EDeR

Educational Design Research

Volume 2 | Issue 1 | 2018 | Article 13

Contribution Type Academic Article

Title **To adopt or reject? Testing the robustness of a principle-based scenario for guiding effective student questioning**

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Abstract Guiding student questioning to become effective for attaining curriculum objectives is a challenge for many teachers. In two previous studies a principle-based scenario was developed in two primary schools to enhance teacher guidance of effective student questioning. This study aims to determine to what extent the scenario for teacher guidance is robust and transferrable to other teachers in different primary school settings. To test its robustness, 15 trainers introduced the scenario in 23 primary schools to 103 teachers. After teachers completed a six-week trial, they indicated in a questionnaire if they were inclined to adopt, adapt, or reject the scenario for future use. Results show that approximately 80% of all teachers would like to adopt the scenario. About 55% of the teachers see opportunities to adapt the scenario to their needs. However, about 20% of the teachers feel not yet able to judge if and how to adapt, having completed only one trial. The conclusion is that most teachers, despite differences in age, gender, grade, experience and school contexts, are willing and able to guide effective student questioning with the help of the scenario. From a theoretical point of view, this study provides further insight in how successful implementation can supported by a principle-based design.

Keywords
design-based research
implementation study
robustness
student questioning
teacher guidance

DOI dx.doi.org/10.15460/eder.2.1.1221

Citation Stokhof, H., de Vries, B., Bastiaens, T. & Martens, R. (2018). To adopt or reject? Testing the robustness of a principle-based scenario for guiding effective student questioning. *EDeR - Educational Design Research, 2* (1), 1-23. http://dx.doi.org/10.15460/eder.2.1.1221

To adopt or reject? Testing the robustness of a principle-based scenario for guiding effective student questioning

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1.0 Introduction

Asking questions is a basic heuristic for children to explore and to learn about the world (Chouinard, Harris, & Maratsos, 2007). Student questioning is in this study defined as the process in which students generate, formulate, and answer Sincere Information Seeking (SIS) questions, to seek knowledge or to resolve cognitive conflicts (Van der Meij, 1994). Chin and Osborne (2008) show in their review, that asking and answering SIS questions has multiple benefits for teaching and learning (social) science. Moreover, Sikko, Lyngved, and Pepin (2012) found that many teachers are positive about the educational value of student questions and forms of inquiry-based learning. However, Engel and Randall (2009) report that student questioning is rarely observed in classrooms, while teacher questioning seems to be predominant. According to Penuel and Yarnall (2005) a major challenge for most teachers is to offer the opportunity for student questioning, when confronted with the pressure to cover mandatory domain content. Rop (2002) found that when teachers are faced with such curricular pressures, a spontaneous student question can be easily perceived as a distracting factor in the smooth delivery of a well-devised lesson plan. Teachers seem to struggle to align the freedom required to elicit student questions, with the structure needed to attain curricular goals (cf. Brown, 1992). Therefore, teachers seem in need of support to guide effective student questioning, defined as the degree to which student questions contribute to learning curriculum objectives. To provide this support, a scenario for teacher guidance of effective student questioning was developed and tested for its relevance, ease of use, and learner effects in two previous studies (Stokhof, De Vries, Bastiaens, & Martens, 2017b, 2018). This study will focus on scaling up the developed solution.

Ideally, the development of support for teacher guidance takes place in a limited number of trial classrooms. Nieveen (2009) contends that in such small scale studies the relevance, practicality, and effectiveness of a prototype of the educational innovation can be more effectively evaluated and improved. Ultimately, the goal of the development is to make the innovation available to the larger community and therefore the prototype will need to be up scaled at some time. Fullan and St. Germain (2006) claim that to scale up the use of an innovation, its adoptability and adaptability for a wider variety of teachers and school settings needs to be taken in consideration in the design. Moreover, Blumenfeld, Fishman, Krajick, Marx, and Soloway (2000) suggest that to support successful implementation on a wider scale, innovations should not only be aligned to multiple differences in teacher and student characteristics, but also to differences in school culture, curricula, policy and management. Consequently, for a method of guiding effective student questioning to be adopted by teachers in multiple school contexts, it needs to be flexible and adaptable. However, Roschelle, Tatar, Shechtman, and Knudsen (2008) point out that to remain successful in all contexts, the method also needs to retain consistency in its effective components.

Although the developed solution for guiding effective student questioning was experienced as relevant, practical, and effective in the development schools, it is yet unclear if these benefits will be experienced by other teachers in different settings. The specific contexts of the development schools and teachers' participation in the development process might have contributed to its success, and this might not be transferrable to other settings or to other teachers. Therefore, the aim of this study is to test to what extent of a method for guiding effective student questioning is "robust", defined as the consistency of its benefits when deployed consistently to a variety of teachers, students, and settings (Roschelle et al., 2008)

1.1 Implementation of educational innovations

To be able to study the robustness of an educational innovation, first the concept of implementation needs to be clarified. In this study the implementation of an educational innovation refers to the introduction, trial, and the adoption, rejection or adaptation of a new approach to teaching which changes the status quo of common classroom practice. Such an innovation is designed to change one or more aspects of teaching such as instruction, (student) interaction, curriculum materials, and or learning environments (Ellsworth, 2000).

To understand the complex nature of implementation, it is important to consider it as a multi-step process rather than an event, as suggested by Nilsen (2015). Rogers (2003) identified five subsequent stages in the implementation process: the *Knowledge, Persuasion, Decision, Implementation, and Confirmation* stages. In the Knowledge stage potential users become aware of the existence of the innovation, gain information how to apply it, and learn about the principles which make the innovation effective. In the Persuasion stage potential users become more involved with the innovation, seek information about its expected consequences, and develop a general perception about its benefits for their specific circumstances. In the Decision stage users engage in activities that lead to a choice either to adopt or reject the innovation. Most users, however, will not decide without trying it out on a small scale in order to determine its usefulness for their own needs and contexts. In the Implementation stage the innovation will be actually put to practice. Finally, in the Confirmation stage the users seek reinforcement in daily practice for the implementation decision made, but may also reverse earlier choices if the innovation does not meet expectations. This study focuses on the Decision stage in which teachers choose to adopt or reject an innovation after a trial.

