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“I had imagined it would be worse”—implementing a standard-based quality management system for teacher education

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Introducing quality management systems is often a strenuous undertaking. Work processes need to be carefully examined, organized and systematized. In the field of education, quality management usually focuses mainly on organizational procedures, while the actual quality of knowledge transfer is only minimally assessed through poorly validated evaluation tools more akin to subjective happiness scales. DIN 33459, published by the German Institute for Standardization, outlines specific quality standards regarding the requirements for educators. As part of the *LFB-Labs digital* project, we have worked in collaboration with several science outreach laboratories to support the implementation of quality management based on DIN 33459. Our goal was to assess the difficulty of implementing the standard and identify necessary adjustments required to ensure compliance with its criteria. To achieve this, we utilized qualitative data analysis gathered from conversations with laboratory leaders and workers as well as observations during the creation of the organization's own quality manuals. In particular, we examined whether DIN 33459 is appropriate as a minimum benchmark for teacher training programs to address the increasing demand for quality assurance in this sector. Our findings indicate that implementing DIN 33459 required very little effort from the participating organizations, with only a few work processes needing alteration. The quality manuals developed on the basis of DIN 33459 effectively helped establish a quality management system, which helped systematize and standardize the science outreach laboratories' work processes. Nevertheless, future research must still assess the results regarding teaching efficacy utilizing a DIN 33459-based quality management system. Finally, we also explore and assess potential pitfalls of utilizing DIN 33459 but still encourage policymakers to take adopt the standard for further use.

KEYWORDS

quality management, DIN 33459, implementation, teacher education, training

Introduction

In the education sector, quality management (QM) is often associated with quality assurance in administration, research and teaching at universities, whereby teaching usually takes a rather superficial part—for example through teaching evaluations (see, e.g., [Bauer et al., 2013](#); [Mallich et al., 2007](#); [Petzoldt et al., 2008](#); [Pistor, 2014](#)). Since teaching evaluations themselves often work with unvalidated, shallow scales and evaluators are prone to biases, their results are often of questionable usefulness (e.g., [Barrie and Ginns, 2007](#); [Kreitzer and](#)

Sweet-Cushman, 2022; Uttl et al., 2017). Additionally, traditional approaches to QM typically rely on the process-oriented QM standards of the ISO 9000 series (e.g., ISO 9001; e.g., Bauer, 2014; Bauer et al., 2013; Markowitz et al., 1997; Schönherr et al., 2001).

The introduction of DIN 33459—*Requirements for the assessment, maintenance and improvement of the competences of learning facilitators—Requirements for persons* (Deutsches Institut für Normung, 2021) from the German Institute for Standardization (DIN) marks a shift toward content-related aspects of education. It differentiates itself from existing education standards (such as ISO 29993; International Organization for Standardization, 2017), by addressing the actual learning facilitation process itself and providing ways to generate measurable data points. This means that QM in the education sector in Germany can now also be introduced and analyzed far away from management processes and closer to the relevant subject matter, the educational service itself (Biehl and Koerber, 2024).

While utilizing science outreach laboratories (SOLs) as places for teacher training has already been investigated in several projects (e.g., Dohrmann and Nordmeier, 2015; Krofta et al., 2012), the integration of QM in SOLs as part of the development of teacher training programs represents a completely new approach. Due to the relative novelty and the low level of awareness of the standard, publications focusing on DIN 33459 are still a rarity (see, e.g., Biehl and Koerber, 2024, 2025). However, this is decidedly not due to a lack of relevance; the importance of the standard and the relevance of addressing it—especially in connection with alternative venues for teacher training—is substantiated by several reasons.

Firstly, the topic of teacher training is highly controversial, especially in Germany due to its federal education system, and the current lack of binding nationwide standards is a recurring topic at the KMK (Daschner, 2023; KMK, 2020). The emergence of a standard that enables all federal states to subject themselves to a minimum standard for their teacher training programs is therefore a unique opportunity to take a major step forward in the quality of teacher training in Germany and at the same time to research this step and all its effects from a scientific perspective.

Secondly, the intensive assessment of the implementation process of a new standard for educational service providers offers the opportunity to work out the requirements and effects of QM with a specific reference to education. Learning facilitators and educational organizations can use these findings to optimize their work (make knowledge transfer more effective—i.e., more productive) and design their processes more efficiently. At the same time, the findings can also be used to raise awareness for the standards of teaching and training in organizations among those who are not directly involved in teaching themselves.

The final point to be made is that the experience gained by organizations and individuals during the introduction of DIN 33459 may also be suitable for bringing about changes or, in particular, improvements to the standard itself. Standards are revised at irregular intervals—depending on requirements (Deutsches Institut für Normung, 2024)—and reports on experiences with their application can lead to important changes. At the same time, educational service providers and other organizations and individuals who offer (teacher) training can benefit from the experience gained during the implementation of the standard in terms of good practice criteria. In

the long term, all of these results could strengthen Germany as a center of education, research and, ultimately, business.

In this current article, we use a case study with eight STEM SOLs and a non-university teaching/learning workshop to examine whether DIN 33459 can fulfil the self-imposed requirements of educational organizations for an in-house QM system (QMS) or whether it is also insufficient as a minimum standard. At the same time, we will examine how the implementation of a QMS based on the standard can succeed and what obstacles might arise.

