Evaluating visible learning: Mathematics teachers’ practices in technology-enhanced classrooms

Ahlam Mohammed Al-Abdullatif and Maha Saad Alsaeed

Abstract: The present study examined the extent to which mathematics teachers’ practices reflect visible learning (VL) at their schools and in their technology-enhanced classrooms. A number of determining factors influencing mathematics teachers to practice VL were also investigated. The Visible Learning Scale (VLS) instrument was conceptually developed based on Hattie’s eight mind frames of VL. The survey results from 119 participants indicated that Saudi mathematics teachers expressed a moderate to great level of evidence-based VL practice to enhance and promote students’ learning achievements and progress. The results also showed that the competence level of information and communication technology (ICT) integration is a determining and influential factor that enhances the practices teachers undertake to achieve a better effect on their students’ learning progress. The findings of this study were interpreted in light of the current educational context of mathematics teaching and technology integration in Saudi Arabia’s

ABOUT THE AUTHORS

Ahlam Mohammed Al-Abdullatif is an assistant professor in Educational Technology Department at King Faisal University, Saudi Arabia. She is an active professor and researcher. She is a member of the International Society for Technology in Education (ISTE). Al-Abdullatif’s research interest is in the area of eLearning particularly on how Information and Communication Technology (ICT) enhances teaching and learning practices. Currently, she is engaging in a number of research projects that are investigating the quality of teachers’ knowledge and competences when using technologies in classrooms.

Maha Saad Alsaeed is an assistant professor in Mathematics Education at King Faisal University, Saudi Arabia. Her research interest lies on the interaction of mathematics, education, technology, and professional development. Her recent administration activity involves the advancement of pre-service teaching practices. Currently, Alsaeed engaged in various research projects that are exploring the advancement of teaching mathematics through STEM education.

PUBLIC INTEREST STATEMENT

This research investigates Saudi mathematics teachers’ practices towards visible learning (VL) within technology-enhanced classrooms. VL is a conceptual framework by John Hattie (2012) that emphasizes the impact of teachers on students’ learning through various evidence-based practices. The 119 in-service mathematics teacher participants were selected randomly from different gender, age group, teaching level and years of teaching experience. Data indicate that Saudi mathematics teachers have an average level of practicing VL to enhance and promote students’ learning achievements and progress. Technology competence level is highlighted, in this research, as a determining and influential factor that enhances teachers’ practices to achieve a better impact on their students’ learning. This research highlights the importance of supporting teachers to understand the power of their impact on students’ learning. Pre-service and in-service teachers’ programs should be strengthened by VL framework in order to create a culture of teaching practices that is evidence-based.
education system, and their implications for researchers, teacher educators and policymakers were discussed.

**Subjects:** Mathematics Education; Educational Technology; Teaching & Learning - Education; Education Studies

**Keywords:** ICT integration; mathematics classrooms; technology-enhanced; technology integration; visible learning

1. Introduction

Saudi Vision 2030, a blueprint for reform, is about transforming the Saudi economy away from an overreliance on oil incomes to a more balanced and multi-sourced, investment-based model. This ambitious vision requires revolutionizing goals in several sectors of the Kingdom of Saudi Arabia, including the educational sector. Through Vision 2030, educators and policymakers are anticipated to participate by reconstructing the educational system to focus on workforce skills, stimulate creativity and highlight children’s characters and talents. Accordingly, the Saudi teaching standards addressing this vision currently mandate a high-quality agenda for Saudi teachers from all educational levels to possess essential competences, such as strong language and number skills, knowledge about students’ characteristics and how they truly achieve authentic and lifelong learning, knowledge about their area of expertise and how it is taught and knowledge about integrating information and communication technology (ICT) to effectively enhance and transform the quality of teaching and learning (Education and Training Evaluation Commission, 2018).

In the realm of education, there is a tremendous amount of research advocating methods and tools that influence student learning. The focus on learners and their success, inculcating skills, personality development, improving confidence and promoting creativity requires educators and policymakers to be aware of changes that are occurring, thereby shifting to more impact-based processes. The focus on teachers’ influence on their students’ learning achievements and progress was introduced and well studied by John Hattie (2012) through his notion of visible learning (VL). As discussed in Hattie’s research, VL is a specific mind frame for teachers that underpins their everyday actions and decision making in schools when they see learning as the ultimate and transparent goal, continually question themselves about the effect they have on student learning and value formative feedback on learning as a significant element of their everyday practice (Hattie, 2012; Hattie, Fisher, & Frey, 2017; Hattie & Yates, 2014).

How teachers perceive VL is crucial in Saudi classrooms, given the reform settings that Saudi teachers are currently facing. Especially, Vision 2030 is pushing technology as a key enabler and driver of future Saudi transformation (Forbes, 2018). Consequently, there is a considerable focus on teachers’ technological competences, as well as an increased demand to integrate ICT into Saudi classrooms. In this regard, technological integration in teaching practices has increasingly become an imperative element of our school system in the Kingdom, as well as in many educational societies around the world (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012). In terms of teaching in a mathematics context, there are various specialized ICT software applications that mathematics teachers can utilize for enhancing their teaching and promoting improved student learning (Isman, Abanmy, Hussein, & Al Saadany, 2012). However, the related literature has shown a low level of ICT integration in mathematics teaching that would support students’ achievements and promote their learning and progress (Alshehri, 2012; Dick & Hollebrands, 2011). According to National Council of Teachers of Mathematics’s position statement (2018), professional development must continually support teachers, equipping them with knowledge of the technology used in mathematics classrooms. Teachers need to have access to relevant materials, such as lesson plans for technology-rich environments, that support and guide student learning. The National Council of Teachers of Mathematics’s position statement (2018) highlights the importance of the strategic use of technology when the focus is not on the technology proper but on how to learn mathematics through the integration of advanced tools. Curriculum
developers and teacher training programmes must have the power to aid practitioners in using technology strategically aimed at powerful student engagement and learning (Young, 2017).

In terms of the current initiation of educational reform in Saudi Arabia and the new teaching and learning standards, mathematics teachers are faced with challenges to shift their thinking and decisions to achieve better and high quality, evidence-based teaching and learning practices in a more technology-enhanced learning environment. Therefore, this study examines Saudi mathematics teachers’ evidence-based practices to integrate VL at their schools and inside their technology-enhanced classrooms. This study is conceptually guided and underpinned by Hattie’s eight mined frames of VL (Hattie, 2012). The conceptual framework of the current study is discussed in the subsequent sections.

2. Significance and aim of the study
Teacher quality is a critical factor in achieving quality learning outcomes for students. However, the quality of an education system cannot exceed the quality of its teachers (Barber & Mourshed, 2007). The Ministry of Education has launched the Future Gate Programme to facilitate the evolution towards digital education. Students and teachers (the core of the educational process) have been the focus of the Ministry in creating a new learning environment based on technology that strengthens the delivery of content knowledge to students and equips teachers with the necessary content and pedagogy. Technology integration has been a critical research topic in teacher education for over 30 years (Ertmer et al., 2012). The current study aims at examining the level of mathematics teachers’ evidence-based practices to incorporate VL at their schools and inside their technology-enhanced classrooms. A descriptive survey approach was used in this research study. The aim of descriptive surveys is acquiring information from one or more groups of people about their characteristics, opinions, attitudes, self-reported beliefs or behaviours (Leedy & Ormrod, 2005; Neuman, 2006). Therefore, the guiding research question of this study is as follows: To what extent are mathematics teachers practicing evidence-based VL at their schools and in their technologically enhanced classrooms? The study also investigates the relationship between the competence level of ICT integration and VL practices in mathematics classrooms, as well as the relationship between several demographic characteristics, such as gender, school type, teaching level, teaching experience and VL practices. The results of this study provide insights for Saudi educators and policymakers on the level of evidence-based VL practices adopted by mathematics teachers, an essential component of their professional teaching and learning in the 21st century. Drawing on these results, the study highlights future perspectives and recommendations for the Ministry of Education related to the quality of the agenda of teachers in Saudi Arabia.