1.2 Levels of curriculum representations

To understand the factors that influence teachers' implementation decisions, an analytic framework is needed that describes the relations between the designers' intentions, the teachers perceptions, the actual use in classrooms, and the outcomes for teachers of the innovation. The model of "*levels of curriculum representations*" of Goodlad (1994) and Van den Akker (2003) provides such a framework. We identify in this framework four levels: 1) the *intended* curriculum, 2) the *perceived* curriculum, 3) the *operational* curriculum and 4) the *realized* curriculum (Figure 1). The intended curriculum consists of the vision, rationale, and mission, which are aspired for the curriculum innovation, and the documentation how the vision can be applied to classroom practice. The perceived curriculum refers to how users understand the intended curriculum. The operational curriculum refers to the actual use of an innovation in the classroom. The realized curriculum refers to the outcomes of the innovation for teachers. Next to these four levels of curricula, Snyder (1971) and Denscombe (1982) also identify the teacher's *hidden* curriculum. The hidden curriculum refers to the sociocultural norms and values in schools that dictate what teachers accept as desirable or acceptable in teaching (Joughin, 2010). The ways teachers perceive, operate, and realize a curriculum, will therefore be affected by the hidden curriculum.

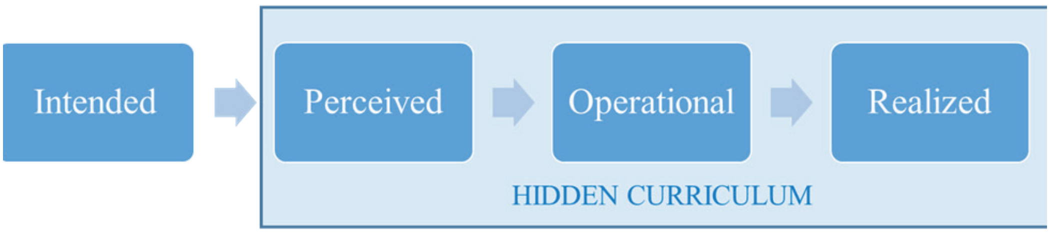

Figure 1: Curriculum representations

The perceived curriculum is expected to influence teachers' implementation decisions. Rogers (2003) showed that when an innovation, for example a curriculum, is perceived as beneficial by the end-users, they will be more inclined to adopt it. The quality of the perceived curriculum can be examined using Rogers' (2003) attributes of innovations: *relative advantage, compatibility, trialibility, complexity, and observability*. The scores on these attributes predict the appeal for, and rate of, adoption of innovations. Relative advantage refers to the degree that the proposed innovation is perceived as an improvement of the previous situation. (Rogers, 2003). Compatibility is the degree to which an innovation is perceived as consistent with existing values, past experiences and needs of potential adopters (Rogers, 2003, p.240). Because the hidden curriculum affects teachers' perceptions of compatibility and relative advantage, this study also measures the hidden curriculum, however, only indirectly. Trialibility is the degree to which users can experiment with the innovation on a limited basis (Rogers, 2003, p.258). Complexity refers to the degree the innovation is perceived as difficult to understand and use (Rogers, 2003, p.257). Finally, observability refers to the degree to which the results of an innovation are visible to others (Rogers, 2003, p.258).

The quality of the operational curriculum can be operationalized as *adherence*, which is the degree to which teachers actually use the innovation in the classroom (Mombray, Holter, Teague, & Bybee, 2003). Cuban (1995) noticed that teachers have considerable autonomy in choosing if and how to teach, and therefore classroom practice can differ substantially from what was intended. Therefore, Mombray et al. (2003) suggest that the degree of adherence to the activities of the innovation is an indicator of its appeal for teachers. Furthermore, Mombray et al. argue that when adherence is high, teachers are more able to give valid judgements on the effectiveness of these activities for their intended objectives.

Finally, also the realized curriculum is likely to influence teachers' implementation decisions. The higher the experienced support for teacher guidance, the more likely it will be that teachers choose to adopt the innovation. Gorodzidis and Papaioannou (2014), Jansen in de Wal (2016), and Lam, Cheng, and Choy (2010) showed that teachers' experience of autonomy, relatedness and competence during implementation, correlates strongly with the decision to adopt or to reject an innovation. Therefore, in this study the realized curriculum is operationalized as the teachers' experience of autonomy, relatedness, and competence in guiding student questioning. Relatedness refers to the need to feel belongingness and connectedness to others (Ryan & Deci, 2000). Autonomy is the degree to which an individual perceives an internal locus of causality, or in other words, has the ability to determine his or her personal choices and actions (Ryan & Deci, 2000). Competence refers to experience of "behaviour as effectively enacted" (Niemiec & Ryan 2009, p. 135).

The framework of curriculum representations will be used in this study to analyze which factors influence teachers' implementation decisions. In this study the intended curriculum will be the independent variable, because it is the constant factor for all teachers. The perceived, operational, and realized curriculum will be the dependent variables which are likely to influence teachers' implementation decisions. The main hypotheses is that the scenario can be considered "robust" when teachers' implementation decisions are not only positive, but also independent of school context or teacher characteristics. It is expected that teachers' implementation decisions will correlate with findings on the perceived curriculum, the operational curriculum, and the realized curriculum.