Quality management in teacher training

There have been attempts for some time to establish a system of different standards and criteria in teacher training in Germany (see, e.g., Fischer, 2007 or Koerber, 2015). However, these have not yet been successful across the board. In the course of the quality debate, the KMK (2020) defined several standards that were intended to ensure the effectiveness and ultimately the quality of teacher training programs. However, these key points lacked both commitment and precision (e.g., ensure the subject focus and depth of content of the programs; KMK, 2020). The existence of a more precisely formulated and binding standard—because it can be measured with specific indicators—could be the key to uniform agreement on a concrete minimum standard throughout Germany.

DIN standard 33459 (Deutsches Institut für Normung, 2021) now provides a set of instruments that can ensure these requirements of accuracy, commitment and measurability (Biehl and Koerber, 2024). In order to establish a quality standard, it usually has to be anchored within organizations in the form of QMSs. For this purpose, quality manuals are used to codify the quality requirements and work processes of the organization in question. They are used for documentation, but above all for monitoring work processes (Bittorf, 2008). The structure of DIN 33459 makes it suitable in principle as a foundation for the implementation of a QMS for individuals and organizations involved in teacher training (Biehl and Koerber, 2024, 2025) and could therefore represent an important step in the area of QM in the education sector.

Science outreach laboratories as locations of teacher training

The use of SOLs in teacher training is not an entirely new field of research (see, e.g., Dohrmann and Nordmeier, 2015; Euler et al., 2020; Euler and Schüttler, 2020; Käpnick et al., 2016; Krofta et al., 2011, 2012, 2013; Schehl et al., 2020). What is new in the BMBF-funded LFB-Labs digital project, however, is the systematic accompanying investigation taking place at several levels, including at subject and system level (Kirchhoff et al., 2024). In this way, further training courses are being designed and the conditions for the acquisition of digitalization-related skills by teachers are also examined and worked out. The use of SOLs for teacher training has the advantage that they offer authentic, motivating and innovative learning settings (Kirchhoff et al., 2024) in which teachers can learn in a playful, exploratory way, just as students can. The authenticity of the equipment used in the labs can increase the situational interest of learners (Schüttler et al., 2021), which is particularly advantageous for STEM subjects and the associated loss of interest

during the course of school (e.g., [Großmann et al., 2021](#)). SOLs also have the advantage that, due to the strong scientific connection, they can generally also draw references to current findings from research, which is not necessarily the case with traditional teacher training programs. Additionally, teachers can network and exchange ideas more easily due to the collaborative work in the labs, and can thus learn from each other and build low-threshold networks. It can also be assumed that teachers who familiarize themselves with SOLs as part of their own training are more likely to understand the benefits of these labs for their own students and will therefore be more inclined to use them. The use of SOLs therefore has several advantages; teachers benefit not only from the teaching staff, who are specifically trained in the subject and didactics for the respective purpose of the labs ([Kirchhoff et al., 2024](#)), but also—if the respective SOL offers further training with appropriate methodology—from the associated gain in digitalization-related skills.

DIN 33459 as a standard for teacher training

DIN 33459 is a standard that provides learning guides with 14 different quality standards to enable them to deliver effective training ([Biehl and Koerber, 2025](#); [Deutsches Institut für Normung, 2021](#)). As a successor standard to PAS 1064 ([Becker et al., 2006](#)), it has been designed to serve as a potential foundation for the introduction of a QMS. It is important to emphasize that DIN 33459 is not a dedicated teacher training standard, but a standard that formulates requirements for learning facilitators (e.g., trainers or teachers). However, this fact does not make it any less suitable as a standard for teacher training, but is merely an indication of its wide range of possible applications. In the standard, the individual quality standards are each underpinned by criteria that attempt to reflect various aspects of the respective quality standard. These criteria can be assessed by measurable indicators. This enables objective, reliable and, above all, valid measurements of the relevant quality standards and thus comparability between the educational services of different individuals and institutions. The quality standards contained within DIN 33459 are divided into 10 normative (mandatory) and four informative (voluntary) standards ([Deutsches Institut für Normung, 2021](#)). Most of the quality standards are those that would be expected of professional trainers anyway ([Biehl and Koerber, 2024](#))—nevertheless, or rather for this reason, DIN 33459 should be suitable as a binding minimum standard, as the requirements are low enough to avoid major resistance on the part of training organizations or individuals, but at the same time demanding enough to enforce important quality requirements for effective training. DIN 33459 not only specifies the quality standards that must be met, but also offers suggestions for the associated criteria and indicators. Conformity with DIN 33459 is therefore deemed to have been achieved if the quality standards are met—regardless of whether the associated criteria and indicators have been modified. The fit of the criteria and indicators with the associated quality standards must be checked by the body that confirms conformity with the standard.

Materials and methods

As we are approaching a yet unexplored topic, we addressed the research question using a multi-method approach consisting of a

combination of qualitative interview analyses and document analyses. This enabled us to work out what priorities SOLs set in their work, what thoughts they have on the subject of QM and what challenges they face when implementing a QMS based on DIN 33459. To this end, we systematically analyzed the quality manuals produced as part of the project and their development process, including the accompanying final interviews. We analyzed the quality manuals in particular with regard to changes in the quality standards, criteria and indicators from the foundation (DIN 33459). The relatively open interviews—researcher-led, guided conversations that were recorded after the creation of the quality manuals—can depict the complexity of thought processes and cognitive structures of the interviewees more accurately than closed questions ([Kohli, 1978](#)) and thus, in combination with the document analysis, help to understand the interviewees' thought processes in the course of the development of the quality manuals and the QMS.

