



Operationalized Adaptive Teaching and Individualized Learning for Improving Achievement with K-12 Students in Classroom Settings: A Systematic Review

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TITLE OF THE REVIEW

The Effects of Operationalized Adaptive Teaching and Individualized Learning for Improving Achievement with K-12 Students in Classroom Settings: A Systematic Review

BACKGROUND

Conceptual understanding of individualized learning and adaptive teaching varies broadly, encompassing a multitude of instructional strategies, approaches, and activities. It stretches from accounts as narrow and specific as scaffolding adaptive feedback in computer-based instruction (e.g., Atkinson, Renkl & Merrill, 2003) to more general conceptions, such as cooperative and collaborative learning (e.g., Johnson & Johnson, 2002) and educational concepts derived from elements of constructivism, such as discovery learning, inquiry-based learning, experiential learning, problem-based learning and other forms of student-centered education. These instructional forms were systematically summarized by Tobias & Duffy (2009) and earlier criticized by Kirschner, Sweller & Clark (2006).

For the purposes of this project we will operationally define individualized learning and adaptive teaching (i.e., the treatment in question) as instructional conditions with higher (in comparison with the control) degree of responsibilities/control over major instructional events (e.g., stating learning objectives, defining pacing of the instruction) delegated to learners.

The learning sciences have further contributed to instructional system designs by providing a theoretical grounding to teacher vs. learner-based strategies (Kolodner, 2004). Current and developing applications, informed by pedagogical principles from case-based learning (e.g., Kolodner et al., 2008), exemplify the transformation of learning environments which apply Bruner's (1961) concept of not just discovery for the student, but co-discovery on the part of the teacher.

Examples of various attempts to make teaching and learning more adaptive can be found in both early and current research literatures. They include, though are not limited to, Personalized Systems of Instruction or PSI (e.g., Keller, 1968; Gifford & Vicks, 1982; Davies, 1981), assorted forms of peer instruction (e.g., Mazur, 1997), various reciprocal reading/writing activities (e.g., Huang & Yang, 2015; MacArthur et al., 1991), and more recently, Intelligent Tutoring Systems or ITS (e.g., Huang & Shiu, 2012; VanLehn, 2011). Findings of primary research on these and related instructional practices have been summarized in two rather sparse collections of meta-analyses separated in time by almost three decades.

In the late 1970s and early 1980s, several relevant meta-analyses were published. First, Kulik et al. (1979) reviewed 75 individual comparative studies of Keller's PSI college teaching method. In comparison to conventional instruction the PSI was demonstrated to have a

positive effect on student achievement and course perception (mean effect size of nearly 0.70 for both). Aiello and Wolfle (1980) summarized research on individualized instruction in science compared with traditional lectures and found that the former instructional method was more effective. Horak's (1981) study of self-paced modular instruction of elementary and secondary school math (1981) produced a wide variety of both positive and negative effect sizes. Bangert and Kulik (1982) looked at the effectiveness of the Individualized Systems of Instruction (ISI) in secondary school students. They broadened the list of outcomes to account not only for student achievement (e.g., final exam), but also critical thinking, attitudes toward subject matter, and student self-concept. For all outcome types the findings were rather inconclusive. For example, for the achievement data only eight out of 49 studies demonstrated statistically significant results in favor of ISI (four studies favored more conventional teaching methods and the findings of the rest were mixed). Finally in 1984, Kulik attempted a wider research synthesis (encompassing over 500 individual studies) of the effectiveness of programmed instruction and ISI, paying special attention to the moderator variables of study dates and grade levels. Among the most promising findings, the author indicated that more recent studies showed higher effects than the earlier studies and that college-level students benefited significantly from using ISI compared with elementary and secondary school students. In summary, these meta-analyses produced inconclusive results. Moreover, they are outdated – practically none of the instructional methods addressed there exists now in its original form (e.g., Eyre, 2008 was able to identify less than 50 studies of PSI for the period between 1990 and 2006 in the PsychInfo database). All this clearly justifies the need for a more refined (both methodologically and substantively) update of systematic review in the field, especially taking into account how much the methodology of meta-analysis itself has evolved since then.

Several more recent meta-analyses addressed the topic of individualized instruction, though in very specific forms. Cole (2014) examined the effectiveness of cooperative, collaborative, and peer tutoring for English language learners. A low-to-moderate average effect size of $\bar{g} = 0.49$ was found in favor of peer tutoring over individualized or teacher-centered comparison instructional conditions. The effect size tended to be relatively small in middle school students, but higher at elementary and high school levels. More in line with the already mentioned earlier meta-analyses of various forms of computer-assisted instruction, Ma et al. (2014) meta-analyzed studies of Intelligent Tutoring Systems (ITS) in a variety of subject matters, from reading and math to law and medical education. The list of moderator variables included the type of both experimental and comparison treatments, as well as outcome type, student academic level, discipline studies, etc. The highest achievement effects of using ITS were found in comparison with non-ITS computer-based instruction ($\bar{g} = 0.57$) and teacher-centered, large-group instruction ($\bar{g} = 0.42$), whereas in comparison with human tutoring it was even negative ($\bar{g} = -0.11$), though statistically non-significant. ITS-based practices were similarly effective when used either alone or in combination with various forms of teacher-led instruction in many subject domains.

