Professional Development for Missouri's STEM Teachers:
A Statewide Needs Assessment of K-12 STEM Teachers

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Executive Summary

The purpose of this project was to determine the current professional development (PD) needs of educators teaching Science, Technology, Engineering, and Mathematics (STEM) topics in Missouri school districts. In the spring of 2016, a representative sample of STEM teachers in Missouri public schools was surveyed and 800 (16%) responded. Teachers represented small, medium, and large school districts and all levels of teaching experience. Their responses were analyzed and reported by district size, elementary or secondary grade level, and years of teaching experience.

Nearly one-third of respondents reported participating in 21 to 40 hours of PD during the past 12 months; however, little of that PD was in STEM areas. Secondary teachers reported a higher level of participation in STEM PD activities than did elementary teachers. Respondents expressed interest in attending STEM PD to improve instructional practices, believed that attending STEM PD would help improve their teaching, and indicated that STEM PD access can potentially benefit students in their school. Teachers at all levels reported it was very important to be able to access ready-to-use materials from PD programs and to be able to learn from other teachers.

When asked about their preferred modes of PD delivery and formats, respondents were most interested in one-time, half-day workshops or all-day workshops. Teachers indicated a higher level of interest in face-to-face PD formats compared to all online formats, preferring to attend programs offered at their school site or in their district or region. Teachers indicated the least interest in PD delivered via online formats or scheduled on weekends or during the summer.

Teachers were asked about 22 PD topic areas in order to assess their perceived importance of each topic and also their level of interest in attending PD about this topic. Responses varied by district size, grade level, and years of teaching experience. Overall, using real world issues in the classroom was perceived to be the most important topic area and had the highest level of interest. The second and third areas of both importance and interest were problem-based learning and using educational technologies to support learning.

Nearly 90% of respondents indicated that reliable access to an internet connection for email and web browsing was available at their school; however, teachers from small districts were more likely to indicate limited access to high-speed Internet, social media sites, and online management systems (e.g., Blackboard and Moodle) compared to teachers from medium or large districts.

Several key findings are highlighted, and five sets of recommendations for addressing the needs of STEM teachers are offered. These recommendations are summarized below.

In order to improve STEM teaching across the state and expand opportunities for high-quality, STEM learning experiences for all students, Missouri educators and PD providers need to:

- Create opportunities for all STEM teachers, and elementary teachers in particular, to build their STEM teaching expertise;
- Explore new ways of providing and encouraging participation in PD for teachers in the small districts, which tend to be located in the rural areas of the state*, and:*
- Encourage teachers with more years of experience to be open to new STEM PD opportunities to stay at the cutting edge of their disciplines, building awareness of new knowledge and reformed teaching practices.

In order to meet the expectations of Missouri teachers, PD providers should highlight the ways in which PD provides access to teaching materials and strategies as well as opportunities to learn from teachers and educational experts.

Preferences among Missouri teachers for PD timing and format tend to be at odds with what research indicates is best practice and with mechanisms (i.e., virtual formats) that may make delivery of PD easier. In order to address teacher preferences, PD providers should carefully consider the ways in which technology is used to support PD and attempt to avoid fully virtual PD offerings (when possible). In contrast, teacher preference for PD timing should not determine PD design. Research has shown that the PD delivery formats that responding teachers expressed the most interest in (i.e., one-time workshops) are not optimal for sustaining impact,; therefore, PD providers are encouraged to help teachers understand why longer-term PD programs designed with more intensive engagement opportunities.

PD opportunities should be framed in terms of strategies for engaging students in student-centered, reform-oriented learning. These approaches often align with new standards such as the Next Generation Science Standards and Common Core, but PD providers should be encouraged to lead with a focus on innovative teaching and learning strategies. PD providers may also need to help educators better understand important, emerging ideas in STEM (e.g., big data and bioinformatics) and the significance of exposing students to these ideas. There is also a need for helping educators, particularly those working in small and rural districts, develop an appreciation for the need to broaden participation among groups under-represented in STEM.

PD providers should carefully consider limitations to high-speed Internet access and learning management systems, which may be problematic for teachers from small districts, as they design learning experiences for Missouri teachers. Tools such as streaming video designed for showcasing exemplar practices or videoconference software may be difficult to use in some of the smaller districts.