1.3 The scenario for teacher guidance of effective student questioning

The solution we try to upscale is a principle-based scenario for teacher guidance of effective student questioning (Stokhof, De Vries, Martens, & Bastiaens, 2017a; Stokhof et al., 2017b). Figure 2 shows the working principles of the scenario to guide the process of student questioning in five consecutive phases. In the Preparation Phase teachers design an expert mind map of the topic under study and explore which potential questions could be elicited. In the Introduction Phase teachers activate students' prior knowledge and students construct a classroom mind map. In the Questioning Phase the classroom mind map is the prompt for students to raise questions and discuss potential lines of inquiry. In the Construction Phase students investigate and answer their questions and the learning outcomes are exchanged and visualized in the classroom mind map. In the Evaluation Phase teachers use individual and classroom mind maps to evaluate and discuss learning outcomes. Within the structure of this scenario teachers have ample opportunity to fill it with specific curriculum content and are encouraged to adapt activities to specific classroom needs, as suggested by Zhang, Hong, Scardamalia, Teo, and Morley (2011).

	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
	Preparation	Introduction	Questioning	Knowledge construction	Evaluation
collective responsibility	teacher team	teacher & students	teacher & students	teacher & students	teacher & students
conceptual focus	identify core curriculum	prior knowledge core curriculum	questions about core curriculum	elaboration of core curriculum	reflect on core curriculum
question potential	explore question potential	elicit curiosity	generate & formulate	answer & exchange	reflect on questions
visual tools	design expert mind map	initial classroom mind map	mind map as question focus	elaborate mind map	reflect on mind map

Figure 2: Five consecutive phases and design-principles of scenario

To assess the potential of the scenario for future adoption, the relevance, practicality, and effectiveness for teachers were already tested and improved during the development by multiple cycles of design, implementation, evaluation, and redesign (Stokhof et al., 2017b, 2018). From these findings it was concluded that the scenario was effective for its main objective: supporting teachers in guiding students to attain curricular objectives by means of effective student questioning. However, although these studies showed that the principle-based scenario was effective in the settings where it was developed, it was not clear, if and to what extent this innovation could be successfully transferred to other teachers in different settings. Therefore, we focus in this study on the suitability of the scenario for scaling-up.

1.4 Testing suitability for scaling-up

Multiple studies have shown that the diffusion of an educational innovation beyond its original settings is difficult. For example, Pea and Collins (2008) report that many attempts to scale up classroom innovations to the level of educational systems have been relatively unsuccessful. Therefore, the next step in the development of the scenario is to evaluate the quality of its implementation beyond the original settings. However, the challenge in this study is "not to "sterilize" naturalistic contexts from all confounding variables so the generated theory/model is more valid and reliable" (Barab & Squire, 2004, p.11). Instead, the aim is to test the adoptability and adaptability of the scenario by researching if it remains useful for teachers in new different school settings.

To optimize the scenario for upscaling, it was designed to be principle-based rather than highly scripted and proceduralized. A scripted proceduralized approach describes very specifically the tasks and activities and the order and form these should take. The aim of this approach is to provide clarity and structure. However, Zhang et al. (2011) suggest that this type of teacher support is not very flexible, does not take differences between educational contexts into consideration, and allows little opportunity for adaptation by the teacher. Furthermore, a highly scripted proceduralized approach seems to limit teacher's experiences of autonomy and competence when working with an educational innovation (Zhang et al., 2011). This influences the success of the implementation, because Jansen in de Wal (2016) proved that a limited experience of autonomy and competence obstructs the adoption of innovations. By contrast, Wen, Looi, and Chen (2012) found that a principle-based approach provides a sequence of pedagogical activities which supports teachers to translate design-principles into concrete classroom teaching. Zhang et al. (2011) showed that a principle-based design supported teachers in making adaptive decisions to accommodate activities to local contexts, needs, and possibilities. Therefore, it is expected that a principle-based scenario supports the experience of autonomy and competence, which fosters adoption.

In accordance with its principled-based character, each phase in the scenario consists of essential activities and optional activities (Appendix A). Essential activities in the scenario are necessary to put design principles to work in classroom practice. Optional activities might support classroom practice, but are not essential to make design principles operational in class. For example, constructing an expert mind map is considered to be an essential activity, but constructing the expert mind map with colleagues is optional. The degree of adherence to the essential activities is considered in this study to be an indicator for the relevance and practicality of the scenario.

1.5 School and teachers characteristics as co-variables

Although, the scenario was designed to be adaptable to multiple school contexts and the varying teachers' personal needs, it was hypothesized that specific school and or teacher characteristics might still influence implementation decisions (cf. Ellsworth, 2000). Roschelle et al. (2008) suggest that the innovation can only be considered "robust" when the majority of teachers from different school contexts with various teacher characteristics adopt it. Therefore, several school-context and teacher-characteristics will be included as co-variables in this study (Table 1).

School Characteristics	Teacher Characteristics
alignment of school vision	gender
organization of social science curriculum	age
curriculum materials	general teaching experience
single or combined-grade classes	experience with mind mapping
size of school team	experience with inquiry-based learning
size of student population	experience with co-designing
percentage special care students	perceived support school management
location: rural or (sub)urban	perceived support trainer
	motivation for student questioning

Table 1: School and teacher characteristics as co-variables

The school characteristics will be selected as co-variables for several reasons. The alignment of school vision to the use of student questioning in teaching is examined because the congruence between vision and the innovation is assumed to support implementation (cf. Fullan & St.Germain, 2006). The organization of social science curriculum is taken in consideration because the scenario is expected be more aligned to project-based curricula than cursory curricula. Also curriculum materials are selected as a co-variable because the scenario encourages teachers to self-design and adapt materials. For schools that work with a textbooks the scenario might be less attractive. Another co-variable is the organization of the school in single or combined-grades classes. Teachers in combined-grades might either perceive the scenario as appealing for its adaptivity, or as too complex for the variety in their classroom population. Furthermore, several demographic variables are selected, such as the size of the school team, the size of the student population, the percentage of special care students, and the location of the school in either rural or (sub)urban areas.