Document analysis

The quality manuals were created in an iterative, collaborative process, whereby the respective laboratory managers or employees marked the respective quality standards, criteria and indicators of their own laboratory in a ready-made Excel spreadsheet based on DIN 33459 and furthermore highlighted adoptions, adaptations and omissions in color. We then analyzed the quality manuals with regard to changes from DIN 33459. We systematically noted how many changes were made at which levels. This made it possible to calculate three change quotients (CQ) for each SOL:

$$CQ_i = \frac{\text{Indicators changed}}{\text{Indicators overall}}, CQ_c = \frac{\text{Criteria changed}}{\text{Criteria overall}},$$

$$\text{and } CQ_s = \frac{\text{Standards changed}}{\text{Standards overall}}.$$

Indicators, criteria and quality standards are also considered changed here if they were either canceled without replacement or replaced. A deletion of criteria or indicators that occurred due to the deletion of the associated quality standard or criterion was not included in the calculation. This means that if a standard is deleted, the denominators are reduced by the number of criteria and indicators of this quality standard contained in the DIN (total indicators or total criteria). If a laboratory deletes a quality standard, for example, but does not change anything else, CQ_k and CQ_i still remain at 0. The manuals were also analyzed with regard to added quality standards, criteria and indicators, as well as their prioritization and the order in which the individual standards are listed.

Qualitative analysis

Participants

We recruited the interviewees by approaching them directly, as they were involved in the same project—as was the case with the SOL-employees—or, in the case of the makerspace, because they were personally known to us. They were either themselves entrusted with the management of the SOL or the training institute or were heavily involved in the creation of training content and the actual teaching or training, being regular employees within the laboratory. A total of 15

people from the relevant educational organizations were involved in the interview processes, with most laboratories choosing to partake with two participants, although some had only one or even three individuals taking part in the implementation process.

Data collection procedure

The primary method of data collection were semi-structured interviews, allowing for an open dialogue while guiding participants through key themes related to the QMS implementation. While the QMS introduction process itself consisted of multiple (typically three) appointments and accompanying talks with the SOL employees, we systematically analyzed only the final appointment, as this was designed to be a reflection session where we posed several interview questions. After the first appointment, the laboratory managers or the employees responsible for QM were asked to look at the individual quality standards of DIN 33459 and check whether and to what extent they applied to their own organization. This was done sequentially; first the quality standard was checked, if it was approved, the criteria proposed by DIN 33459 were checked, if they were approved then the indicators also proposed by the standard were checked. Both criteria and indicators could be rejected or modified, as specified in DIN 33459. It was relevant that the selected quality standards (i.e., those that were approved) could each be concretized and mapped by criteria and indicators. In the second appointment, we went through the table together and focused in particular on the standards, criteria and indicators that the respective organization could not or did not want to accept. In the case of minor changes to criteria or indicators—e.g., in one case, “Der Lernbegleiter greift Beispiele aus der Praxis der Teilnehmer auf.” (“The learning facilitator uses examples from the practice of the participants.”) became “Moderierende greifen Beispiele aus der erweiterten Lebenswelt der Teilnehmenden auf.” (“Moderators take examples from the participants’ wider environment.”), this was usually a smooth process. In the case of more drastic changes, the interviewees had to argue clearly why these changes could still reflect the standards. This process took the form of a consensus-building dialogue, in which we represented the interests of DIN 33459 and the laboratories represented theirs, always with the aim of finding and highlighting similarities between their work and the standard. Between the second and third meetings, we drew up the quality manual based on the information provided by each laboratory in the table. We sent the quality manuals to the laboratories and the process ended with the reflection meeting. All meetings were conducted via the Zoom video conferencing platform and recorded with each participants’ consent, then the reflection meetings were transcribed verbatim for further analysis. In order to counteract potential social desirability bias in the answers (Paulhus, 2002) we referred to several techniques from Bergen and Labonté (2020)—providing assurances, probing for more information and requesting examples—that were likely to help us collect less biased data. With the whole process being in German, the first author translated sample quotes into English, with two bilingual English teachers independently checking for accuracy of translation afterwards.