Introduction

The fields of Science, Technology, Engineering, and Mathematics (STEM) and the ways in which they intersect have evolved dramatically in the past decade and education in these areas has also changed significantly. The development and deployment of new standards for STEM teaching (National Governor's Association, 2010) and assessment systems (National Academies of Science, Engineering, and Medicine, 2017) reflect the substantial changes underway in the STEM education space. Professional development (PD) provides a critical mechanism to help teachers develop understandings of how STEM fields and STEM education are changing and helps teachers adjust classroom practices in response to these changes for the purpose of improving teaching and learning (Capps, Crawford & Constas, 2012). Extensive research and evaluation efforts have documented the impacts of PD (e.g., Yoon, Duncan, Lee, Scarloss & Shapley, 2008) and explored best practices for PD (e.g., Loucks-Horsley, Love, Stiles, Mundry & Hewson, 2003). However, less attention has been directed toward clarifying teacher perspectives on what they are looking for and expecting in their PD experiences. The purpose of the study featured in this report was to address this gap in the field's knowledge base.

This project was conducted as a part of the Missouri Transect, a project funded by the National Science Foundation (NSF) through the Experimental Program to Stimulate Competitive Research (EPSCoR). EPSCoR is designed to promote research progress and infrastructure nationwide. The Missouri Transect focuses on promoting research and educational competitiveness across the state of Missouri. The needs assessment research featured in the current report was conducted as a part of the Education and Outreach dimensions of the Missouri Transect. The Education and Outreach team was charged with numerous activities to support learning among Missouri's students, teachers, and the general public, and several of these activities included PD opportunities for teachers. Given the limited information available regarding teacher perspectives on their PD and the potential for this information to impact the effectiveness of PD efforts, the Education and Outreach team sought to conduct a statewide assessment of PD for STEM teachers. It is anticipated that the results of this study will be useful to STEM educators and PD providers across the state. Ultimately, the STEM education community should be able to use this report for improving the quality and impact of PD for STEM teachers.

Methods

Needs Assessment Survey

Measurement specialists and STEM education researchers collaborated to develop a survey framework for the needs assessment. This process was informed by research literature related to teacher PD (Capps et al., 2012; Committee on Science and Mathematics Teacher Preparation, 2001). While an extensive literature base exists that is focused on best practices for conducting PD (e.g., Guskey, 2003; Loucks-Horsley et al., 2003; Yoon et al., 2008), research related to teacher perspectives on their PD needs and their preferences associated with PD are more limited (Chval, Abell, Pareja, Musikal & Ritzka, 2007; Park Rogers, Abell, Lannin, Wang, Musikul, Barker & Dingman, 2007). Insights derived from both of these areas of work were used to inform the survey framework.

The framework included five areas of emphasis. These areas are identified and brief descriptions of items falling within each of the areas are provided below:

(1) Teacher Demographic Information: Three items regarding grade level, subject(s) taught, and years of teaching experience
(2) Participation in PD: Two items regarding hours of PD in the past 12 months and hours of PD related to STEM
(3) PD Preferences: Four question clusters regarding general interest in PD (7 items), value/beliefs toward PD (8 items), preferred delivery of PD (9 items), and preferred format of PD delivery (10 items)
(4) PD Topic Areas: Several question clusters regarding teachers' perceived importance of, and interest in, STEM PD topics and non-discipline-specific content areas (30 items)
(5) Internet Access: One question cluster regarding types of online access at their school building (5 items)

The survey was administered online (via Qualtrics) and made available in paper copy to teachers who did not respond to electronic requests to complete the survey (via email) or did not have email addresses available in the state database of teachers. Collection of survey responses took place throughout the spring of 2016.

Population and Sampling

According to data collected from the 2015–2016 academic year by the Missouri Department of Elementary and Secondary Education (DESE), there were 19,678 elementary teachers, 4,287 secondary math teachers, 4,155 secondary science teachers, and 336 technology/engineering teachers. These teachers represented 516 public school districts throughout the state of Missouri. For the purposes of this needs assessment, teachers from charter school districts or other special Local Educational Agencies (LEAs) were not included in the population.

The sampling strategy was devised in order to generate data that was representative of the perspectives of STEM teachers across the state. As a part of this strategy, key stratifications were attended to including district size[1], grade levels (clustered as elementary or secondary), and subject areas (mathematics, science, and technology/engineering). Table 1 presents a matrix showing the number of elementary, secondary mathematics, secondary science, and technology/engineering teachers in small, medium, and large districts across the state of Missouri. Teachers assigned to a district within each category were part of the pool of educators from which a representative sample was selected for participation in this needs assessment. The number of teachers who were invited to participate is indicated in parentheses in Table 3. Because the number of technology and engineering teachers was small, *all* of the technology and engineering teachers in Missouri were surveyed.