3. Conceptual framework of the study
VL is not a new method of teaching or a new educational philosophy; nevertheless, it represents a shift in teachers’ thinking and decision making. The VL framework assists teachers in continually questioning and evaluating the influence they have on their students’ learning by gathering various pieces of evidence about how their students interact and achieve in the classroom environment. According to Hattie’s research, VL can be achieved when teachers become active learners and listeners of their teaching and when students develop self-learning attributes as they become their own teachers (Hattie, 2012; Hattie et al., 2017; Hattie & Yates, 2014). Hattie studied more than 800 meta-analyses of about 50 000 research articles and 150 effect sizes. He published a list of influences on achievement and the effect size of many variables that can affect learning and focused on the variables that have a greater influence on student learning. Generally, according to Hattie’s research findings, there are multiple evidence-based practices related to teachers that affect student learning, such as the power of the teacher as a challenger and evaluator of his or her influence on students, feedback seeker, class discourse promoter, collaborative planner and someone with positive and high expectations. These practices address Hattie’s VL notion (Hattie, 2012).

“Challenge” is a term that is always associated with setting higher expectations for students’ achievements, accepting their errors, and valuing their thinking by pushing rigorous concepts to be learned in the lessons. The term “challenge” was introduced in Hattie’s teacher mind frames.
(Hattie, 2012) to conceptualize the passion and persistence that teachers must possess regarding their students at all levels of learning. Engaging students in demanding cognitive activities and non-routine problem-solving situations that allow for challenges in the classroom is one of the main trending issues in teaching mathematics (Boston & Smith, 2009; Doyle, 1988; Hattie et al., 2017; Stein, Smith, Henningsen, & Silver, 2009). However, such challenges may not work well with students at all instruction levels. In her study, Alsaeed (2012) claimed that mathematics teachers in Saudi Arabia tend to overprotect their students by avoiding struggles while working on complex problems, misunderstanding that such challenges may empower and deepen their mathematics learning. According to Stein et al. (2009), a mathematical task must sustain its challenge in every part of the lesson to be termed a demanding cognitive task. Whether teachers are using the most advanced technology or providing students with a modern teaching method, what matters most is the level of challenge offered to students at all levels of instruction. Challenging students requires awareness, a specific mind frame, experience and knowledge (Boston & Smith, 2009; Hattie, 2012; Saudi Ministry of Education. Saudi standards, 2018). At present, teachers are required to improve their knowledge of teaching mathematics to engage students in demanding cognitive tasks (Charalambous, 2010; Ottmar, Rimm-Kaufman, Larsen, & Berry, 2015).

One of the clear messages of Hattie’s research is the emphasis on making learning visible by focussing on influences that can be evidence-based. Feedback is among the top influences that has a greater effect on students’ achievements, with an effect size of 0.75 (Hattie, 2012). According to the Australian Institute For Teaching And School Leadership (2017), effective feedback should define goals that are conveyed clearly to students, explicitly highlighting the positive elements of their performances and including practical criticism for how to improve incorrect task performances. In addition, for feedback to affect student learning, it must be presented at all stages of classroom teaching at the four following levels: learning tasks, the process of learning, students’ self-planning and self-mentoring and the personal potential (self-regulation) revealed by students.

The role of classroom discourse in teaching mathematics is one of the major requirements known to foster student learning. It is one of the influences with a significantly high effect size in mathematics learning, at 0.82 (Hattie et al., 2017). Rich classroom discourse requires a significant level of teacher knowledge and understanding regarding students’ responses, thinking and misconceptions, as well as the content (Alsaeed, 2012; Boston & Smith, 2009; Feiman-Nemser, 2001). In addition, teachers must be able to orchestrate a productive classroom discourse that admits errors, represents a variety of student solutions and ideas and facilitates a productive struggle among students that constitutes the path to solutions (Hattie et al., 2017; Smith & Stein, 2011). In their research, Smith and Stein (2011) identified five practices that can develop rich classroom dialogues. These practices include anticipating students’ solutions, monitoring students’ real responses to the tasks, selecting certain students to present their thinking, sequencing responses and questioning and connecting different responses. Such teaching practices give teachers a systematic approach to continually questioning the value of their teaching through the planning, enacting and assessment phases of instruction and evaluating the learning process.

Several researchers have shown that teachers’ expectations for students can positively and negatively affect students’ achievements (Rubie-Davies, 2014; Weinstein, 2002; Zohar, Degani, & Vaaknin, 2001). Rubie-Davies (2014) identified the key characteristics of teachers who have high expectations of their students: They do not group their students by ability to engage in core subjects; their class climate is more positive than that of other teachers; they manage behaviour positively and create a cohesive class environment where high levels of teacher care are evident along with goal setting; they use assessment information to regularly set goals with students; monitor students’ progress frequently and provide ongoing feedback to students; they consider students’ interests when planning activities; and they give students some autonomy in selecting learning activities. Educators and policymakers should consider the improvement of teachers’ attitudes and beliefs to facilitate a focus on students’ potentials and abilities, while at the same time, acknowledging their biases (Rubie-Davies, Hattie, & Hamilton, 2006).
There is no doubt that the quality of teaching is among the most important factors that affect students’ achievements in all educational contexts (Akiba, LeTendre, & Scribner, 2007; Feiman-Nemser, 2001; Hattie, 2012; Hattie et al., 2017; Hattie & Yates, 2014; U.S. Department of Education, 2010). To achieve the best of Saudi Vision 2030’s ambitious goals, educators at all levels, teachers, principals, education leaders and decision makers must target evidence-based practices in our school system that directly aim at learning achievements (U.S. Department of Education, 2010), as Hattie’s VL notion suggested (Hattie, 2012). Therefore, the current study adopts Hattie’s eight mind frames, which he introduces in his VL framework, to show the level of teachers’ VL practices at their schools and inside their classrooms. The eight mind frames that support VL practices describe teachers as evaluators and activators, change agents, seekers of feedback and practitioners who talk more about learning than teaching, use dialogue more than monologue, enjoy challenges more than doing the best, develop positive relationships and are passionate and promote the language of learning. For the purpose of this study, a survey instrument was conceptually constructed based on these eight mind frames, as discussed in the next section (Hattie, 2012).