Furthermore, several teacher characteristics will be selected as co-variables. Gender is taken into consideration because it is yet unclear if the scenario will be gender-neutral. Age is selected because it is unclear if the scenario is suitable for all age groups or only for specific age-groups. General teaching experience is included to explore if the scenario will be more appealing for experienced teachers because of its demands on teacher competencies, or more appealing to novice teachers because they might still be more appreciative of non-traditional ways of teaching. Next to general teaching experience also more specific experience will be examined. Will the degree of experience with mind mapping make adoption more likely because mind mapping is used in every phase of the scenario? Will the degree of experience with forms of inquiry learning influence the implementation decision because teachers are more acquainted with the inquiry processes? Will experience in co-designing support adoption because the scenario encourages teachers to co-design the preparation? Perceived support of school management and of the trainer will be included because Hargreaves and Fullan (2012) showed that safe and supportive leadership enhanced professional development and implementation of innovations. Finally, teacher motivation to integrate student questioning in their teaching is expected to be major factor in the implementation decision (Ryan & Deci, 2000).

1.6 Research questions

To research the robustness of the scenario the following main research question will be addressed: *What is the robustness of a principle-based scenario for guiding effective student questioning?*

To address this main question four subquestions are formulated. First, how do teachers perceive the scenario, operationalized as Rogers' attributes of innovations? Second, to what extent do teachers adhere to the essential and optional activities of the scenario in the operational curriculum? Third, to what extent do teachers experience support for their basic psychological needs in the realized curriculum? And finally, if and to what degree do the (co)variables influence the teachers' implementation decisions?

2.0 Method

This study is part of a series of design-based research studies, which aim to support teacher guidance of effective student questioning. In this implementation study the focus is on the robustness of a principle-based scenario for teacher guidance-when introduced in a variety of school contexts.

2.1 Procedure

The scenario was introduced in primary schools that had no prior experience with working with guiding effective student questioning. To offer the participating teachers the minimal required support to understand the intended curriculum, 15 trainers were trained by the first author to provide a basic introduction to the scenario. The trainers were all teacher-educators or senior teachers with previous experience in coaching teams of primary school teachers.

Each trainer organized two meetings at the participating schools to introduce the scenario and to help teachers to set up a trial of the scenario. In these meetings, teachers prepared an expert mind map about a social science topic of their choice, prepared an introduction for this topic, brainstormed which potential questions might be elicited from the pupils in class, and discussed what kind of guidance these questions may require. All teachers were provided with a manual of the scenario for reference purposes (Stokhof, De Vries, Bastiaens, & Martens, 2017c). After these preparations teachers trialed the scenario in their own classrooms for about six weeks, each class working three to four hours each week on their projects.

2.2 Participants

In total 103 teachers in 23 primary schools in the Netherlands participated in this study. There was no prior selection of schools on specific school characteristics. Any school that had interest in trialing the scenario could participate.

The sample of participating schools can be characterized as heterogeneous. About half the schools are situated in a (sub)urban setting, the remainder can be characterized as rural. The schools vary in size between 70-601 pupils, although most schools are considered medium size: 36% consisting of 101-200 pupils, and 43% of 201-300 pupils. The percentage special care pupils is in 80% of the schools around the national average of 5%. Teacher teams range from 9-43 practitioners. However, most schools teams consist of 9-10 teachers (41%) or 11-20 teachers (42%). In 70% of the participating schools teachers teach combined-grade classes, often a combination of two or three grades. The social curriculum for which the scenario is trialed, is organized in 40% of the schools as cursory and in 60% of the schools as projects. Curriculum materials consist in 70% of the schools of standard textbooks, but in 30% of the schools teachers self-design and self-collect instructional materials. In 92% of the schools the documents on the school vision seem aligned to the idea that students should be able to raise and investigate self-formulated questions. However, in none of the schools this was common classroom practice yet when starting the trial.

The sample of participating teachers is also heterogeneous. The ratio between males and females in the sample is 23-77%, which is representative for the teacher population in primary education in the Netherlands. The age of the teachers ranges between 20 and 65, the average age being 40 years. Just over half of the teachers (55%), work four days or more in a week, the other teachers work part-time. Teachers of every grade are well represented in the sample, probably because 70% of them teach classes of combined grades. Their numbers range between 17 participants teaching Grade 1 and 33 teaching Grade 5. Participants have between 1 and 46 years of general teaching experience, the average being 17 years. Many teachers (around 60%) rate themselves as beginners in mind mapping and in guiding forms of Inquiry Based Learning (IBL). A smaller group in the sample (around 30%) perceive themselves as more advanced in mind mapping and guiding IBL. A small majority of teachers rate themselves to be advanced (55%) or even experts (7%) in co-designing projects for their pupils. When introduced to the scenario, almost 95% of teachers felt inspired and supported by the trainer and felt motivated to trial the scenario. About 80% of the teachers felt sufficiently supported by their school management to do so.