Interview analysis methodology

We then analyzed the interviews, drawing from both Mayring and Fenzl’s (2019) qualitative content analysis (QCA) as well as from Braun and Clarke’s (2006) thematic analysis (TA). We combined these methods as to first reduce and summarize the rather large amount of data using QCA and then focus on identifying and interpreting relevant themes within the summarized dataset, using TA. Our coding approach was

such, that both coders came to a negotiated agreement (Campbell et al., 2013), which we felt best to decrease potential researcher biases from a reflexivity standpoint. This was, because one coder was strongly involved with the interviewees and the whole implementation process, while the other coder had a very different, more distant perspective. Utilizing a computer assisted qualitative data analysis software (Yin, 2016), the transcribed texts were first edited (incorrect sentence beginnings were removed and/or corrected, identifying names and places were redacted) and then divided into individual coding units (i.e., several words with context, Mayring and Fenzi, 2019). We adopted a flexible unitization strategy, as we did not divide the text into predefined spans beforehand, but rather into meaning units during coding, which is more flexible for exploratory research. This approach is supported by qualitative methodology literature (Campbell et al., 2013), which led to the unit range varying from individual words to whole paragraphs. It is important to note, that not every uttered word and/or sentence is categorized, as when they are irrelevant for the research topic, they are just ignored (Mayring, 2015; Schreier, 2012). Following an inductive—bottom-up—process, we generated categories from the coding units (Saldaña, 2021) as opposed to setting categories before analyzing the data. We allowed segments to receive multiple codes when applicable, as statements often addressed several categories and/or themes at once. This process was iterative, meaning after going through the whole dataset once, we did it again due to the emergence of new categories during the ongoing process. It is important to note, that prevalence, i.e., number of interviewees who talked about a certain subject or number of instances they talked about that subject, is not necessarily an indicator of a relevant theme. As Braun and Clarke (2006) note, researcher judgement is necessary to determine whether a particular topic is a relevant theme. The spontaneous, inductive and iterative category development process led to a finalized coding scheme which included 12 categories. During further discussions, we tried to find broader patterns within and between the categories, looking for meaningful connections within and between categories, while keeping the research questions in focus. The development of themes from the codes was a process that was more top-down than the bottom-up code generation, as we looked at the codes from the perspective of our research questions. Through that lens, we generated six themes, which captured the codes which we deemed most important with regard to our research, while leaving out the codes which were less relevant to our concrete topic at hand. Looking at the finalized coding scheme helped us identify six wider overall themes. In order to increase transparency in how we moved from our initial codes to themes, we visualized this process using a Sankey diagram (Figure 1). In this diagram, flows illustrate how segments coded with initial codes were subsequently grouped and condensed into broader themes. The thickness of each flow corresponds to the number of coded data extracts contributing to that theme. While frequency does not determine thematic importance, the diagram provides an illustrative overview of the analytic condensation process and helps to see how we reorganized the data during theme development.

Results

Document analysis

The creation of the quality manuals themselves was relatively straightforward for all participating SOLs. As they were created on the

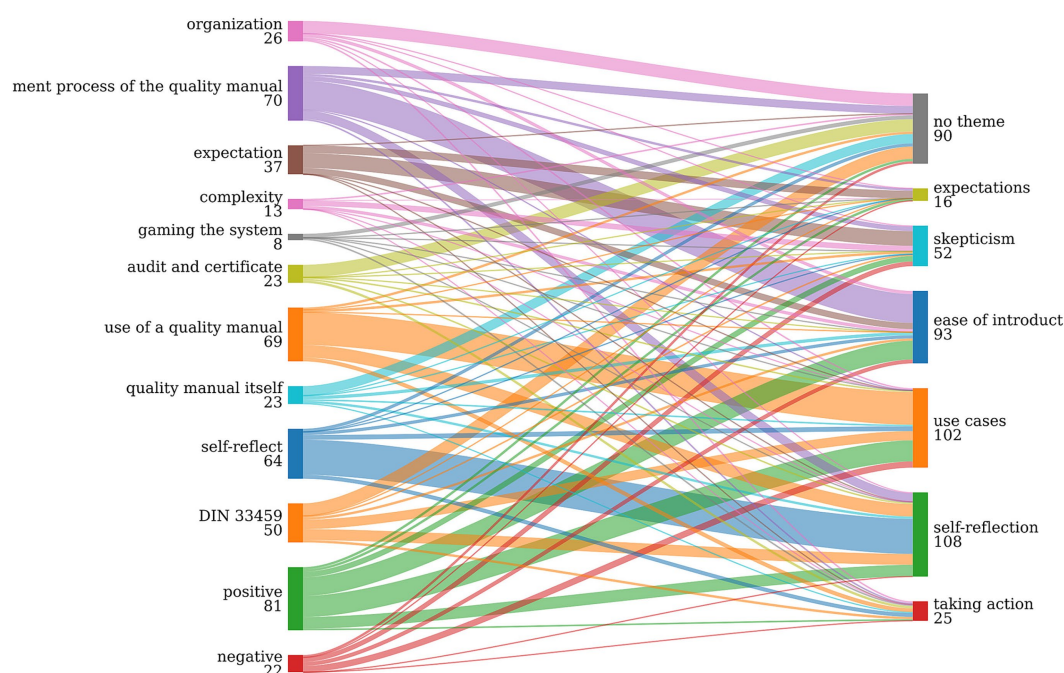


FIGURE 1
Visual representation of theme development from initial codes.

basis of the DIN 33459 standard, the changes made by the laboratories are of particular interest. These adaptations by the laboratories thus represent the deviations from the proposals of DIN 33459. A descriptive overview of the number of changes from the total standards, criteria and indicators and the respective CQs for the standards, criteria and indicators in the quality manuals of the laboratories can be found in Table 1.