4. Method

4.1. Instrument

The survey instrument that was used in this study is the Visible Learning Scale (VLS). This scale instrument was developed for the purpose of the current study to measure the mathematics teacher participants’ evidence-based practices to incorporate VL at their schools and in their technology-enhanced classrooms. The instrument consists of two sections, starting with eliciting general demographic information regarding gender, school type, teaching level and teaching experiences. This section also asks respondents about their real use of certain ICT applications in their classrooms. Here, the participants were asked to rate their competence in relation to their level of ICT integration in teaching and learning on a 4-point Likert scale with items ranging from “no competence” to “very competent”. The criterion indicating participants’ competencies was as following; “no competence” represents participants with no actual use of any ICT applications in their teaching, “some competence” represents participants with basic use of one to three ICT applications, “competence” represents participants with moderate use of four to five ICT applications, and “very competent” represents participants with advanced use of six and more of ICT applications.

The extent to which participants utilize evidence-based VL practices at their schools and in their technology-enhanced classrooms was surveyed in the second section using the VLS instrument. The VLS instrument was conceptually developed and underpinned by Hattie’s eight mind frames (Hattie, 2012). The VLS comprises 44 statement items derived from the eight mind frames to address the purpose of this study. All 44 statements asked the participants to indicate the extent to which they practice VL at their schools and in their technology-enhanced classrooms on a 5-point Likert scale, with items ranging from “not at all” to “to a very great extent”. The validity and reliability of the VLS are discussed in the next section.

4.2. Validity

For investigating the validity of the VLS, factor analysis using principal component analysis with a varimax rotation (SPSS 23) was conducted on the 44 items of the scale. As initial extraction yielded eleven factors, a fixed number of factors were selected to extract five factors of the scale items. A number of five factors was determined due to the nature of the scale items and its purpose in measuring VL practices. The analysis yielded a simple and conceptually robust five-factor solution explaining a total of 55.848% of the variance for the entire set of scale items, accounting for a high amount of the variance shown by these factors (Table 1). In regards to determining the scale items’ loadings, Field (2013) stated that “a loading of .4 is substantial, but so we do not throw out the baby with the bath water, setting the value to 0.3 is sensible: we will see not only the substantial loadings but those close to the cut-off (e.g., a loading of .39)” (p. 692). Therefore, in this study, all items with loadings less than 0.3 were requested to be suppressed in
Table 1. Items with varimax rotated factor loadings and reliability coefficients for the visible learning instrument (N = 119)

| Items                                                                 | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 |
|----------------------------------------------------------------------|----------|----------|----------|----------|----------|
| 1.1 Explicit learning objectives and success criteria                | .447     |          |          |          |          |
| 1.2 Classroom’s climate and level of trust                           | .485     |          |          |          |          |
| 1.3 Dialogue and monologue about learning                            | .435     |          |          |          |          |
| 1.4 Continuum level of actual learning                               | .526     |          |          |          |          |
| 1.5 “Backward design” plan and success criteria                      | .593     |          |          |          |          |
| 1.6 Providing constructive feedback                                   | .717     |          |          |          |          |
| 1.7 Student praise vs feedback                                       | .757     |          |          |          |          |
| 1.8 Various assessment methods for enhancing learning                 | .580     |          |          |          |          |
| 1.9 Students receive and interpret feedback                           | .729     |          |          |          |          |
| 1.10 Feedback about learning progress vs corrective feedback          | .749     |          |          |          |          |
| 1.11 Students ask for, understand and use feedback                    | .709     |          |          |          |          |
| 1.12 Peer feedback                                                    | .598     |          |          |          |          |
| 1.13 Effect of teachers’ work on their students                      | .561     |          |          |          |          |
| 2.1 Passionate and inspired                                          | .482     |          |          |          |          |
| 2.2 Professional development programme and subjects’ deep understanding | .745     |          |          |          |          |
| 2.3 Professional development programme and teacher–student interaction | .789     |          |          |          |          |
| 2.4 Professional development programme and providing useful feedback  | .776     |          |          |          |          |
| 2.5 Professional development programme and students’ effective attributes | .754     |          |          |          |          |
| 2.6 Professional development programme and students’ surface and deep learning | .751     |          |          |          |          |
| 2.7 Professional development programme and monitoring students’ progress | .560     |          |          |          |          |
| 3.1 Critiquing learning objectives/success criteria and students’ achievements | .643     |          |          |          |          |
| 3.2 Critiquing learning objectives/success criteria and planning new lessons | .668     |          |          |          |          |
| 3.3 Evaluating the effect of teachers’ work on students’ achievements | .515     |          |          |          |          |
| 3.4 Teachers as change agents                                         | .470     |          |          |          |          |
| 3.5 Talking about learning more than teaching                         | .692     |          |          |          |          |
| 3.6 Assessment reflecting teachers’ influence                         | .642     |          |          |          |          |
| 3.7 Challenge rather than doing the best                              | .610     |          |          |          |          |
| 3.8 Positive relationships in classrooms/staffrooms                   | .588     |          |          |          |          |
| 3.9 Inform everyone about the language of learning                    | .445     |          |          |          |          |

(Continued)
the analysis output. Items 4.8 and 5.4 were also retained due to their importance in measuring the purpose of this study.

Factor 1 was labelled Feedback due to the high loadings by 13 items. This first factor explained 16.967% of the variance, and the eigenvalue was 7.46. This factor means that teachers, with all practices, placed a greater value on providing, receiving and interpreting feedback in terms of learning objectives and success criteria for maximizing their influence on students’ learning and progress. The second derived factor was labelled Professional Development. This factor consisted of seven items that explained 11.838% of the variance, and the eigenvalue was 5.21. This factor represented all the in-service training programmes that teachers engaged in for the purpose of enhancing and transforming their everyday practices to evaluate their influence on students’ learning and progress. The third factor consisted of nine items and was labelled Evaluation and Challenge. This factor indicated that teachers enjoy the challenge of collaboratively critiquing and analysing their practices, as well as engaging in a continuum evaluation process for maximizing students’ learning and progress. The variance explained by this factor was 10.487%, and the eigenvalue was 4.61. Eight items were loaded under the fourth factor, labelled Planning and Discourse Promotion, which had a value of 48.444 of the squared loadings and explained 9.152% of the variance with an eigenvalue of 4.02. This factor emphasized setting learning intentions in response to teachers’ expected influence on student learning, as well as enacting a friendly and welcoming classroom environment that would encourage student discussions of solutions and
admissions of their errors. The final and fifth factor, Student Expectations, comprised seven items. It explained 7.403% of the variance, and the eigenvalue was 3.25. This factor represented teachers’ self-perceptions about their students’ attributes and their investments in students as a positive factor in the learning process.

Sample adequacy was measured using the Kaiser–Meyer–Olkin (KMO) test and Bartlett’s test of sphericity (Table 2). Both tests indicated that the sample size and data set were adequate for factor analysis; the KMO (.870) measure was a high value close to the correct one, values in the 80s is considered “Meritorious” according to Hutcheson and Sofroniou (1999). Bartlett’s test was also significant (p < .001), indicating that all variables are correlated significantly different than zeroes. Therefore, scale items were verified for factor analysis that should yield distinct and reliable factors (Field, 2013). Substantively, this means that we could identify five clear and patterns of response among the participants, as follows: Feedback, Professional Development, Evaluation and Challenge, Planning and Discourse Promotion and Student Expectation. These five tendencies are independent of one another.

Table 3 illustrates the intersections between each of the VLS factors and Hattie’s eight mind frames (Hattie, 2012). It shows that all 44 statement items of the VLS were formulated for addressing several practices under the eight mind frames.