2.3 Instruments

The primary source of data in this study is a questionnaire for teachers. The questionnaire consists of five sections: a) teacher characteristics, b) operational curriculum, c) perceived curriculum, d) realized curriculum, and e) implementation choices. The first section focuses on general personal teacher characteristics such as gender, age, working in which grade, and teaching experience, but also collects more specific information on previous experience with inquiry-based learning, mind mapping, and co-designing courses. The second section addresses the operational curriculum and collects data on which intended activities in the scenario were actually executed in class. The third section of the questionnaire collects data on the perceived curriculum, operationalized as the *Attributes of Innovations* (Rogers, 2003). This section is based on the questionnaires of Moore and Benbasat (1991), Dupaghne and Driscoll (2005), and Stachewicz (2011). The items focus on teachers' perception of the relative advantage, compatibility, complexity, trialibility, and observability of the scenario in general, and the use of mind mapping in particular for each phase. The fourth section of the questionnaire addresses the realized curriculum and is based upon *Basic Psychological Needs Scale at Work* (Deci et al., 2001). This section inquires how teachers experience support for autonomy, competence, and relatedness when: a) deciding to trial the scenario, b) preparing the scenario, c) working with the scenario in the classroom, and d) reflecting on the learning outcomes of the scenario. In the final section of the questionnaire teachers are asked which implementation choices they would make when considering future use: Which phases of the scenario would they like to adopt or reject, and which phases would they like to adapt? To give teachers the opportunity to add comments to their responses, open questions are included at the end of each section in the questionnaire.

2.4 Data collection

All data was collected during the school year 2016-2017. Table 2 provides an overview on all collected data. The questionnaire was distributed digitally by email to all 103 participating teachers. In total 91 teachers completed the questionnaire. Next to the questionnaire also other sources of data were used to triangulate findings. To triangulate self-report on the operational curriculum, teacher and student products were collected for each phase of the scenario such as expert mind maps, classroom mind maps, question worksheets, etc. (Appendix B). To collect data on the school context, existing sources such as school documents and publicly available statistical data on school performance were consulted.

(co-) variables	Indicators	Instruments	Based upon
School characteristics	Location, vision aligned to student questioning, curriculum materials, curriculum organization, single/combined-grade classes, size teacher team, size student population, percentage special care students.	School documents Consultation of trainers	Ellsworth, 2000; Fullan and St.Germain, 2006
Teacher characteristics	Age, gender, grade, previous experience (general, mind map, IBL and co-design), support school management, support trainer, motivation	Questionnaire	Ellsworth, 2000; Hargreaves and Fullan, 2014; Ryan and Deci, 2000
Perceived curriculum	Relative advantage, compatibility, complexity, trialibility and visible success.	Questionnaire	Rogers, 2003; Stachewitz, 2011
Operational curriculum	Activities performed in the five phases of scenario (Appendix A)	Questionnaire Product collection	Stokhof et al., 2017b
Realized curriculum	Experienced relatedness, autonomy and competence.	Questionnaire	Deci et al., 2001
Implementation decision	Teacher's choice to adopt, adapt or reject	Questionnaire	Rogers, 2003

Table 2: Data collection: (co-)variables, indicators, and instruments

2.5 Analysis

The analysis process consisted of 5 consecutive steps (Figure 3). First, the teachers' implementation decisions were determined for each phase of the scenario. The 7 point-scale of teachers' choices to adopt or reject, was clustered as follows: Scores 1-3, indicating 0% to 30% likeliness, were interpreted as "rejection". Score 4, indicating a 50% likeliness, was classified as "in doubt". The scores 5-7, indicating a 70-100% likeliness, were regarded as a choice for "adoption" or "adaptation". Then the percentages of the three implementation decisions were calculated for each Phase.

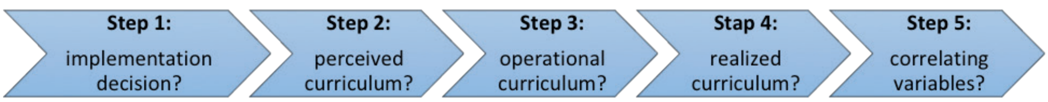

Figure 3: Steps in analysis process

To determine an overall score of the implementation decision for the scenario as a whole, the Phases Introduction, Questioning, and Construction were considered to be the essential components of the scenario. This is because these three Phases concern the actual classroom activities to support both student questioning and build collective knowledge about the topic under study. The scores for these three Phases were examined to determine which percentage of the teachers either choose to adopt, to reject, or remained in doubt for the scenario as a whole. If a teacher scored 5 or higher in all three Phases this was classified as a choice to "adopt". If a teacher scored 3 or lower in all three Phases this was interpreted as "rejection". All intermediate scores were classified as "in doubt".

In the second step the perceived curriculum was examined, which was operationalized as the attributes of innovations (Rogers, 2003). The questionnaire included two items for each attribute for each phase. Because of the need to calculate sum scores, internal consistency was checked first. Reliability was found to be high for all attributes, ranging between Cronbach's α = .876 and α = .923. Then the sum scores for each attribute in the whole scenario were calculated. To relate the sum scores to the original 7-point Likert scale, a range of corresponding frequencies was calculated by dividing the sum scores by the number of questions. Subsequently, on the basis of this range of frequencies, it was determined which percentage of teachers scored for which attribute on which scale. To identify possible influences of specific phases, the sum of attributes for each phase was also calculated in a similar procedure.

The third step in the analysis was to determine the operational curriculum, operationalized as to what degree teachers adhered to the intended curriculum. Teachers could indicate on dichotomous scale which activities they had executed in the classroom. In this step, first the frequencies of executed essential activities and optional activities were determined, and then the percentage of adherence was calculated for each activity in each phase of the scenario.

In the fourth step the realized curriculum was analyzed. This was operationalized as the degree to which teachers experienced autonomy, relatedness, and competence when implementing the scenario. For each of the variables multiple items were included in the questionnaire. Therefore, to ensure internal consistency Cronbach's α was calculated for all three variables. Reliability was found to be sufficient to high: autonomy, 4 items, α = .759, relatedness, 9 items, α = .799, competency, 16 items, α = .764. Subsequently, frequencies were determined for each of these variables and the distribution of scores over the 7-point scale was calculated for percentages of teachers. Finally, to compare the means and standard deviations between the variables, the outcomes were divided by the number of items in the questionnaire.