The average overall change quotient is just over 0.07—this means that the participating organizations only removed or changed an average of 7% of the standards, criteria and indicators when the QMS based on DIN 33459 was introduced. Completely newly added standards, criteria and indicators are not included here, but were only found in three of the SOLs (two—LFB-Labs001 and LFB-Labs002—each added a new standard with one criterion and one indicator; another laboratory—LFB-Labs004—added seven new standards, supported by 15 criteria and 43 indicators). The removed quality standards were always informative standards (voluntary, not required for conformity with DIN 33459), so that the requirements of DIN 33459—even with the removal or modification of individual criteria and indicators of the normative quality standards—were met in their entirety. The *demand* quality standard was removed twice, the *multiphase* quality standard was removed five times. With regard to other conspicuous features, it should be noted that the order of the quality standards as specified by DIN 33459 was largely adopted by the laboratories—although some laboratories made changes here. The changed order was a way for the organization to express the relevance of the standards—typically, the quality standards considered more important were placed earlier in the text than those considered less important.

Overall, while these results are not a robust foundation for inferential statistics and assumptions, they nevertheless can be viewed as a cautious indicator that DIN 33459 is a suitable basis

for a QMS in the education sector. The vast majority of the standard could be adopted without modification in order to create an educational organization's own quality manual. The low level of change required by most laboratories indicates that the integration of the QMS—at least on system level—tends to be unproblematic. Only very minor processes, if at all, had to be changed, which apparently did not provoke any organizational resistance. Once the quality manual has been created, it is then up to the participating organizations to inform their employees about the contents of the manual and to implement the quality standards it contains in their daily work. Future research as part of the LFB-Labs digital project will show the extent to which the success of this integration is also possible at the micro level, i.e., the staff level.

Interview analysis

Analyzing the interviews, we noticed several recurring themes among the answers given by the participants. While the recurrence of certain topics is not surprising, given the nature of guided interviews, we nevertheless recognized several talking points, which we deemed relevant enough to be pointed out. Guided by our research questions and looking at topics which were supported by enough relevant interview data, we broadly identified six core themes, which we named (1) expectations, (2) skepticism, (3) ease of introduction, (4) use cases, (5) self-reflection, and (6) taking action.

Expectations

When asked about their expectations going into the undertaking of developing a quality manual and implementing a QMS based on DIN 33459, most of the interviewees expected the process to be more

TABLE 1 Change quotients of the examined quality manuals.

Organization	CQ _s (changes/ total)	CQ _s	CQ _c (changes/ total)	CQ _c	CQ _i (changes/ total)	CQ _i	CQ _{All}
LFB-Labs000	2/14	0.143	0/34	0.000	0/55	0.000	0.048
LFB-Labs001	1/14	0.071	1/36	0.028	2/57	0.035	0.045
LFB-Labs002	1/14	0.071	1/36	0.028	2/57	0.035	0.045
LFB-Labs003	1/14	0.071	7/36	0.194	10/57	0.175	0.147
LFB-Labs004	1/14	0.071	1/36	0.028	2/61	0.033	0.044
LFB-Labs005	0/14	0.000	3/38	0.079	2/63	0.032	0.037
LFB-Labs006	0/14	0.000	2/38	0.053	12/63	0.191	0.081
LFB-Labs007	0/14	0.000	1/38	0.026	5/62	0.081	0.036
LFB-Labs008	1/14	0.071	5/36	0.139	14/57	0.246	0.152
Global mean	–	0.056	–	0.064	–	0.092	0.071
Global SD	–	0.048	–	0.064	–	0.088	0.047
Global med.	–	0.071	–	0.028		0.035	0.045

LFB-Labs000 is an outlier regarding its nature as it is not a SOL but rather a makerspace, a collaborative work space at TU Dresden. However, this did not lead to relevant differences in CQ values.

arduous and to take a lot more time (see theme *skepticism*), though there were a couple more optimistic ones:

“Damals habt ihr mich gecatcht, dass ich es spannend finde und dachte, das würde uns auch helfen. Aber das ist so schnell geht hätte ich nicht erwartet.” (“Back then, you got me excited about it, and I thought it would help us too. But I didn’t expect it to happen so quickly.”—LFB-Labs006, para. 15)

“Das [Prozessbeginn] war schon recht transparent, da habe ich mich immer recht sicher gefühlt. Eigentlich.” (“That [start of process] was quite transparent, so I always felt quite safe. I think.”—LFB-Labs003, para. 16)

The only participant among interviewees to have undergone a quality manual construction and QM introduction beforehand (in a different setting) had their expectations fulfilled:

“Ja, ich glaube, das liegt aber auch daran, dass ich schon mal Qualitätshandbucharbeit in anderem Kontext miterlebt habe. Ich hatte ja auch eine Erwartung und die ist auch erfüllt worden. So, also ich wusste, warum wir aufeinandertreffen.” (“Yes, I think that’s also because I’ve seen quality manual work in other contexts before. I had certain expectations, and they were met. So, I knew why we were meeting.”—LFB-Labs004, para. 12)

It is important to note, however, that as these interviews were conducted after the process, meaning the retrospective of the interviewees might have influenced the answers regarding their expectations in a particular way without them being aware of it. Still, the consistency among participants showed, that there were only very few positive expectations, meaning organizations are unlikely to seek out a QMS implementation themselves, as they fail to anticipate enough benefits before the start of the process.