4.3. Reliability
The reliability of the VLS was calculated using Cronbach’s alpha, as shown in Table 4. It is noted in the table that all the stability coefficients in the Cronbach’s alpha method were high, at 0.955 for the total score, indicating the high reliability of the VLS.

For measuring the internal consistency of the VLS factors, a Pearson correlation was conducted to calculate the correlation coefficients between the items of each VLS factor and the total sum of the items of the same factor (Table 5). The results showed that all the correlation coefficients between the factor items and total score of the factor to which they belonged were acceptable at the levels of p < 0.01 and p < 0.05, with the following ranges: 0.60–0.79 for Feedback; 0.64–0.86 for Professional Development; 0.53–0.80 for Evaluation and Challenge; 0.63–0.75 for Planning and Discourse Promotion; and finally, 0.50–0.73 for Student Expectations. These findings indicate that the measure is characterized by very high internal consistency; that is, all its items are in line with its goal of measuring VL practices. Internal consistency was also calculated by measuring the correlation coefficients between the degrees of each factor of the VLS and the total sum of the VLS factors (Table 5).

Table 6 illustrates that the correlation coefficients between each factor and the total score of the VLS functioned at the 0.01 level, which is a significant indicator of the scale’s validity. Moreover, it shows that the scale measures one structure of VL competences and practices.

4.4. Participants and procedure
A total of 119 in-service mathematics teachers voluntarily participated in this study. Participants were selected randomly through approaching the Coordinating Research Office (CRO) in the Ministry of Education in Eastern Province, Saudi Arabia. The CRO is the responsible office for

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**Table 2. KMO and Bartlett’s test of sampling adequacy**

| KMO Measure of Sampling Adequacy | .870 |
|----------------------------------|------|
| Bartlett’s Test of Sphericity    |      |
| Chi-square                       | 3584.793 |
| df                               | 946 |
| Sig.                             | .000 |
selecting in-service mathematics teacher participants from different characteristics including: gender, age group, teaching level and years of teaching experiences. As a result, the participants were Saudi men and women from both the private and public education sectors, representing a variety of teaching levels (elementary, intermediate and secondary level); they had differing amounts of teaching experience, ranging from less than 5 years to more than 10 years of experience.

The data were collected by the end of the 2017/2018 academic year, and ethical approval was obtained from the Research Ethical Committee of the university where the authors work. The VLS survey was electronically distributed to 119 in-service mathematics teachers via emails sent to their school principals by CRO. The data were collected from the participants anonymously by self-assessing themselves using the VLS scale. The authors’ identities and backgrounds were revealed in the cover letter, which was attached to the survey. The participants’ agreement to submit their responses to the survey was determined by informed consent. The cover letter emphasized the privacy and confidentiality of participation in the research study. Moreover, it indicated that the research would be beneficial for the participants, as the results of this study will contribute to the

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**Table 3. Intersections between the five factors of the VLS in Hattie’s (2012) eight mind frames**

| Hattie’s Eight Mind Frames                                                                 | VLS Factors                              |
|-------------------------------------------------------------------------------------------|-------------------------------------------|
|                                                                                           | Factor 1: Feedback | Factor 2: Professional Development | Factor 3: Evaluation and Challenge | Factor 4: Planning and Discourse Promotion | Factor 5: Student Expectations |
| 1. Evaluate effect                                                                        | X                          | X                                      | X                                        | X                                         |                              |
| 2. Change agents                                                                          | X                          | X                                      | X                                        | X                                         |                              |
| 3. Talk more about learning than teaching                                                 | X                          | X                                      | X                                        | X                                         |                              |
| 4. Feedback seeking                                                                      | X                          | X                                      | X                                        | X                                         |                              |
| 5. Dialogue more than monologue                                                          | X                          | X                                      | X                                        | X                                         |                              |
| 6. Challenge more than doing the best                                                     | X                          | X                                      | X                                        | X                                         |                              |
| 7. Developing positive relationships                                                      | X                          | X                                      | X                                        | X                                         |                              |
| 8. Passionate and promoting the language of learning                                     | X                          | X                                      | X                                        | X                                         |                              |

**Table 4. VLS Reliability Using Cronbach’s Alpha**

| Factor                               | Cronbach’s Alpha |
|--------------------------------------|------------------|
| Factor 1: Feedback                   | .918             |
| Factor 2: Professional Development   | .897             |
| Factor 3: Evaluation and Challenge   | .864             |
| Factor 4: Planning and Discourse Promotion | .858         |
| Factor 5: Student Expectations       | .737             |
| Total Sum                            | .955             |
successful technological integration of mathematics teaching and learning for enhancing VL practices in the Saudi educational context. Furthermore, the cover letter emphasized that there was no risk associated with participation in this study and that participation would be entirely

### Table 5. Correlation coefficients between the items and total score of each VLS factor

| Factor 1 | t | Factor 2 | t | Factor 3 | t | Factor 4 | T | Factor 5 | t |
|----------|---|----------|---|----------|---|----------|---|----------|---|
| Item 1.1 | **.602 | Item 2.1 | **.643 | Item 3.1 | **.694 | Item 4.1 | **.749 | Item 5.1 | **.512 |
| .000 | .000 | .000 | .000 | .000 | .000 |
| Item 1.2 | **.622 | Item 2.2 | **.860 | Item 3.2 | **.724 | Item 4.2 | **.635 | Item 5.2 | **.657 |
| .000 | .000 | .000 | .000 | .000 | .000 |
| Item 1.3 | **.624 | Item 2.3 | **.823 | Item 3.3 | **.609 | Item 4.3 | **.744 | Item 5.3 | **.705 |
| .000 | .000 | .000 | .000 | .000 | .000 |
| Item 1.4 | **.679 | Item 2.4 | **.836 | Item 3.4 | **.538 | Item 4.4 | **.731 | Item 5.4 | **.506 |
| .000 | .000 | .000 | .000 | .000 | .000 |
| Item 1.5 | **.672 | Item 2.5 | **.804 | Item 3.5 | **.773 | Item 4.5 | **.724 | Item 5.5 | **.561 |
| .000 | .000 | .000 | .000 | .000 | .000 |
| Item 1.6 | **.766 | Item 2.6 | **.799 | Item 3.6 | **.700 | Item 4.6 | **.710 | Item 5.6 | **.685 |
| .000 | .000 | .000 | .000 | .000 | .000 |
| Item 1.7 | **.756 | Item 2.7 | **.722 | Item 3.7 | **.719 | Item 4.7 | **.711 | Item 5.7 | **.729 |
| .000 | .000 | .000 | .000 | .000 | .000 |
| Item 1.8 | **.749 | Item 3.8 | **.803 | Item 4.8 | **.690 |
| .000 | .000 | .000 | .000 |
| Item 1.9 | **.788 | Item 3.9 | **.685 |
| .000 | .000 | .000 |
| Item 1.10 | **.754 |
| .000 |
| Item 1.11 | **.788 |
| .000 |
| Item 1.12 | **.718 |
| .000 |
| Item 1.13 | **.741 |
| .000 |

**Correlation is significant at the 0.01 level (2-tailed).

### Table 6. Correlation coefficients between each factor of the VLS and the total VLS score

| Factors | Sum |
|---------|-----|
| Factor 1: Feedback | .892** |
| .000 |
| Factor 2: Professional Development | .775** |
| .000 |
| Factor 3: Evaluation and Challenge | .809** |
| .000 |
| Factor 4: Planning and Discourse Promotion | .876** |
| .000 |
| Factor 5: Student Expectations | .759** |
| .000 |

**Correlation is significant at the 0.01 level (2-tailed).
voluntary, confidential and anonymous. Finally, it clearly stated that the participants had the right to refuse to participate or terminate their involvement at any time.