Table 1. Sampling Matrix with Population and Number of Teachers Invited to Participate

District Size	Elementary N (n)	Secondary Math N (n)	Secondary Science N (n)	Technology / Engineering N_a	Total N (n)
Small	4,841 (417)	1,082 (380)	1,107 (399)	32 (32)	7,472 (1228)
Medium	7,342 (632)	1,558 (547)	1,510 (545)	113 (113)	10,523 (1837)
Large	7,145 (615)	1,647 (578)	1,538 (555)	191 (191)	11,127 (1939)
Total	19,678 (1664)	4,287 (1505)	4,155 (1499)	336 (336)	28,456 (5004)

$_a$All technology and engineering teachers were included in the sample.
Note: In the ( ) is the number of individuals in each group that were randomly selected to participate, in order to achieve the required sample size based on a 40% response rate. The required sample size was estimated based on population size, 4% margin of error, and 95% confidence level.

Respondents

From the 5,004 teachers in the sample, 800 responses were recorded for an overall response rate of 16%. Given this response rate and the number of responses received, there is an expected overall margin of error of +/- 3.4 percentage points at the 95% confidence level. A margin of error at or below 5% is typically considered acceptable for the analysis of categorical variables (Krejcie & Morgan, 1970). Response rates for several subgroups of interest are presented in Table 2.

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[1] District size was categorized as small, medium, or large based on four quantitative criteria. The criteria and procedures for determining district size are detailed in the full technical report: https://missouriepscor.org/education/needs-assessment-k-12-stem.

Table 2: Response Rates by Grade Level and District Size

Grade Level	Population	Sample	Respondents	Response Rate
Elementary	19,678	1,664	221	13.3%
Secondary*	8,778	3,340	566	16.9%
District Size	**Population**	**Sample**	**Respondents**	**Response Rate**
Small	7,062	1,228	231	18.8%
Medium	10,523	1,837	317	17.3%
Large	10,871	1,939	238	12.3%
Total	28,456	5004	**800	16.0%

**Technology and engineering teachers were all considered part of the secondary population and sample*
***An additional 13 respondents did not indicate their grade level, and 14 respondents did not have a district size but are included in the total count.*

Survey respondents indicated the STEM subjects and grade levels they taught. Table 3 presents numbers of respondents from different grade levels and STEM subjects. In many cases, especially among elementary teachers, respondents reported teaching multiple STEM disciplines. Secondary teachers were much more likely to report teaching a single discipline.

Table 3: Respondent Subject(s) Taught by Grade Level

Subject(s) Taught	Elementary (n=221)	Secondary (n=566)	Total (N=787)
Mathematics	202 91.4%	263 46.5%	465 59.1%
Science	193 87.3%	328 58.0%	521 66.2%
Technology	109 49.3%	96 17.0%	205 26.1%
Engineering	25 11.3%	102 18.0%	127 16.1%

Note: Percentages will not add to 100 because teachers were asked to indicate all subjects taught.
13 respondents did not indicate a grade level.

The distribution of respondents was relatively even in terms of years of teaching experience. Table 4 presents the distribution of teaching experience among study participants.

Table 4: Years of Teaching Experience

Years of Experience	Respondents	Percent
0–5 years	145	18.2%
6–10 years	173	21.7%
11–15 years	156	19.6%
16–20 years	142	17.8%
Over 20 years	181	22.7%
Total	797	100.0%

Results

Participation in PD

Respondents reported a wide range of participation in PD in the year prior to their survey responses. Approximately 70% of the participating teachers indicated that they had participated in at least 20 hours of PD, and 20% of the sample reported having participated in over 60 hours of PD. However, participation in STEM-focused PD had occurred far less frequently. Almost 30% of the sample had not participated in any STEM-focused PD; 75% of the sample had participated in fewer than 10 hours of STEM-focused PD. The amount of STEM-focused PD significantly differed by grade level with secondary teachers reporting far more participation than elementary teachers.