Skepticism

A recurring theme was skepticism regarding the concrete use of a quality manual and the QMS and fearfulness with regard to the

amount of work they thought was coming due to the implementation of the standard. Interviewees had difficulties imagining how implementing DIN 33459 into their work processes could yield any benefits for their organizations:

“[Als ich] dann gehört hatte, dass das jetzt ansteht und ich war erst ein bisschen skeptisch, weil ich mir dachte ‚ja, gut, wozu brauchen wir ein Qualitätshandbuch? Weil es läuft doch alles und wir haben das irgendwie alles gut im Griff.’” (“[When I] then heard that this was coming up and I was a bit skeptical at first because I thought to myself ‘yes, well, why do we need a quality manual? Because everything is running smoothly and we somehow have everything under control.’”—LFB-Labs008, para. 36)

Additionally, many participants mentioned that their impressions from before the start of the process were a lot worse concerning the amount of work and/or difficulty of the process they expected to have to do:

“Nee, nee, äh, nee, ganz im Positiven. Ich hatte da irgendwie viel, viel mehr Arbeit erwartet.” (“No, no, uh, no, in a positive way. I had somehow expected much, much more work.”—LFB-Labs004, para. 18)

“Also, wir haben ja gesagt, dass es uns leichter gefallen ist als gedacht.” (“Well, we said that it was easier than we thought.”—LFB-Labs005, para. 71)

Many interviewees had difficulties imagining concrete use cases for their quality manual and therefore their DIN 33459-based QMS before the process. This theme reveals, that people in organizations are very likely to underutilize DIN 33459, as it is hard to imagine how it can benefit the organization, while at the same time its introduction appears like a more stressful undertaking than it actually is.

Ease of introduction

There was an extremely high consistency among the interviewees regarding the ease of applying DIN 33459 as a base for a QMS for their

SOL. All interviewees mentioned how the process went smooth and overall easier than expected:

“Äh, der [Prozess der QM-Einführung] war viel leichter [als erwartet], weil ihr das meiste gemacht habt.” (“Uh, it [process of QMS introduction] was much easier [than expected], because you have done most of the work.”—LFB-Labs004, para. 16)

“Ansonsten fand ich das Vorgehen nicht schwierig. Das hat auch ehrlicherweise gar nicht so lange gedauert, wie ich das befürchtet hatte.” (“Apart from that, I didn't find the process difficult. To be honest, it didn't take as long as I had feared.”—LFB-Labs008, para. 31)

Some participants noted, that many of the requirements were those, they already fulfilled, which was a large part why introduction went so smoothly:

“Du hattest ja vorher auch schon gesagt, dass die Wahrscheinlichkeit relativ hoch ist, dass wir da [in der DIN 33459] ganz viele Dinge finden, die wir eben sowieso schon machen. Und das ist uns eigentlich nur durch den Prozess verdeutlicht worden, würde ich sagen.” (“You had already said before that the probability is relatively high that we will find a lot of things [in DIN 33459] that we are already doing anyway. And I would say that this has actually only been made clear to us through the process.”—LFB-Labs005, para. 43)

“Also ehrlich gesagt, so richtig viel anpassen mussten wir gar nicht.” (“To be honest, we didn't really have to adjust much at all.”—LFB-Labs001, para. 24)

It is very notable that zero interviewees made mention of any consistent difficulties regarding the actual implementation of the QMS. These results are a clear indicator, that the introduction of a DIN 33459 based QMS is unlikely to be a heavy burden on an organization, as we encountered no organizational resistance. The only (minor) problems that were mentioned were some inconsistent design choices with our own excel sheet we used for implementation purposes.

Use cases

When we asked the lab employees about potential use cases for DIN 33459 and their new quality manual, we identified several different applications. These ranged from providing new employees with the manual as a sort of guidebook on what to expect and what is expected of them to utilizing their DIN 33459 conformity as a way of external credentialing.

“[Dass man das Qualitätshandbuch beim] Onboarding nutzt für neue Moderierende, dass die halt quasi so auf Grundlage des Qualitätshandbuchs, ähm ich sage mal eine Arbeitsgrundlage haben.” (“[That the quality manual is used during] onboarding for new moderators, so that they have, um, a working basis based on the quality manual.”—LFB-Labs008, para. 36)

“Für neue Veranstaltungen ist es schon gut. Also dass man einfach immer so ein bisschen ein Backup hat.” (“It's good for new

courses. So you always have a bit of a backup.”—LFB-Labs000, para. 14)

“Also wir werden das [dass sie DIN 33459-konform arbeiten] auf jeden Fall auf der Homepage schreiben [...]. Ich sehe das schon als so eine Chance, sich von den anderen Laboren abzuheben.” (“So, we will definitely write that [that they are working in accordance to DIN 33459] on the homepage [...]. I see it as an opportunity to stand out from the other labs.”—LFB-Labs003, para. 20)

There were a couple of interviewees who had harder times thinking of ways to make use of the quality manual, though:

“Also tatsächlich bin ich gerade im Moment noch so der Ansicht, dass es eher so für die Vitrine ist.” (“So actually, at this moment, I think it's more for the display case.”—LFB-Labs000, para. 11)

“Bis auf den Fall [das Qualitätshandbuch als Qualitätsmerkmal zeigen] wüsste ich ehrlicherweise nicht, wofür ich es benutzen sollte.” (“Apart from this case [showing off quality manual as proof of quality] I honestly don't know what I would use it for.”—LFB-Labs008, para. 38)

Overall, participants mentioned several very different use cases for their quality manual, every participant found at least some. These findings suggest, that DIN 33459 has potential practical relevance, with different people extracting different use cases and many of those being mentioned several times. This wide range and variability of mentioned use cases can be seen as an indicator of flexibility of the standard.