In the final step of analysis the correlations between all variables and co-variables and the implementation decisions were examined. First, significance and size of Spearman's correlations between the implementation decisions and the teacher and school co-variables were calculated in SPSS. Then also the variables for the perceived, operational, and realized curriculum were included in this correlation analysis.

3.0 Results

3.1 Implementation decisions

Teachers could indicate on a 7-point Likert scale the likeliness they would adopt or reject the scenario for future use. Table 3 shows the findings for adoption in the questionnaire for each of the five phases of the scenario. In the first three Phases over 80% of the teachers show willingness to adopt the scenario for future use. However, in Phases 4 and 5 the likeliness to adopt decreases slightly and more teachers are in doubt or do not expect to continue working with (parts of) the scenario. The overall implementation decision, combining the scores for Phases 2, 3, and 4, indicate that a majority of teachers show willingness to adopt the scenario as a whole for future use.

Phase	Decision: reject (0-30% likely to adopt)	Decision: in doubt (50% likely to adopt)	Decision: adopt (70%- 100% likely to adopt)
1: preparation	4,8%	14.2%	81.0%
2: introduction	7.1%	9.5%	83.4%
3: questioning	3.6%	9.5%	86.9%
4: construction	10.7%	13.1%	76.2%
5: evaluation	14.3%	15.5%	70.2%
Overall score	**10.7%**	**13.1%**	**76.2%**

Table 3: Decision to adopt or reject scenario

A small majority of teachers, around 55%, indicate they would like to adapt the scenario in future use (Table 4). From the teachers' comments to the open questions it is understood that teachers have different arguments for their decision to adapt or not. Some teachers find the scenario fitted to their needs and feel no urgency to adapt it. Other teachers see various opportunities to fit the scenario to their needs, or express willingness to experiment with variations on the scenario. Other teachers indicate they are just getting acquainted with the scenario and feel they are not yet able to determine if and how to adapt the scenario.

Phase	Decision: don't adapt (0 – 30% likely to adapt)	Decision: in doubt (50% likely to adapt)	Decision: adapt (70% - 100% likely to adapt)
1: preparation	23.8%	19.0%	57.1%
2: introduction	23.8%	21.4%	54.8%
3: questioning	27.4%	17.9%	54.7%
4: construction	27.4%	14.3%	58.3%
5: evaluation	26.3%	15.5%	58.3%
Overall score	**27.4%**	**21.4%**	**51,2%**

Table 4: Decision to adapt scenario

3.2 The perceived curriculum

The perceived curriculum is operationalized as the five attributes of innovation (Rogers 2003). As Figure 4 shows, 87% of the teachers perceive the attributes of the scenario generally as "somewhat positive" (score 5 = 26%), "positive" (score 6 = 46%) or "very positive" (score 7 = 15%). The most positive attribute is

Relative Advantage (M= 5.43, SE= .85), followed by Compatibility (M=5.36, SE= .88). Complexity is perceived as the least positive attribute, although the average score is still positive: 4.87 (SE= .84)

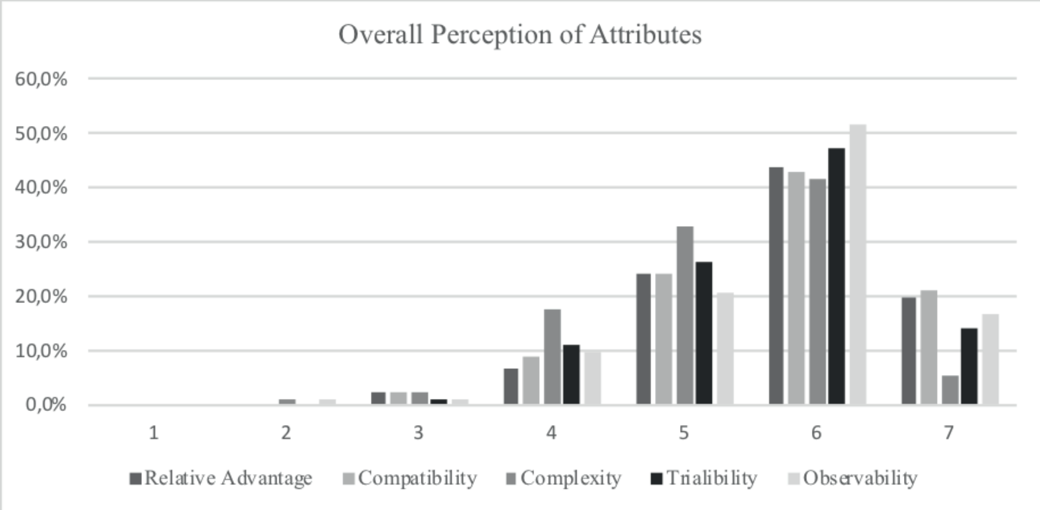

Figure 4: Teachers' overall perception of attributes

The distribution of scores on perception of attributes in the various Phases, is shown in Figure 5. More teachers are more positive about the Preparation (Phase 1 = 92.3%), the Introduction (Phase 2 = 85.7%), and the Questioning (Phase 3 = 81.3%), than about Construction (Phase 4 = 74.7%), or Evaluation (Phase 5 = 74.7%). Highest appreciated are Preparation (Phase 1: M= 5.56, SE= .83) and Introduction (Phase 2: M= 5.87, SE= .99). The Evaluation Phase is appreciated least (Phase 5: M= 4.85. SE= 1.02).