The size of a teacher's district made a difference in the amount of both overall and STEM-focused PD attended by respondents. Scaled mean scores were calculated to compare the amount of overall PD and STEM-focused PD across the subgroups. An ANOVA indicated that there were significant differences between district size subgroups in terms of hours of PD attended (p-value $< .05$). As district size increased, so did participation in PD.

Perspectives on STEM-focused PD

Teachers were asked to indicate their level of agreement with seven statements related to STEM-focused PD and their teaching environment. Teachers were given five response choices (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree). Scaled mean scores indicated that, on average, teachers strongly agreed with the following three statements (scaled means scores ranged from 4.20-4.23):

- I would like to attend PD for STEM teaching and learning to improve my instructional practices.
- My participation in STEM PD would help to improve my teaching.
- The students in my school stand to benefit from STEM PD available to our teachers.

On average, teachers agreed with three additional statements, but not quite as strongly as the statements listed above (scaled means scores ranged from 3.62—3.92):

- STEM PD would be received positively within my school.
- I have support from my principal to pursue PD for STEM teaching and learning.
- I am able to adopt or adapt strategies learned from STEM PD programs into my teaching practice.

Teachers tended to provide a neutral response or disagreed with the final statement in this category (scaled means score = 2.79):

- Quality PD programs for STEM teaching and learning are readily available to me.

Teachers were shown eight statements related to potential affordances of PD and asked to indicate the level of importance of each aspect to them using a five-point scale (1 = Not Important; 5 = Extremely Important). Table 5 presents the scaled mean scores for each of these items.

Table 5: Importance of Aspects of PD Programs

Aspects of PD Programs	Responses	Mean	SD
Accessing ready-to-use materials	774	4.21	0.9
Learning from other teachers	776	4.07	0.7
Learning about new and innovative teaching strategies a***	773	4.05	0.8
Learning from experts in the field a**	776	4.01	0.8
Learning about new ideas emerging from STEM fields	772	3.94	0.9
Networking with other teaching professionals	773	3.90	0.9
Receiving feedback on teaching practices a**, c***	776	3.73	0.9
Meeting PD requirements from my school or district b*, a***, c***	774	3.19	1.2

*a Significant differences based on grade level (ANOVA, **p-value < .01, ***p-value < .001)*
*b Significant differences based on district size (ANOVA, * p-value < .05)*
*c Significant difference based on years of teaching experience (Pearson Correlation, ***p-value < .001)*

Overall, respondents agreed with the importance of all aspects of PD listed with the exception of "Meeting PD requirements from my school or district." The scaled mean score for this item indicates generally neutral responses. Interestingly, teachers from small districts were significantly more likely to ascribe higher value to this item than teachers in medium or large districts.

There were also statistically significant differences in responses to half of the items (see Table 5) when comparing responses from the elementary and secondary respondents.

Delivery Formats

Respondents were given a list of ten possible timeframes of PD program delivery and were asked to indicate their level of interest in attending each delivery timeframe using a three-point scale. The scaled mean scores were calculated (not interested = 1, possibly interested = 2, and definitely interested = 3). Table 6 shows the mean scores representing the interest in the timeframe of PD delivery from highest to lowest score. Teachers were most interested in one-time, half-day workshops (mean = 2.4) and one-time, all-day workshops (mean = 2.4). Teachers were least interested in intensive summer trainings (mean = 1.9) and weekend trainings (mean = 1.6). Statistical analyses indicated that there were some significant differences in level of interest based on grade level and years of teaching experience. Elementary teachers were more interested in recurring sessions during school hours (mean = 2.3) than were secondary teachers (mean = 2.0; *p-value* < .001). Though the interest level was relatively low for attending intensive summer workshops and weekend trainings, secondary teachers were more interested in these formats compared to elementary teachers (*p-value* < .001). Interest in several timeframes of PD delivery negatively correlated with years of teaching experience.