Most of the significant effects from the meta-analyses clustered around $+0.40SD$, but the data also reflect a wide range of effects, depending on the whole spectrum of moderator variables. In other words, the picture painted by these meta-analyses remains mostly inconclusive. Of special concern to us is the fact that both earlier and recent meta-analyses are rather limited in scope, addressing very specific instructional practices and technological tools.

In summary, the literature cited tends to examine specific instructional strategies separately (e.g., cooperative learning), but none have addressed strategies in their more general form (e.g., student-student collaboration) as they are practiced in classroom settings. In the current proposal, collaboration, for example, is investigated in its broader meaning, related to but not limited by individual instructional strategies.

OBJECTIVES

In the proposed review, Student-Centered (SC) and Teacher-Centered (TC) educational strategies, operationally defined based on ratings of a collection of instructional events, will be compared to each other on the basis of student achievement outcomes to address the main research question of the effectiveness of adaptive teaching and individualized learning, namely:

Can SC (i.e., more adaptive and individualized) approaches to instruction be distinguished from TC approaches in terms of their effect on student achievement and what substantive and demographic factors moderate these effects? Instructional context, grade level, and subject matter will be studied as categorical moderator variables, along with other important characteristics of instructional treatments.

These characteristics of instructional treatments determine the key quality of instruction as “adaptive” and “individualized” - a more student-centered (adaptive) classroom is one in which students play a more central role in the conduct of instructional events. If these events can be isolated they can then be rated individually on a TC to SC continuum.

Each event could then be: 1) examined separately to determine their individual strengths; 2) examined in clusters as combinations of events; or 3) collapsed into a multi-dimensional composites that would yield a “greater-than to lesser-than” distinction between two different instructional settings. This approach avoids problems associated with either subjectively defining instructional conditions as SC vs. TC or vaguely labelling and isolating them, as in the cases of PSI, mastery learning, etc. It also has the advantage of allowing us to examine instructional events in isolation and in various combinations in the search for optimal instructional practices.

EXISTING REVIEWS

Aiello, N. C., & Wolfle, L. M. (1980). *A meta-analysis of individualized instruction in science*. Paper presented at the annual meeting of the American Educational Research Association, Boston, MA. Retrieved from <http://files.eric.ed.gov/fulltext/ED190404.pdf>

Bangert, R. L., & Kulik, J. A. (1982). *Individualized Systems of Instruction: A Meta-Analysis of Findings in Secondary Schools*. Paper presented at the annual meeting of the American Educational Research Association, New York, NY. Retrieved from <http://eric.ed.gov/?id=ED220358>

Decanay, L.S., & Cohen, P.A. (1992). A meta-analysis of individualized instruction in dental education. *Journal of Dental Education*, 56(3), 183-189.

Gersten, R., Chard, D., Jayanthi, M., Baker, S., Morphy, P., & Flojo, J. (2008). *Mathematics instruction for students with learning disabilities or difficulty learning mathematics: A synthesis of the intervention research*. Portsmouth, NH: RMC Research Corporation, Center on Instruction.

Horak, V.M. (1981). A meta-analysis of research findings on individualized instruction in mathematics. *Journal of Educational Research*, 74(4), 249-253. <http://dx.doi.org/10.1080/00220671.1981.10885318>

Kulik, J. A. (1984). *The fourth revolution in teaching: Meta-analyses*. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA. Retrieved from <http://eric.ed.gov/?id=ED244617>

Kulik, J. A., Kulik, C.-L. C., & Cohen, P. A. (1979). A meta-analysis of outcome studies of Keller's Personalized System of Instruction. *American Psychologist*, 34(4), 307-318. <http://dx.doi.org/10.1037/0003-066X.34.4.307>

Ma, W., Adesope, O. O., Nesbit, J. C., & Liu, Q. (2014). Intelligent tutoring systems and learning outcomes: A Meta-analysis. *Journal of Educational Psychology*, 106(4), 901-918. <http://dx.doi.org/10.1037/a0037123>

All and all this proposed systematic review is unique, as it neither relies on labeling instructional intervention nor singles out any their particular aspect to define the treatment, but attempts to account for the entirety of instructional events in their meaningful combinations.