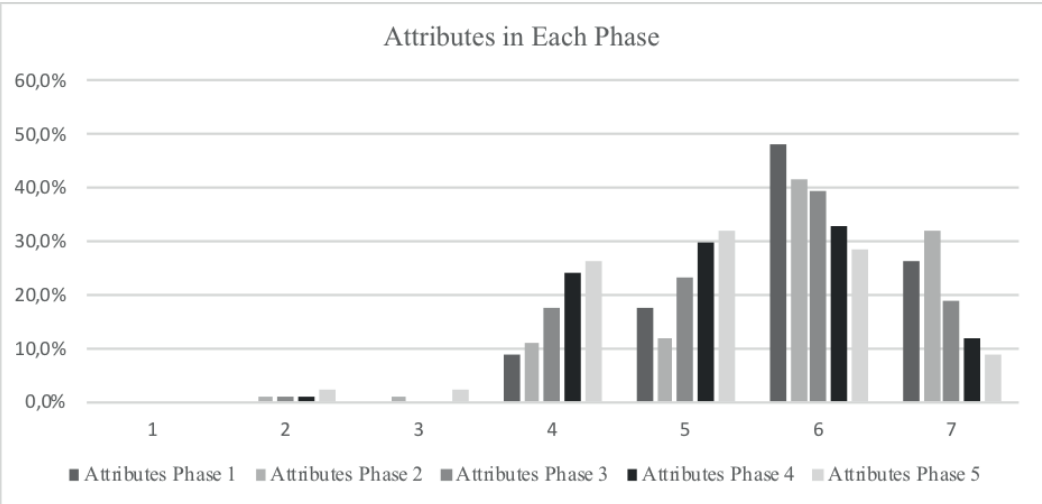

Figure 5: Teachers' perception of attributes in each phase

3.3 The operational curriculum

To check if teachers' implementation decisions are influenced by the extent to which the scenario is implemented in the classrooms both the use of essential and optional activities were monitored (Table 5). In the first three Phases of Preparation, Introduction, and Questioning, the teachers' adherence to the essential activities is found to be high. However, in the Construction and Evaluation Phases the adherence percentages decrease significantly. Teachers' comments to the open questions show that some teachers felt somewhat time-pressured in the course of activities, and were either not able, or choose not to engage in all activities in the last two Phases of the scenario.

Essential Activities		Optional Activities	
Phase 1 Preparation			
Construct expert mind map	83%	Collectively construct expert mind map	76%
Prepare introduction	93%	Collectively prepare introduction	73%
Prepare prompts for questioning	91%	Collectively prepare prompts	69%
Phase 2 Introduction			
Elicit prior knowledge	87%	Think of individual prior knowledge	80%
Exchange prior knowledge	88%	Note prior knowledge	68%
Structure classroom mind map	80%		
Phase 3 Questioning			
Question brainstorm	81%	Discuss question quality	73%
Select questions together with pupils	79%	Discuss question formulation	67%
		Allow students to adopt questions	51%
Phase 4 Construction			
Link questions to mind map	64%	Discuss links between questions	50%
Expand mind map with answers	51%	Collective responsibility for mind map	58%
		Expand mind map with teacher lessons	46%
Phase 5 Evaluation			
Discuss development mind map	57%	Individual pretest mind map	18%
		Small group pretest mind map	41%
		Individual posttest mind map	16%
		Small group posttest mind map	24%
		Compare pre and post mind map	20%
		Alternatives to discuss development	78%

Table 5: Adherence to essential and optional activities

3.4 The realized curriculum

The realized curriculum is operationalized as the extent to which the scenario supported teachers' feelings of autonomy, relatedness, and competence. Table 6 shows how the average scores of participants are distributed over the 7-point Likert scale. Teachers experience in general positive levels of autonomy (M=5.91, SE=. 84), of relatedness (M=5.61, SE= .66), and of competence (M= 5.36, SE= .60).

Variables	Percentages of average scores						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Autonomy (4 items)	0%	0%	0%	6%	10.7%	32.1%	51.2%
Relatedness (9 items)	0%	0%	0%	4.8%	13.1%	57.6%	25.0%
Competence (16 items)	0%	0%	0%	2.4%	23.8%	63.1%	10.7%
Sum score self-determination variables(29 items)	0%	0%	0%	2.4%	13.1%	66.6%	17.9%

Table 6: Results of the realized curriculum

3.5 Correlations with the implementation decision

To check for possible influences of the various variables on teachers' implementation decisions, correlations were calculated.

	Variables	Correlates with	
		Adopt	Adapt
Operational curriculum	Essential activities Phase 2 (Introduction)	.309**	-
	Essential activities Phase 4 (Construction)	.479**	-
	Essential activities Phase 5 (Evaluation)	.497**	-
Perceived curriculum	Relative Advantage	.567**	-
	Compatibility	.626**	-
	Complexity	.437**	-
	Trialibility	.543**	-
	Observability	.528**	-
Experienced curriculum	Autonomy	.571**	.234*
	Relatedness	.497**	-
	Competence	.576**	-
	SDT-(all)	.624**	-
School characteristics	Size school team	.223*	-
	Single or combined-grades classes	-.250*	-
Teacher characteristics	Support school management	.294**	-
	Support trainer	.462**	
	Motivation for student questioning	.625**	-

- = non-significant, * = p <.005, **= p <.001

Table 7: Variables that correlate with teachers' implementation decisions

Table 7 shows that of the operational curriculum only the essential activities of Phases 2, 4, and 5 correlate positively with adoption. This finding suggests that those teachers who did adhere to these essential activities, are more inclined to adopt the scenario in the Introduction, Construction, and Evaluation Phases. Regarding the perceived curriculum, the attributes of the scenario are not only generally appreciated as positive but also significantly influence the decision to adopt. Especially, compatibility, relative advantage, and trialibility are strongly correlated with adoption. Similarly, high scores in the realized curriculum, concerning teachers' feelings of autonomy, relatedness, and competence, are significantly correlated to adoption. The only significant and relatively weak correlation with adaptation is autonomy.

Only two of the eight school variables have a small influence on adoption: the size of school team and teaching in combined-grades classes. Just three teacher variables are correlated with adoption: perceived support of the school management, perceived support of the trainer, and teacher motivation. This suggests that most differences in teacher and school variables do not influence the decision to adopt the scenario.