4.5. Data analysis

Data were analysed using SPSS V23. Several statistical methods of analysis were used in this study. Descriptive statistics, such as frequencies and percentages, were used for describing the participants’ demographic characteristics (gender, school type, teaching level and teaching experience), ICT software application usage and level of technology integration competence in teaching and learning mathematics. Means, standard deviations (SDs) and standard errors were used for describing how the participants perceived themselves in practicing VL at their schools and in technology-enhanced classrooms (the 44 VLS statement items), as well as the five VLS factors. One-way analysis of variance (ANOVA) was used for investigating the differences between the participants’ demographic characteristics and their competence level with ICT integration in teaching and learning practices. A comparison of means (with SDs) for the participants’ demographic characteristics and level of ICT integration of the five VLS factors were also performed. Multivariate analysis using the multivariate MANOVA test was performed to detect the statistical differences in the participants’ demographic characteristics and level of ICT integration competence in relation to the five VLS factors.

5. Results and discussion

5.1. The relationships between gender, school type, teaching level, teaching experience and the level of ICT integration

The participants in this study were 119 in-service mathematics teachers. Table 7 lists their demographic characteristics in terms of gender, school type, teaching level, years of teaching experience and competence integrating ICT in classrooms for teaching and learning. As shown in the table, 67.2% of the in-service mathematics teachers surveyed were women and 85% worked in public schools. The participants represented different teaching levels, but most (41.2%) taught K–6 and more than half had over 10 years of teaching experience.

Table 7 indicates how generally competent the participants were at integrating ICT into their classrooms for teaching and learning. Through self-assessment, none of the participants indicated having no competence at all, while most (67%) indicated some competence in integrating ICT in their teaching and learning. However, around 33% of the participants were either competent or very competent in integrating ICT for teaching and learning, which is a comparatively small percentage. This conclusion is supported by Figure 1, which illustrates the percentages of participants who indicated using various ICT software applications in their mathematics classrooms. As shown in the figure, presentation software (76.5%) and interactive smartboards (48.7%) were the ICT applications used most often by the participants. These applications are considered to be basic. The participants showed a lower percentage level, ranging from 51% to 94%, that indicated no use at all of advanced applications, such as apps, multimedia, virtual labs, animation, GeoGebra and mathematics, graphing calculators, augmented reality, blogs and learning management systems. All these applications are considered to be valuable resources for future mathematics teaching and learning.

The limited use of advanced ICT software applications could be explained by the scarcity of related professional development programmes in which mathematics teachers are engaged. The extremely low percentage of mathematics teacher participants using specialized advanced and essential ICT software applications poses a major concern that may affect the quality of their future teaching. Engaging students with the rich mathematics learning environment facilitated by advanced ICT tools allows for the effective and strategic use of technology to support teachers in developing non-routine problems, simulations for conceptual understanding and lesson plans that promote higher order thinking (National Council of Teachers of Mathematics, 2018; Young, 2017).
Table 7. Demographic information on mathematics teacher participants (N = 119)

|                                | Number | %  |
|--------------------------------|--------|----|
| **Gender**                     |        |    |
| Male                           | 39     | 32.8 |
| Female                         | 80     | 67.2 |
| Total                          | 119    | 100 |
| **School Type**                |        |    |
| Public                         | 102    | 85.7 |
| Private                        | 17     | 14.3 |
| Total                          | 119    | 100 |
| **Teaching Level**             |        |    |
| K–6                            | 49     | 41.2 |
| Middle school                  | 34     | 28.6 |
| High school                    | 36     | 30.3 |
| Total                          | 119    | 100 |
| **Years of Teaching Experience**|      |    |
| Less than 5 years              | 18     | 15.1 |
| 5–10 years                     | 33     | 27.7 |
| More than 10 years             | 68     | 57.1 |
| Total                          | 119    | 100 |
| **Level of ICT Integration**   |        |    |
| No competence                  | 0      | 0   |
| Some competence                | 80     | 67.2 |
| Competent                      | 33     | 27.7 |
| Very competent                 | 6      | 5.0 |
| Total                          | 119    | 100 |

Figure 1. Frequency of mathematics teacher participants’ use of ICT software applications (N = 119).

Table 8 describes the participants’ level of competence in using ICT with students for teaching and learning in relation to the demographic characteristics of gender, school type, teaching level and years of teaching experience. One-way ANOVAs were conducted for investigating the relationship between the participants’ demographic characteristics and their competence level with ICT integration.
Table 8. Relationships between mathematics teachers' gender, school type, teaching level, teaching experience and level of ICT integration (N = 119)

|                      | % No competence | % Some competence | % Competent | % Very competent | F    | df | Sig. |
|----------------------|-----------------|-------------------|-------------|-----------------|------|----|------|
| **Gender**           |                 |                   |             |                 |      |    |      |
| Male                 | 0               | 29                | 10          | 0               | 2.619|    | 0.112|
| Female               | 0               | 51                | 23          | 6               |      |    |      |
| **School Type**      |                 |                   |             |                 |      |    |      |
| Public               | 0               | 73                | 23          | 6               | 2.571|    | 0.108|
| Private              | 0               | 7                 | 10          | 0               |      |    |      |
| **Teaching Level**   |                 |                   |             |                 |      |    |      |
| K–6                  | 0               | 35                | 13          | 1               | 1.735|    | 0.181|
| Middle school        | 0               | 24                | 9           | 1               |      |    |      |
| High school          | 0               | 21                | 11          | 4               |      |    |      |
| **Years of Teaching Experience** |            |                   |             |                 |      |    |      |
| Less than 5 years    | 0               | 15                | 3           | 0               | 1.445|    | 0.240|
| 5–10 years           | 0               | 22                | 9           | 2               |      |    |      |
| More than 10 years   | 0               | 43                | 21          | 4               |      |    |      |

*Indicates significance at p < .05
As shown in Table 8, the results indicated no statistically significant differences between the participants’ different groups of gender, school type, teaching level and years of teaching experience in relation to their level of competence in ICT integration ($p > .05$). This means that none of the participants’ characteristics were an indicating factor in their perceived competence at integrating ICT into their mathematics classrooms.

5.2. Visible learning practices in mathematics technology-enhanced classrooms

In this study, to measure how well and to what extent mathematics teachers practiced VL in their technology-enhanced classrooms and their school environments, the participants were asked to rate their responses to 44 statement items, which were then rated on a 5-point Likert scale, as follows: $1 = $ Not at all, $2 = To some extent, $3 = To a moderate extent, $4 = To a great extent and $5 = To a very great extent. This process helped in identifying how participants felt about practicing VL to support their students’ achievements and learning progress. Table 9 lists the means (with SDs) for each of these 44 statements, as well as the percentages of participants who perceived themselves as having no or a limited level of VL practice to support effective teaching and learning in their mathematics classrooms.