INTERVENTION

For better understanding and more successful application, educational practices subsumed under the generic category of 'student-centered' deserve a valid conceptual model – both

inclusive enough to account for various forms of personalized/individualized instruction, and sufficiently sensitive to fluctuations due not only to the influence of numerous moderator variables, but also to the nuanced qualities of particular instructional approaches themselves. SC instructional strategies could, in our view, serve such an overarching conceptual framework with adequate explanatory power, but only if operationalized properly to avoid an oversimplified dichotomy of inductive vs. deductive education (constructivism vs. direct instruction).

Indeed, we are less interested in deciding between these two extremes and more interested in understanding the circumstances or combination of circumstances that optimize teaching and learning. Gresalfi & Lester (2009) for mathematics teaching, and Klahr (2009) for science teaching argue that the goal of instruction should be to achieve curricular and process objectives by choosing the most appropriate method based on student age, ability, prior knowledge, level of content, etc. In this regard, we would like to avoid the conceptual error of falsely dichotomizing pedagogical environments as either TC or SC since neither instructional practice likely exists in its pure form. As Gersten et al. (2008) observed in their systematic review of mathematics teaching practices: “[We] found no examples of studies in which students were teaching themselves or each other without any teacher guidance; nor did the Task Group find studies in which teachers conveyed ... content directly to students without any attention to their understanding or response. The fact that these terms, in practice, are neither clearly nor uniformly defined, nor are they true opposites, complicates the challenge of providing a review and synthesis of the literature ...” (p. 12). Since SC pedagogical practices try to emphasize guidance over direct instruction, the question becomes how much and what kind of guidance is offered to students and who takes responsibility for the design and implementation of various components of the learning experience to make them truly adaptive/individualized and, hence, more effective.

To define the key quality of instruction as “adaptive” and “individualized,” for the purposes of the proposed systematic review, we suggest deconstructing teaching and learning according to the events associated with them (e.g., setting objectives, implementing instructional methods, assessing learning). Accordingly, a more SC (more adaptive) classroom is one in which students are active participants in defining and implementing the instructional events. If these events can be isolated in reports of primary classroom research, they can be rated individually on a TC to SC continuum. Each event could then be: 1) examined separately; 2) examined in clusters; or 3) collapsed into a multi-dimensional composite that would yield a “greater-than to lesser-than” distinction between two different instructional settings.

Following a review of the literature on instructional practices across elementary and secondary grade levels and subject matters, we developed a tentative list of instructional events that can be rated on a TC to SC continuum. These include establishing learning objectives; designing the course; selecting and implementing methods of instruction; developing and using source materials; pacing instruction; assessing and evaluating learning

outcomes; and adapting learning materials, group formation, activities, etc. to the needs, interests and abilities of individual students. Each of these dimensions will be rated independently by two trained reviewers from our research team on a scale of 1 to 5. This rating reflects the extent to which the responsibility for planning and implementing particular instructional events is entrusted to students (i.e., 1 = TC through 5 = SC).

In the proposed review, TC and SC instruction, operationally defined based on ratings of a collection of instructional events, will be compared to each other on the basis of student achievement outcomes. Instructional context (i.e., face-to-face classrooms, blended classrooms, distance education), grade level (K-12), and subject matter (e.g. STEM) will be studied as categorical moderator variables along with other important characteristics of classroom studies.

Hence, the main research question is: Can SC (i.e., more adaptive and individualized) approaches to instruction be distinguished from TC approaches in terms of their effect on student achievements and what substantive and demographic factors moderate these effects?

Specifically, each study identified through systematic literature searches will be subjected to a screening process to establish whether it satisfies the project inclusion criteria. Namely, to be retained for further analyses, a study should:

- Be publicly available (or archived) and encompass studies from 2000 onward;
- Feature at least two groups of different instructional strategies/practices that can be compared according to the research question as SC/TC instruction;
- Include course content and outcome measures that are compatible in these groups;
- Contain sufficient descriptions of major instructional events in either instructional condition;
- Satisfy requirements of experimental (RCT) or high-quality quasi-experimental research design;
- Be conducted in formal K-12 educational settings eventually leading to a certificate, diploma, degree, or promotion to a higher academic level;
- Contain legitimate (representative) measures of academic achievement (i.e., teacher-made, standardized); and
- Contain sufficient statistical information to enable effect size extraction.

Then two researchers will review each pre-selected study to decide to what extent control over/responsibility for particular aspects of educational process was delegated to students.

To that end, they will independently rate on a scale from “1” [Predominantly TC] to “5” [Largely SC] the following instructional events:

- (1) Establishing learning objectives
- (2) Selecting and implementing methods of instruction (including particular learning activities, projects, and exercises);
- (3) Developing and/or using source materials;
- (4) Pacing instruction (both in terms of time management and content navigation);
- (5) Assessing and evaluating learning progress and outcomes (including peer-review and self-evaluation);
- (6) Forming groups for various collaborative/cooperative activities;
- (7) Adapting content (including feedback), class settings and events to account for the needs, interests and abilities of individual students.