Self-reflection

One of the most important aspects of not just the implementation of DIN 33459 but QMSs in general is the process of the respective organization reflecting their own processes and their own work results, which may lead to them finding new efficiencies. Asking about possible processes of self-reflection during the implementation process, we found that participants generally appreciated how they were compelled to reflect on their own stabilized work processes:

“Der ganze Prozess hat ja zum Reflektieren angeregt über sämtliche Bereiche und das war eigentlich ganz cool.” (“The whole process encouraged reflection on all areas and that was actually quite cool.”—LFB-Labs008, para. 45)

“Ähm, so dass uns das in dem Moment auch so ein bisschen darin bestätigt hat, dass das, was wir gerade weiterführen wollen und irgendwie ausbauen wollen gar nicht so verkehrt ist.” (“Um, so that kind of confirmed to us at that moment that what we want to continue and somehow expand is not such a bad idea after all.”—LFB-Labs007, para. 44)

These self-reflective passages often led to certain processes and topics becoming salient within the participants, which sometimes led to changes in thinking or behavior:

“Da gab es dann ein paar Stellen, also genau in dieser Spannweite, die du beschrieben hast, so wie von bis schon einmal 'okay, so in der Art machen wir das ja auch. Würde ich auch so sehen 'bis hin

zu 'Ah ja, stimmt, das hatten wir ja auch angedacht und das müssen wir jetzt noch mal anstoßen wieder den Prozess, das ist so eine blinde Stelle. Gut, dass ich noch mal daran erinnert werde 'bis hin 'guck mal, so könnte man es auch noch angehen.' ” (“There were a few things, exactly in this range that you described, like from 'okay, that's how we do it. That's how I would see it 'to 'Ah yes, that's right, we had thought about that and now we have to initiate the process again, that's such a blind spot. It's good to be reminded of that again 'to 'look, you could also approach it like this.' ”—LFB-Labs003, para. 26)

Some participants noted how during the implementation of the QMS and the construction of the quality manual, they often felt it helped explicate the implicit. This was felt to be a valuable tool of self-reflection.

“Also ich hätte jetzt gesagt, so 90 % der Sachen, die da drin stehen, sind eh Teil in meiner Fortbildung immer gewesen, waren aber nie so explizit aufgeschrieben.” (“Well, I would say that about 90% of the things in there have always been part of my training, but they were never written down so explicitly.”—LFB-Labs006, para. 33)

“Und diese Erkenntnis zu haben, dass man zum Beispiel sagt okay, wie sind denn die Moderierenden qualifiziert? Ja, wir haben natürlich einen Rahmen schon überlegt, aber der ist halt nie so in dem Sinne festgelegt worden.” (“And to have this realization that you say, for example, okay, how are the moderators qualified? Yes, of course we have already considered a framework, but it has never been defined in that sense.”—LFB-Labs008, para. 44)

The theme of self-reflection is especially relevant, when the process of self-reflection triggers change in some organizational process, which was the case multiple times, as mentioned by the interviewees. The self-reflective thinking was also helpful in making interviewees aware, that some work processes might well be regularly performed by those who already work there, but are not or hardly visible to outsiders. Organizations might benefit from codifying these implicit processes into a quality manual, as to reduce their opacity and make them more accessible for potential new employees.

Taking action

In addition, that process of self-reflection usually resulted in calls to (own) concrete action among the interviewees, as some of them used the insight gained from it to identify possible next steps to take in improving their laboratory.

“Und wir haben was da steht [das Leitbild auf der Internetseite] nie weiter eigentlich großartig hinterfragt. Wir sollten es vielleicht einfach mal hinschreiben.” (“And we have never really scrutinized what it says [the mission statement on the website]. Maybe we should just write it down.”—LFB-Labs005, para. 21)

“Und das habe ich mir jetzt auch für Januar vorgenommen, eben auch auf Grundlage des Qualitätshandbuchs, wie auch schon mal angekündigt, so eine Art Leitbild auch noch mal extra zu erstellen.” (“And that's what I've decided to do in January, as I've already announced, to create a kind of mission statement based on the quality manual.”—LFB-Labs008, para. 36)

The introduction of a QMS based on DIN 33459 led some SOLs to specific and concrete next steps into action, with some likely only taking place because the DIN 33459 standard required them for conformity (e.g., the existence of a mission statement).