The results in Table 9 mostly indicate that the Saudi mathematics teacher participants expressed a moderate to great level of VL practice ($3.5 < \text{mean} < 4$) at their schools and in their classrooms for supporting the quality of student learning, as well as enhancing the quality of their teaching. This relatively high level of practice pertained to most of the VLS examples, while a slightly lower level of practice ($3 < \text{mean} < 3.5$) was expressed by the participants for some of the VLS examples, such as items 2.4, 2.7, 3.5, 3.7, 5.3 and 5.4 in the instrument. Moreover, 10% to 21% of the participants rated themselves as having limited or no practice at all engaging in professional development activities that enhance teachers’ deep understanding of their subjects (11.8%), support learning by analysing teacher–student classroom interactions (10.9%), support teachers in providing useful feedback (13.5%) and help teachers address their students’ effective attributes (14.3%). Likewise, more than 10% of the participants expressed limited or no practice at all with other VLS examples, such as clearly explaining and clarifying the lessons’ learning objectives and success criteria for their students (11.4%); providing a fair climate in their classrooms, where students trust their teachers to learn and make progress (10.1%); using backward design in planning lessons or moving from the learning outcomes to learning goals and then to the activities and resources (11.8%); engaging in staffrooms and classrooms that featured more dialogues than monologues (10%); collaborating in critiquing learning objectives and success criteria, and accordingly, providing evidence of their use of information in encouraging students’ achievements (10.9%) and planning new lessons (12.6%); believing that assessments reflected their effect as teachers on their students’ achievements (12.8%); enjoying challenges rather than doing their best (10.9%); being interested in informing everyone about the language of learning (15.9%); collaborating on writing lesson plans (12.6%); using the power of peers to achieve progress in learning (12.6%); affording students the space to ask questions more than teachers (21%); rarely labelling students in classrooms (16%); evaluating teaching methods in light of their effect on students (10.1%); and lastly, viewing learning from the perspective of their students (10%).

The results indicate a level of awareness among teacher participants regarding the need to undertake classroom practices that are visible and have a strong effect on student learning and progress. The teachers’ self-ratings may represent a response to new reform action in the Kingdom. Teachers need to develop in the area of understanding their students’ progress and deepen their knowledge of the subject matter and teaching practices. Such knowledge cannot be taught at the college level, but it may well be learned through the evolving interaction of reforms, interactions with students and application-based professional programmes (Feiman-Nemser, 2001).

The first 13 items in Table 9 comprise the feedback factor ($m = 3.7$) of the instrument. The next seven items comprise the professional development factor ($m = 3.5$). The following nine items comprise the evaluation and challenge factor ($m = 3.5$). The next eight items comprise the planning and discourse promotion factor ($m = 3.6$). Finally, the last seven items comprise the
Table 9. Perceived VL practices—descriptive statistics of means and SDs of all 44 VLS items (N = 119)

| VLS Items                                                                 | Mean (SD) | % Not at All/To Some Extent |
|---------------------------------------------------------------------------|-----------|----------------------------|
| 1.1 Explicit learning objectives and success criteria                     | 3.73 (.77) | 11.4                       |
| 1.2 Classroom’s climate and level of trust                                | 3.63 (.95) | 10.1                       |
| 1.3 Dialogue and monologue about learning                                 | 3.58 (.92) | 10                          |
| 1.4 Continuum level of real learning                                      | 3.70 (.77) | 4.2                        |
| 1.5 “Backward design” plan and success criteria                          | 3.47 (.87) | 11.8                       |
| 1.6 Providing constructive feedback                                       | 3.77 (.91) | 7.5                        |
| 1.7 Student praise vs feedback                                            | 3.95 (.92) | 5.8                        |
| 1.8 Various assessment methods that enhance learning                      | 3.78 (.82) | 3.4                        |
| 1.9 Students receive and interpret feedback                               | 3.89 (.82) | 1.7                        |
| 1.10 Feedback about learning progress vs corrective feedback              | 3.64 (.78) | 5                          |
| 1.11 Students ask for, understand and use feedback                        | 3.91 (.79) | 2.5                        |
| 1.12 Peer feedback                                                       | 3.58 (.82) | 5.9                        |
| 1.13 Effect of teachers’ work on their students                          | 3.65 (.86) | 5.1                        |
| 2.1 Passionate and inspired                                              | 3.68 (.87) | 4.2                        |
| 2.2 Professional development programme and subjects’ deep understanding  | 3.52 (1.0) | 11.8                       |
| 2.3 Professional development programme and teacher–student interaction   | 3.50 (1.1) | 10.9                       |
| 2.4 Professional development programme and providing useful feedback      | 3.42 (1.0) | 13.5                       |
| 2.5 Professional development programme and students’ effective attributes| 3.47 (1.0) | 14.3                       |
| 2.6 Professional development programme and students’ surface and deep learning | 3.55 (.89) | 6.5                        |
| 2.7 Professional development programme and monitoring students’ progress | 3.21 (.98) | 16.8                       |
| 3.1 Critiquing learning objectives/ success criteria and students achievements | 3.53 (.91) | 10.9                       |
| 3.2 Critiquing learning objectives/ success criteria and planning new lessons | 3.46 (.95) | 12.6                       |
| 3.3 Evaluating the impact of teachers’ work on students’ achievements     | 3.86 (.89) | 5.1                        |
| 3.4 Teachers as change agents                                             | 3.47 (.90) | 9.2                        |

(Continued)
student expectation factor ($m = 3.4$). Table 10 lists the means, SDs and standard errors for the five VLS factors. As shown in the table, the mean score for the feedback factor was the highest, while that for student expectations was the lowest among the five VLS factors. This means that the participants expressed a high level of providing, receiving and interpreting feedback in terms of learning objectives and success criteria to maximize their influence on students’ learning and progress, citing this factor more than the VL practices related to the other four factors. However, teachers conceptualize, design, implement and evaluate the learning process based on their students’ attributes and invest in them as a positive factor of that learning process. This result supports the previous research findings of Alsaeed (2012).
Table 11 lists a comparison of means (with SDs) for the mathematics teachers’ responses according to gender, school type, teaching level, years of teaching experience and competence level with ICT integration for the five VLS factors. As shown in the table, the mean response of male teachers was slightly higher than that of female teachers for all five VLS factors, with an approximately 0.2 difference for factor 1 (feedback), factor 3 (evaluation and challenge), factor 4 (planning and discourse promotion) and factor 5 (student expectations) and a 0.3 difference for factor 2 (professional development). Likewise, the mean response of the participants teaching at private schools was slightly higher than that of the participants teaching at public schools for all five VLS factors, with an approximate 0.2 difference for factor 2 (professional development), factor 3 (evaluation and challenge), factor 4 (planning and discourse promotion) and factor 5 (student expectations) and a 0.1 difference for factor 1 (feedback). In terms of the teaching level, the mean response of the participants teaching in K–6 mathematics classrooms was higher than that of the participants teaching in middle and high school classrooms for all five VLS factors, as the mean response of middle school teacher participants was the lowest for factor 1 (feedback) and factor 4 (planning and discourse promotion), and the mean response of high school teacher participants was the lowest for factors 2 (professional development), 3 (evaluation and challenge) and 5 (student expectations).

Table 11 shows that the mean response of the participants increased with an increasing number of years of teaching experience. The mean response of participants with more than 10 years of experience was the highest among the three groups for all five VLS factors. Moreover, the mean response of the participants who indicated a competent to very competent level of technology integration for teaching and learning was higher than that of the participants with less competence for all five VLS factors.