4.0 Discussion

The general inclination of teachers to adopt, suggests that the scenario addresses teachers' needs in guiding effective student questioning. The finding that many differences in school and teacher variables do not correlate with the implementation decision shows that the scenario is appealing to a variety of teachers in various school contexts, thus meeting the criteria for robustness (cf. Roschelle et al. 2008). We conclude, therefore, that the scenario is "robust" and transferable beyond the original settings in which it was developed.

When examining the differences in implementation between the phases of the scenario an interesting pattern emerges. The relative low rates of adoption for the phases of Construction and Evaluation (Phases 4 and 5 of the scenario) seem congruent to the gradual decrease in the appreciation of, and adherence to, the essential activities in these phases. Apparently, in the course of the scenario it became gradually more difficult for some teachers to integrate its features in their teaching. Remarkably, adherence to the essential activities in Phase 4 and 5 correlates positively with the teachers' decision to adopt the scenario. This suggests that those teachers who did use mind mapping to build collective knowledge and to evaluate knowledge development, are more inclined to adopt it for future use. This is desirable because in a previous study was found that especially visualizing and discussing collective knowledge construction enhanced student learning outcomes (Stokhof et al., 2018). However, further studies are needed to explore how to encourage a considerable minority of teachers to experience the potential of mind mapping for guiding knowledge construction and evaluation in Phases 4 and 5.

A possible explanation for the high rate of adoption and degree of robustness is that the scenario addresses a felt need of teachers. As Kotter (1995) and Marino (2011) suggested, many successful educational innovations start with the willingness of the participants to change the current status quo. The high levels of motivation of participants to trial the scenario demonstrated teachers' general willingness to experiment with a more student-centered approach to teaching. The high level of adoption could be interpreted as that teachers had experienced a high level of success in trialing the scenario, and were confident that future use would continue to support them in guiding effective student questioning (cf. Abrami, Poulsen, & Chambers, 2004).

Another factor which may have contributed to adoption and robustness, was that the scenario was designed a priori for upscaling by taking into account the basic psychological needs of autonomy, relatedness, and competence during the development. The primary strategy to enhance upscaling was to choose a principle-based approach which could offer both autonomy and competency support (cf. Van Loon, 2013). Teacher's competency is supported in the scenario by offering structure in consecutive phases of guidance. Autonomy is enhanced by providing opportunity for teachers to adjust the scenario to their personal needs and classroom contexts. Moreover, the scenario also supports relatedness between teachers because the collaborative activities in Preparation Phase are highly appreciated (Stokhof et al., 2017b). By taking these basic psychological needs of autonomy, relatedness, and competence into account in the design, the likeliness of adoption seems to be supported (Gorodzidis & Papaioannou, 2014; Jansen in de Wal, 2016; Lam, Cheng, & Choy 2010). Furthermore, when working with the scenario, the teachers are expected to be active and critical participants. In the scenario teachers develop their own projects, make critical choices in curriculum content, and implement classroom activities themselves. This is congruent to the suggestion of Richter and Allert (2017), who advocate that to support the development process teachers should have an active and critical role. As Samoff, Dembélé, and Molapi Sebatane (2013) found, scaling up is enhanced when participants have the opportunity to adapt or redesign specific elements of the innovation and local ownership is thus encouraged. If other principle-based designs will similarly support the implementation of educational innovations, however, will require further study.

Findings on teachers' decisions to adapt, however, seem ambiguous. The open questions reveal that teachers had different arguments whether to adapt or not. The decision not to adapt was based on two different arguments. Either, teachers appreciated the scenario as it is, or teachers felt not yet able to decide, if and how the scenario should be adapted. Even when teachers felt able to decide to adapt, this could mean two things. On the hand, a few teachers indicated that certain flaws in the scenario needed to be addressed. On the other hand, other teachers saw opportunities to adapt the scenario to align it to their specific needs. Therefore, these differences in interpretation are probably the cause that only autonomy is significantly correlated with adaptation. It appears the more teachers feel in control to adapt, the more likely they are to choose for some form of adaptation.

To correctly interpret these conclusions we would like to point out some of the limitations of this study. First of all, the participants were a self-selected sample of teachers from interested schools and not an ad-random sample of all schools. Findings about adoption of scenario are therefore only representative for schools and teachers who are interested in integrating student questioning in their classroom practice. Nevertheless, in the course of this study we found multiple schools and their teachers interested to trial the scenario in the near future. Second, this study describes teachers' perceptions, actions, and experiences of the scenario in the Decision phase of implementation. Further use of the scenario beyond this phase could not yet be monitored. However, the teachers' intention to adopt was considered a predictor for future use, as suggested by theory of Reasoned Action Approach (Fishbein & Ajzen, 2010).

To summarize our conclusions, the findings show that most teachers in our sample are highly motivated to encourage student questioning but experience a need for support. The principle-based scenario for teacher guidance of effective student questioning appears not only to address this need but also proves to be "robust": Various teachers in different school contexts experience the scenario as an appealing and useful support for guiding students to raise SIS questions, which contribute to attaining curriculum objectives. The principle-based character of the scenario offers both the structure for teacher guidance, as well as, freedom for teachers to align this guidance to personal needs and local circumstances. Furthermore, this study contributes to the body of knowledge about the complex, and very often underestimated, process of adoption of educational innovations.

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Journal Details

EDeR – Educational Design Research
An International Journal for Design-Based Research in Education
ISSN: 2511-0667
uhh.de/EDeR
#EDeRJournal (our hashtag on social media services)

Published by

Hamburg Center for University Teaching and Learning (HUL)
University of Hamburg
Schlüterstraße 51
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+49 40 42838-9650 (fax)
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In collaboration with

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