Discussion

The pilot test we carried out as part of this study with eight school STEM SOLs and one other organization in the education sector showed that DIN 33459 provides a solid basis for the introduction of systematic QM in the field of education. Analyses of the quality manuals showed that the contents of the DIN 33459 standard could often be adopted with very few changes; most of the changes were either at indicator (detailed) level or related to specific individual wishes of the respective institution. Our multi-method approach was helpful here as the triangulation of data allowed us to validate these results using different perspectives. Not a single participant we interviewed mentioned any problems regarding the implementation of DIN 33459 into their work processes. We found that participants consistently reported less effort developing and implementing the QMS than expected beforehand, as reflected by strong skepticism and ease of introduction themes. At worst, some of the SOL employees were uncertain as to how it could be of actual use. While general prudence relating to the introduction of QM can be healthy, we argue that the rather consistent finding of skepticism regarding the whole process points to a lack of awareness when it comes to the usefulness of QM in general among educators. Across all interviews, participants mentioned several different use cases (e.g., training new staff, developing new courses, external marketing) for the QMS. As different organizations were each able to find their own useful aspects, this bodes well for the flexibility of DIN 33459. The theme of self-reflection was very common and relevant among interviewees, which is unsurprising, given the self-reflective nature of QM. Introducing a QMS usually leads to periods of intense self-reflection and awareness of organizational processes (Vettori, 2012), which might lead to new efficiencies. With some labs stepping into action as a result of the QM implementation, we see that the standard's (positive and constructive) influence on the labs was more than theoretical.

At this point, we need to mention possible unintended negative side effects of DIN 33459 and its implementation. While we did not find it to be prevalent and poignant enough as to be labelled a theme, we nevertheless found very few instances of what could be labelled as attempts to *game the system* (Baker et al., 2009). With having one's work labelled as compliant with DIN 33459 potentially being a positive in the eyes of external evaluators and potential customers, there is the incentive to try and reach conformity purely as an end in itself with minimal effort. This could potentially lead to minimizing the criteria and adapting their indicators so that they achieve the respective quality standard with minimal effort. Moreover, a training course labeled as DIN 33459 compliant, although meant as an assurance of quality, could also be perceived as boring and uninteresting, as DIN standards in any context are not necessarily seen as exciting and interesting in wider society, but more likely as dry, bureaucratic and inflexible. Lastly, what can be considered a strength, could at the same time be considered a weakness of DIN 33459—its content is often rather surface level and a QMS based on it is likely to leave a lot of space for interpretation.

Depending on the context and perspective, the scope for interpretation can therefore be interpreted as both an advantage regarding its adaptability and a challenge regarding a possible lack of commitment to the quality standards included in DIN 33459.

Despite these potential flaws, though, with DIN 33459, people and organizations in the German education sector can now fall back on a QM foundation that deals with specific teaching/learning processes and not just with general organizational or personnel processes. Furthermore, its ease of introduction and low difficulty of implementation point to a useful tool, which is unlikely to trigger large organizational resistance.

Regarding DIN 33459 implementation processes within our study, it should be taken into account, however, that the participating SOLs are managed by highly trained didactic staff, which is not necessarily the case for all educational organizations. It should also be noted that none of the SOLs already had a QMS in place before the introduction of our QMS. This means, that no remnants of an old system had to be removed, which might have otherwise led to increased organizational resistance among the staff. Additionally, all participants from the SOLs were directly involved in the same funded project as ourselves, which, even though there was no other existing relationship with them, should be taken into account when attempting to generalize results. A further limitation lies in the interpretative nature of qualitative analysis as, despite reflexivity practices, such as analysis documentation and discussions during coding and analysis, interpretation of data is always shaped by the researchers' experiences and backgrounds. As a final limiting aspect to our study, we consider the possibility of social desirability bias. This could have led to more favorable and generous answers with regard to the usefulness of the DIN 33459-based QMS. However, as mentioned, we implemented several counteracting strategies in order to minimize bias.

As the participating SOLs introduced QM at the same time as developing teacher training programs, a review of the practicability and possible perceived benefits of DIN 33459 as a QM tool for teacher training organizations is only possible afterwards and will likely be carried out towards the end of the LFB-Labs digital project. Therefore, it is important to highlight that our research is limited in so far, as only the implementation process of the standard could be examined. The follow-up effects of this implementation on, for example, the effectiveness of training or employee satisfaction are not the focus of this article, as the QMS integration had only just been finished and interviews were conducted in the immediate aftermath. Future research should focus in particular on investigating these other effects. How do employees experience work based on this particular standard? Has anything changed and if so, what? Is there a recognizable influence on the effectiveness of teacher training? Moreover, the aforementioned lack of any previous QMS within the organizations we researched poses the question, how the integration of DIN 33459 into an existing QMS would change its practicability. Nevertheless, we believe state education authorities and ministries of education and cultural affairs should take the opportunity to look at DIN 33459 in order to assess its suitability as a minimum standard for in-service teacher training across the federal states. The opportunity to establish a uniform national standard is now easier than ever before. With this article, we were able to show that the standard has the potential for this due to its particularly smooth integration into existing work processes of educational organizations and that it represents a decent anchor for the implementation of a QMS for

educational organizations. The next few years will show whether DIN 33459 will end up a paper tiger or whether it can become more widespread and possibly establish itself as a relevant (minimum) standard for teacher training.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the studies involving humans because the TU Dresden ethics committee does not require action if no personal reference can be established with regard to the data used (which is the case with the anonymized interview data). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

JB: Methodology, Data curation, Validation, Conceptualization, Writing – original draft, Investigation, Software, Formal analysis, Writing – review & editing. RK: Writing – review & editing, Supervision, Funding acquisition, Resources, Validation, Project administration.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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