Of additional interest for the project are also other instructional qualities, such as: the roles assumed by the teacher (from the sole source of knowledge and expertise to a guide, colleague, and partner in learning), the type and conceptual level of tasks students are facing and the degree of authenticity (i.e., link to and applied value for the real world problems) of any given instructional condition.

POPULATION

K-12 formal educational settings (approximate ages 5-18), i.e., eventually leading to a certificate, diploma, degree, or promotion to a higher level. Educational interventions may take place either in the classroom, via distance education, or as a blended intervention.

OUTCOMES

In the proposed review, TC and SC instruction, operationally defined based on ratings of a collection of instructional events, will be compared to each other on the basis of student achievement outcomes. That includes all types of academic performance measures – standardized and teacher- or researcher-made that are cumulative with regard to the course content (e.g., final exams). Instructional context (i.e., face-to-face classrooms, blended classrooms, distance education), grade level (K-12), and subject matter (e.g. STEM) will be studied as categorical moderator variables along with other important characteristics of classroom studies (including assessment tools’ type, source, and psychometric quality).

STUDY DESIGNS

The review will include studies that are experimental (i.e., RCT) or high-quality quasi-experimental (i.e., statistically verified group equivalence or adjustment) in design that address adequate group comparisons, contain legitimate measures of academic achievement (i.e. teacher-made, standardized), and report sufficient statistical information for effect size extraction.

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REVIEW AUTHORS

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ROLES AND RESPONSIBILITIES

- Content:

Richard F. Schmid has expertise in and has published on topics such as: application of technologies to improve pedagogy and training in the workplace and schools; analysis of learning strategies and collaborative techniques in in-class and distance education contexts; cognitive information processing using technologies, especially with young learners.

As an educational philosopher David Waddington is a specialist in the theory of individualized learning and adaptive teaching. His research on complex educational games and gaming has been applied in areas like responsible citizenship and environmental issue and has been touted as both disruptive and adaptive.

- Systematic review methods:

The Centre for the Study of Learning and Performance (CSLP) Systematic Review Team Leader Robert M. Bernard has been actively involved in conducting and publishing meta-analyses since 1995 and has a long list of accomplishments. The Systematic Review Team published five major meta-analyses in *Review of Educational Research*, AERA's premier review journal (1st/219 in Educational Research with an Impact Factor of 5.00). The team has also published seven other meta-analyses and systematic reviews in other journals and has presented papers in many scholarly venues, with at least one presentation per year at AERA's annual meeting. Members of the team have given workshops, some for the Campbell Collaboration, short courses, and invited methodological presentations, etc. in the U.S., Canada, Great Britain and several European countries, and have published articles about meta-analysis methodology (e.g., Bernard et al., 2014; Abrami & Bernard, 2012) in prominent research journals.

Eugene Borokhovski, as a Systematic Reviews Project Manager, has over 15 years of experience in designing, conducting and publishing meta-analytical research in social science and education, leading teams of graduate student research assistants, as well as teaching relevant university-level teaching and designing professional development training for practitioners.

- Statistical analysis:

Robert M. Bernard is a seasoned veteran in the area of statistical analysis for meta-analysis having provided expertise in numerous projects and authored articles in some of the best journals in Education (e.g., *Review of Educational Research*). He teaches research methods and statistics at the M.A. and Ph.D. levels in the Department of Education and has supervised a number of dissertation students who have (or are currently working on) systematic reviews and meta-analyses.

- Information retrieval:

David Pickup is an Information Specialist with 7 years experience working on systematic review projects. He has previously served (2009-2010) as the Education Trials Search Adviser for the Campbell Collaboration, providing consultations and peer review of search strategies. He continues to provide peer review services for Campbell protocols and reviews on an ad hoc basis.

FUNDING

At the moment, there is no additional funding available.

POTENTIAL CONFLICTS OF INTEREST

None.

PRELIMINARY TIMEFRAME

- Date you plan to submit a draft protocol:

November 2016

- Date you plan to submit a draft review:

November 2017

AUTHOR DECLARATION

Authors' responsibilities

By completing this form, you accept responsibility for preparing, maintaining, and updating the review in accordance with Campbell Collaboration policy. The Coordinating Group will provide as much support as possible to assist with the preparation of the review.

A draft protocol must be submitted to the Coordinating Group within one year of title acceptance. If drafts are not submitted before the agreed deadlines, or if we are unable to contact you for an extended period, the Coordinating Group has the right to de-register the title or transfer the title to alternative authors. The Coordinating Group also has the right to de-register or transfer the title if it does not meet the standards of the Coordinating Group and/or the Campbell Collaboration.

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I understand the commitment required to undertake a Campbell review, and agree to publish in the Campbell Library. Signed on behalf of the authors:

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Date: August 4, 2016