Table 13 presents the effects of gender, school type, teaching level, years of teaching experience and competence level with ICT integration on the practice level of VLS examples in terms of the five VLS factors, as follows: factor 1 (feedback), factor 2 (professional development), factor 3
According to Table 13, the MANOVA comparing the means of school type for each of the five VLS factors measured by the instrument revealed no statistically significant differences between the response means of participants at $p < 0.05$ in relation to all five VLS factors. Likewise, the results of the MANOVA comparing the means of gender for each of the five VLS factors measured by the instrument revealed no statistically significant differences between the response means of participants at $p < 0.05$ in relation to factor 1 (feedback), factor 3 (evaluation and challenge), factor 4 (planning and discourse promotion) or factor 5 (student expectations). However, there were statistically significant differences between the response means of male teachers ($m = 3.71$) and female teachers ($m = 3.37$) in relation to factor 2 (professional development). This shows that male mathematics teachers indicated a higher level of engagement in professional development programmes that enhance and support VL practices in their schools than female mathematics teachers did.

In view of the effect described above, the results of the MANOVA showed no statistically significant differences between the response means of teaching level (K–6, middle school, high school) at $p < 0.05$ in relation to factor 1 (feedback), factor 3 (evaluation and challenge), factor 4 (planning and discourse promotion) or factor 5 (student expectations). However, there were statistically significant differences between the response means of teacher participants from K–6 ($m = 3.71$), middle school ($m = 3.49$) and high school ($m = 3.16$) in relation to factor 2 (professional development). This means that K–6 mathematics teachers engaged more in the professional

| Table 11. Comparison of teachers’ means and SDs on the five VLS factors (N = 119) |
|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| Factor 1: Feedback                           | Factor 2: Professional Development           | Factor 3: Evaluation and Challenge             | Factor 4: Planning and Discourse Promotion    | Factor 5: Student Expectations                |
| Gender                                       |                                               |                                               |                                               |                                               |
| Male                                         | 3.85 (0.54)                                  | 3.71 (0.75)                                  | 3.68 (0.57)                                  | 3.70 (0.54)                                  | 3.54 (0.49)                                  |
| Female                                       | 3.65 (0.62)                                  | 3.37 (0.76)                                  | 3.45 (0.64)                                  | 3.51 (0.61)                                  | 3.35 (0.54)                                  |
| School Type                                  |                                               |                                               |                                               |                                               |                                               |
| Public                                       | 3.70 (0.59)                                  | 3.45 (0.79)                                  | 3.50 (0.64)                                  | 3.61 (0.60)                                  | 3.37 (0.52)                                  |
| Private                                      | 3.79 (0.68)                                  | 3.65 (0.64)                                  | 3.68 (0.55)                                  | 3.77 (0.56)                                  | 3.64 (0.53)                                  |
| Teaching Level                               |                                               |                                               |                                               |                                               |                                               |
| K–6                                          | 3.80 (0.51)                                  | 3.71 (0.66)                                  | 3.59 (0.47)                                  | 3.68 (0.52)                                  | 3.45 (0.51)                                  |
| Middle school                                | 3.61 (0.74)                                  | 3.49 (0.90)                                  | 3.54 (0.74)                                  | 3.43 (0.71)                                  | 3.43 (0.56)                                  |
| High school                                  | 3.70 (0.56)                                  | 3.16 (0.67)                                  | 3.41 (0.69)                                  | 3.54 (0.57)                                  | 3.34 (0.52)                                  |
| Years of Teaching Experience                 |                                               |                                               |                                               |                                               |                                               |
| Less than 5 years                            | 3.28 (0.66)                                  | 3.03 (0.90)                                  | 3.03 (0.76)                                  | 3.38 (0.73)                                  | 3.27 (0.57)                                  |
| 5–10 years                                   | 3.64 (0.56)                                  | 3.41 (0.72)                                  | 3.51 (0.61)                                  | 3.45 (0.54)                                  | 3.34 (0.49)                                  |
| More than 10 years                           | 3.86 (0.54)                                  | 3.64 (0.71)                                  | 3.66 (0.53)                                  | 3.67 (0.57)                                  | 3.48 (0.53)                                  |
| Level of ICT Integration                     |                                               |                                               |                                               |                                               |                                               |
| No competence                                | 0.00 (0.00)                                  | 0.00 (0.00)                                  | 0.00 (0.00)                                  | 0.00 (0.00)                                  | 0.00 (0.00)                                  |
| Some competence                              | 3.58 (0.59)                                  | 3.40 (0.79)                                  | 3.41 (0.66)                                  | 3.45 (0.60)                                  | 3.33 (0.52)                                  |
| Competent                                    | 3.97 (0.55)                                  | 3.70 (0.72)                                  | 3.71 (0.49)                                  | 3.80 (0.54)                                  | 3.63 (0.52)                                  |
| Very competent                               | 4.08 (0.51)                                  | 3.35 (0.59)                                  | 4.00 (0.38)                                  | 3.88 (0.41)                                  | 3.38 (0.54)                                  |

(evaluation and challenge), factor 4 (planning and discourse promotion) and factor 5 (student expectations).
Table 12. MANOVA tests of teachers’ demographics and level of ICT integration of the VLS (N = 119)

| Tests          | Gender | School Type | Teaching Level | Teaching Experience | Level of ICT Integration |
|----------------|--------|-------------|----------------|---------------------|--------------------------|
|                | Sig.   | Partial Eta Squared | Sig.   | Partial Eta Squared | Sig.   | Partial Eta Squared | Sig.   | Partial Eta Squared | Sig.   | Partial Eta Squared |
| Pillai’s Trace | .303   | .051        | .268  | .054            | .016   | .090            | .004   | .108            | .030   | .083           |
| Wilks’ Lambda  | .303   | .051        | .268  | .054            | .017   | .091            | .003   | .112            | .030   | .084           |
| Hotelling’s Trace | .303 | .051        | .268  | .054            | .018   | .091            | .002   | .116            | .030   | .084           |
| Roy’s Largest Root | .303  | .051        | .268  | .054            | .019   | .112            | .000   | .193            | .012   | .121           |

*Indicates significance at $p < .05$
Table 13. MANOVA tests of teachers’ demographics and level of ICT integration of the five VLS factors (N = 119)

| VLS Factors                  | Teaching Experience | Gender 1 | Gender 2 | School Type 1 | School Type 2 | Teaching Level 1 | Teaching Level 2 | Level of ICT Integration 1 | Level of ICT Integration 2 | df 1 | df 2 | Sig       | F    | Partial Eta Squared 1 | Sig       | F    | Partial Eta Squared 2 |
|------------------------------|---------------------|----------|----------|--------------|--------------|------------------|------------------|------------------------|------------------------|------|------|-----------|------|-----------------------|-----------|------|-----------------------|
| Factor 1: Feedback           |                     | 1        | 2        | 1            | 2            | 1                | 2                | 1                      | 2                      | 1    | 2    | .077      | 3.180| .026                 | .016       | 118  | 6.530                |
| Factor 2: Professional       |                     | 1        | 2        | 1            | 2            | 1                | 2                | 1                      | 2                      | 1    | 2    | .026      | 5.471| .002                 | .001       | 1.01  | 1.808                |
| Development                  |                     | 1        | 2        | 1            | 2            | 1                | 2                | 1                      | 2                      | 1    | 2    | .026      | 5.471| .004                 | .009       | 1.01  | 1.808                |
| Factor 3: Evaluation and     |                     | 1        | 2        | 1            | 2            | 1                | 2                | 1                      | 2                      | 1    | 2    | .042      | 3.869| .008                 | .078       | .03  | 1.098                |
| Challenge                    |                     | 1        | 2        | 1            | 2            | 1                | 2                | 1                      | 2                      | 1    | 2    | .011      | 2.413| .041                 | .021       | .02  | .073                 |
| Factor 4: Planning and       |                     | 1        | 2        | 1            | 2            | 1                | 2                | 1                      | 2                      | 1    | 2    | .032      | 2.787| .014                 | .022       | .01  | .073                 |
| Discourse Promotion          |                     | 1        | 2        | 1            | 2            | 1                | 2                | 1                      | 2                      | 1    | 2    | .023      | 3.293| .030                 | .044       | .01  | .073                 |
| Factor 5: Student Expectations|                   | 1        | 2        | 1            | 2            | 1                | 2                | 1                      | 2                      | 1    | 2    | .077      | 3.810| .017                 | .02     | 1.515 | .002                 |

