, particularly with vulnerable populations of veterans and individuals who are homeless and/or involved in the criminal justice system. While MISSION is extensively documented in treatment manuals, a recent multisite implementation study identified the need for more comprehensive training tools (Smelson et al. 2015).

The first phase of the MISSION U project aimed to: (1) demonstrate implementation of a prototype MISSION U software platform with meaningful MISSION content and (2) create a MISSION overview that can be freely distributed to exemplify the instructional technology. We programmed two prototype modules, one a general introduction to the MISSION model and the other on MISSION home visit procedures. Both modules were broken up into smaller units that allowed for frequent learning evaluations and remedial programming.

COURSE DESIGN

Instructional Design

The Individualized Instruction Model (IIM) (or "personalized instruction") specifies that learners should be supported in completing work autonomously and accurately, focusing on their specific capabilities and need areas (Pappas, 2014). This model is directly traceable to behavior analysis research with normally capable adult learners in Skinner (1968) and Keller (1968). In this model, didactic teaching contains frequent assessments to gauge ongoing progress. Tests assess not only acquisition but also application of new material. Our course design draws also from behavior analytic analyses of acquisition and generalization of new behavior (e.g. McIlvane & Dube, 2003).

MISSION U is designed primarily for Case Managers and Peer Support Specialists who deliver and/or coordinate services for persons with COD. These learners are heterogeneous in age, ethnicity, income, SES, level of education, job responsibilities, career objectives, and first language – heterogeneity that virtually demands use of the Individualized Instruction Model.

The design has been influenced also by current teaching principles that posit that some individuals learn best visually whereas others do best when the material is presented in the auditory mode. There is evidence that (1) learners may have distinct preferences for the manner in which information is consumed and (2) multimodal (e.g., combined auditory-visual) presentation has demonstrated advantages (cf. Kharb et al, 2013). Notably, these principles comport well with those of quasi-basic behavioral research with other populations (Green, 1990; Soraci et al., 1991).

Figure 1

Figure 1 shows a simple technique for multimodal guidance of attending. Its bottom portion shows a full frame from the module on home visit procedures. As the frames above it indicate, the constituent information is introduced gradually and coordinated with instructor voice-over narration that conveys the same information simultaneously. The full frame is presented only at the end when the learner is invited to review it before going forward in the program.

Good management of attending also aims to reduce the scanning burden and thus to increase the likelihood of attending to relevant content. To encourage generalization of skills learned in the didactic components of MISSION U, we also incorporate e-simulations in which a Case Manager and a Peer Support Specialist simulate work with a client. Images like those shown in Figure 2 are interspersed throughout the audio-visual e-simulation. Periodic challenge questions require learners to make operational and clinical decisions in which they must apply what they have learned. These questions contrast specific MISSION techniques with clinically plausible choices that do not comport with the MISSION model. Immediate feedback is given, and learners are given an opportunity to respond correctly afterward if errors occurred.

Figure 2

Pretest/Posttest Design

Given the target audience, we have been especially careful to verify that MISSION U instructional procedures are sufficient to teach its learners about the MISSION program specifically (i.e., as opposed to merely recruiting general knowledge and/or opinion about how clients with CODs should be treated). The example in Table 1 shows that pre/post testing contrasts the MISSION model with other plausible clinical options. If learners respond correctly to such posttest questions, they show that they have understood and remembered what was taught during the teaching units. Such questions do not allow them to respond consistently correctly by guessing or by applying previous knowledge about other therapeutic approaches. Challenge questions in the e-simulations have a similar purpose.

Technical Assistance

Consistent with certain aspects of the Keller Plan, our design incorporates an optional 1-hour videoconference that allows learners to interact with instructors who are fully conversant with the MISSION model. These videoconferences allow learners to discuss the e-simulation case and also related topics from their own case management or peer support experience. We plan to expand such supports by including proctor/peer tutoring by Case Managers and Peer Support Specialists in subsequent versions of MISSION U.

Software Architecture

MISSION U is a hybrid of a commercially available e-learning package (iSpring, n. d.) and in-house programming that substantially expands the package's capabilities to meet the needs of our instructional design. In our in-house programming to date, we have emphasized off-the-shelf Open Source components that provided powerful, transparent, non-proprietary resources to give us maximum power and flexibility. In addition, we also developed new software that allows these components to interact functionally.

Consistent with our Open Source approach, our course is currently implemented in a widely used Learning Management System called Moodle. Its features allow for housekeeping such as learner registration, enrollment, and data reporting. Moodle also allows for limited program branching based on learner responses to challenge questions. However, this feature is not sufficiently flexible to optimize the instructional flow for individual learners, especially those who struggle with the material. Thus, our technical development group has developed proprietary software that permits virtually unlimited branching within the Moodle or other Learning Management System environments.

PILOT STUDY OF MISSION U

Nineteen participants were recruited from programs serving clients in 5 states. The racially diverse sample had an average of 8.8 years in the field. All participants received pre/posttests for all units and all completed the e-simulation. The technical assistance opportunity was piloted with nine participants. Participants then completed software satisfaction/content ratings and a final overall post-test. Four results were clear:

(1) Instructional technology delivered highly effective instruction. Even given our demanding question design, pretest/posttest score distribution differences were virtually nonoverlapping visually and thus highly significant ($p < .0000000000001$) based on statistical analysis with the Excel t-test function (paired sample, one-tailed test).

(2) In the e-simulation, there was significant evidence of application of MISSION principles. Accuracy scores on challenge questions averaged 86% (range: 100%-71%), significantly greater than chance scores (~33%).

(3) Technical Assistance was clearly beneficial – and very positively received. On a final overall post-test, scores of those who received technical assistance were substantially higher than those who did not. The Cohen d effect size was large (.833).

(4) Learner satisfaction with MISSION U was high. One satisfaction measure concerned usability of the MISSION U human interface and the other whether MISSION U course content was appropriate to learner needs. Percent satisfaction with usability and content was 94% and 93%, respectively. Disagreements were spread across the range of questions posed. Thus, no

[1] For readers interested in technical details, the program infrastructure is based on: (1) MEAN, an open-source JavaScript software stack for building dynamic web applications. MEAN is an acronym abbreviating its components: (a) MongodB – a free, open source, cross-platform document-oriented database program, (b) ExpressJS – a web framework for NodeJS; see d, (c) AngularJS – a client-side JavaScript framework that extends HTML with new attributes, and (d) NodeJS – an open-source, cross-platform JavaScript run-time environment that executes server-side JavaScript code, and (2) a Nginx Web Server that provides static content for Learning Modules and static resources (html, css and JavaScript files).

specific feature of the human interface design or course content was deemed faulty by users as a group.

CURRENT STATUS OF THE PROJECT

As impressive as these data might seem, we think these findings merely show promise that we are on a path towards a programmed course that would fully satisfy criteria articulated by Skinner, Keller, and Sidman. While most pretest scores were at or near chance levels as we had planned, the final posttest score distribution ranged from intermediate to high accuracy. We could likely have produced high accuracy posttest scores overall by making the posttest questions less demanding, but that would have defeated one important purpose of the pilot – fair witnessing that our procedures for managing attending and other aspects of instructional technology were responsible for posttest gains.

Even though the participants in our pilot were normally capable adults and we gave them an unusual amount of instructional support for training such as this, we were not surprised that posttest scores fell short of perfection. We recalled Holland's Forward II to The Technology of Teaching (2003). His students (Harvard undergraduates) apparently performed similarly on the first efforts of his course development group. We recall also the lessons from the Sidman and Stoddard (1966) description of program development for testing patients with neurological and neurodevelopmental disorders in which many revisions of an initially well-designed teaching program proved necessary before a satisfactory version was produced. Work of this nature virtually demands cycles of program development, testing, and refinement. We have already completed a substantial revision of one of our learning modules that we plan to release when we optimize learning outcomes.

CONCLUSION

We prepared this preliminary report mainly to highlight a research and development opportunity that we hope will attract the attention of and perhaps challenge our colleagues and students. With today's hardware and software, development of carefully programmed courses for normally capable adults has become a feasible and affordable proposition. For our work, we chose iSpring based on program features that we needed for our project. However, there are many such systems to choose from with different features, strengths, weaknesses and price points (cf. Capterra Course Authoring Software, n. d.). If custom programming is needed for certain applications, we and our colleagues have had some success in recruiting low-cost student help from university computer science and engineering programs. Involvement of their faculty in such collaborations has been of particular help.

Whereas the technologies described by Holland and by Sidman and Stoddard led to slow, painstaking work to produce a single program, current technology presents the opportunity to develop much more capable instructional technology in much less time. Although we had resources to do custom programming, current authoring programs have powerful features and built-in tools to aid developers. It is increasingly possible to realize the early vision of Skinner, Keller, Sidman, and others who foresaw a powerful behavioral instructional technology to improve education and training outcomes for a broad range of students. Indeed, we think that a new Golden Age of programmed instruction is within reach.

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