*Indicates significance at p < .05
development programmes supporting VL practices within their schools than middle and high school mathematics teachers did.

The results of the MANOVA revealed no statistically significant differences between the response means of teaching experience (less than 5 years, 5–10 years, more than 10 years) at \( p < 0.05 \) in relation to factor 4 (planning and discourse promotion) or factor 5 (student expectations). However, there were statistically significant differences between the response means of participants with less than 5 years of teaching experience \( (m = 3.28) \), 5–10 years of teaching experience \( (m = 3.64) \) and more than 10 years of teaching experience \( (m = 3.86) \) in relation to factor 1 (feedback); between the response means of participants with less than 5 years of teaching experience \( (m = 3.03) \), 5–10 years of teaching experience \( (m = 3.41) \) and more than 10 years of teaching experience \( (m = 3.64) \) in relation to factor 2 (professional development); and between the response means of participants with less than 5 years of teaching experience \( (m = 3.03) \), 5–10 years of teaching experience \( (m = 3.51) \) and more than 10 years of teaching experience \( (m = 3.66) \) in relation to factor 3 (evaluation and challenge). This signifies that years of teaching experience is an indicating factor in the level of practice of the VL examples; that is, more experienced teachers (more than 10 years of experience) are more likely to be engaging in and practicing VL in their mathematics classrooms and in their schools. However, in terms of lesson planning and discourse promotion, as well as valuing students’ expectations, years of teaching experience is not a determining factor, which means that the practice of these essential educational domains that enhance and support VL practices requires further and urgent consideration for mathematics teachers, no matter how many years of teaching experience they possess.

Finally, the MANOVA results showed no statistically significant differences between the response means of the competence level of ICT integration (some competence, competent, and very competent) at \( p < 0.05 \) in relation to factor 2 (professional development). However, there were statistically significant differences between the response means of the participants with some competence \( (m = 3.58) \) and those who were competent to very competent \( (m = 3.97, 4.08) \) in relation to factor 1 (feedback); between the response means of the participants with some competence \( (m = 3.41) \) and those who were competent to very competent \( (m = 3.71, 4.00) \) in relation to factor 3 (evaluation and challenge); between the response means of the participants with some competence \( (m = 3.45) \) and those who were competent to very competent \( (m = 3.80, 3.88) \) in relation to factor 4 (planning and discourse promotion); and between the response means of the participants with some competence \( (m = 3.33) \) and those who were competent to very competent \( (m = 3.63, 3.38) \) in relation to factor 5 (student expectations). This demonstrates that the competence level of integrating ICT in teaching and learning is a determining and influential factor in teacher participants’ practice of VL in their mathematics classrooms. The more competent teachers were at integrating various ICT software applications in their teaching and learning processes, the more likely they were to practice VL inside their classrooms. The result of this study showed that the competence level of ICT integration enhances the practices teachers undertake to achieve a better influence on their students and evaluate their effect on students’ achievements and learning progress.

6. Conclusion

This study investigated the evidence-based VL practices of 119 in-service mathematics teachers in Saudi Arabia. It also explored aspects of the participants’ VL practice levels, competence levels with ICT integration and relationship to VL practices, as well as the relationships of several indicating demographic factors, namely gender, school type, school level and teaching experience.

Since the primary purpose of this study was to evaluate the evidence-based VL practices of mathematics teachers, a VLS survey instrument based on Hattie’s eight mind frames (Hattie, 2012) was conceptually generated to examine teachers’ real practices of VL in terms of the five following factors: Feedback, Professional Development, Evaluation and Challenge, Planning and Discourse Promotion and Student Expectations. Generally, the mathematics teacher participants in this study
expressed an encouraging and promising (3.5 < mean < 4) level of evidence-based VL practices at their schools and in their technology-enhanced classrooms for all five VL factors. However, the feedback factor was the highest (mean = 3.7), while the student expectations factor was the lowest (mean = 3.4) among the five VLS factors. This means that the mathematics teacher participants expressed a high level of practice that placed a greater value on providing, receiving and interpreting feedback to maximize their influence on students’ learning and progress than on the VL practices related to the other four factors. However, teachers’ self-perceptions about their students’ attributes and investments in them as a positive factor of the learning process constituted the least practiced form of VL among the participants.

The audit of the relationship between mathematics teachers’ level of VL practice and their indicating factors of gender, school type, school level, teaching experience and competence level with ICT integration revealed no statistical differences recorded for gender, school type, school level or VL practice in relation to all five factors. However, the male teachers and K–6 mathematics teachers exhibited a more significant practice level and a readiness to engage in professional development programmes supporting VL practices than the female, middle school and high school mathematics teachers did. In addition, the results showed that years of teaching experience is an indicating factor in the level of engagement with VL practices in mathematics classrooms and schools. Furthermore, the competence level of ICT integration in teaching and learning was highlighted as the most determining and influential factor for whether teachers practiced VL in their mathematics classrooms. As such, the competence level of ICT integration enhanced the practices undertaken by teachers to achieve a better influence on their students and evaluate their effect on students’ achievements and learning progress.

This study advocates that teacher education programmes should be reformed by adopting the VL framework as the evaluation lens for teacher practices in mathematics classrooms and ICT rich environments. Further, this study recommends that teacher education institutes should re-examine their teachers’ effect on student learning and progress in terms of different contexts and larger samples across Saudi Arabia to detect differences in experiences and implications. To gain more in-depth and holistic insights on the quality of today’s mathematics teacher education, more studies are needed to examine the attributes that experienced teachers possess in addressing VL practices and how to empower professional development programmes that support teaching based on the adoption of Hattie’s eight mind frames (Hattie, 2012).

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Author details
Ahlam Mohammed Al-Abdullatif
E-mail: aalabdullatif@kfup.edu.sa
ORCID ID: http://orcid.org/0000-0003-2815-1137

Maha Saad Alsaeed
E-mail: malsaeed@kfup.edu.sa
ORCID ID: http://orcid.org/0000-0001-7652-5602

1 Department of Educational Technology, King Faisal University, P.O. BOX: 400, Al Ahsa 31982, Saudi Arabia.
2 Department of Curricula and Instruction, King Faisal University, P.O. BOX: 400, Al Ahsa 31982, Saudi Arabia.

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