Table 6: Teacher Interest in PD Program Delivery Formats

Delivery of PD Programs	Responses	Mean	SD
One-time, half day workshops $_{b***}$	774	2.41	0.6
One-time, all day workshops $_{b***}$	767	2.41	0.6
Training or workshops during school hours $_{a**, b***}$	776	2.32	0.6
Ongoing support programs	776	2.32	0.6
One-time, short workshops (1–2 hours) $_{a**, b***}$	771	2.31	0.7
Recurring sessions during school hours $_{a***}$	773	2.08	0.7
Recurring sessions outside of school hours $_{a*}$	771	1.95	0.6
Intensive summer workshops (1–2 weeks) $_{a***}$	771	1.90	0.7
Weekend trainings $_{a***}$	768	1.57	0.7

*$_a$ Significant differences based on grade level (ANOVA, **p-value < .01, ***p-value < .001)*
*$_b$ Significant difference based on years of teaching experience (Pearson Correlation, ***p-value < .001)*

The next set of ten items on the survey asked teachers to use a three-point scale to indicate their level of interest in participating in a variety of modes of PD (i.e., on-site, off-site, and virtual ways). The scaled mean scores were calculated for each of the items. These mean scores are reported in Table 7 from highest-to-lowest score. Respondents were most interested in attending face-to-face programs offered at their school site (mean = 2.6). Teachers indicated a higher level of interest in all of the face-to-face PD formats compared to all of the hybrid situations having less direct contact with other teachers/trainers. The formats of least interest are through virtual trainings (mean = 2.0), self-paced online PD (mean = 1.9), and through online forums (mean=1.8). Statistical analyses indicated that there were significant differences in levels of interest in different formats of PD delivery based on grade level. These significant differences or significant correlations are indicated with subscripts. In general, the secondary teachers expressed greater interest than the elementary teachers in traveling to other sites for PD opportunities. The elementary teachers were more interested in observing other teachers.

Table 7: Interest in Formats of Professional Development Delivery

PD Formats	Type	Responses	Mean	SD
Attending face-to-face programs offered at my school site $_{b**}$	On-site	774	2.55	0.6
Traveling to face-to-face programs offered in my district or region $_{a**,c***}$	Off-site	772	2.42	0.6
Collaborating with other teachers in my school/district in a Professional Learning Community $_{b*,c***}$	On-site	773	2.38	0.6
Observing an expert teacher working in his/her own classroom $_{a**}$	On-/Off-site	771	2.30	0.6
Traveling to face-to-face programs offered at central locations $_{a***, b*, c***}$	Off-site	773	2.20	0.7
Receiving mentorship from an expert teacher in my subject area	All	773	2.14	0.7
Participating in the hybrid model that incorporates some face-to-face time with online follow-up opportunities $_{a**, c***}$	All	774	2.10	0.7
Viewing virtual trainings and webinars	Virtual	772	1.97	0.7
Completing online, self-paced learning modules	Virtual	769	1.92	0.8
Using online communities and forums like discussion boards, wikis, and/or blogs $_{c***}$	Virtual	769	1.75	0.7

*$_a$ Significant differences based on grade level (ANOVA, **p-value < .01, ***p-value < .001)*
*$_b$ Significant differences based on district size (ANOVA, * p-value < .05)*
*$_c$ Significant difference based on years of teaching experience (Pearson Correlation, 2-tailed significance, ***p-value < .001)*

PD Topic Areas

The survey asked teachers to indicate the level of importance of, and level of interest in, attending PD related to 22 different topics. Teachers were given a four-point scale to rate the importance of each topic to them and a three-point scale to indicate their level of interest in attending PD on each topic. Scaled mean scores were calculated for importance of topic (1 = not important, 2 = slightly important, 3 = moderately important, 4 = very important) and level of interest in that topic (1 = not interested, 2 = possibly interested, 3 = definitely interested). The mean scores are reported in Table 8, which is organized from highest mean to lowest mean for their perceived importance of the topic.

The ratings for interest and importance were not exactly the same, but they followed general patterns. The highest areas of interest/importance included:

- Using real-world issues in the classroom
- Problem-based learning
- Use of educational technologies to support learning
- Instructional strategies for meeting the needs of diverse learners
- Integrating science, technology, engineering, and math
- Mathematical practices
- Inquiry-based laboratory activities
- Strategies for student use of mobile technologies

Topic areas that received the lowest ratings related to standards, preparing students for achievement tests, analysis of big data, and engineering design practices.

Statistical analyses showed that there were significant differences in perceived importance of these topics and interest in attending PD on these topics based on grade level and district size. These significant differences or significant correlations are indicated with subscripts in Tables 9 and 10, respectively. In these tables, the highly significant differences (*p-values* < .001) in level of interest between these subgroups are explored in greater detail.

Table 8: Importance of, and Interest in, PD Topics

Professional Development Topics	Importance			Interest		
	N	Mean	SD	N	Mean	SD
Using real-world issues in the classroom	749	3.59_{c***}	0.6	728	$2.59_{a***, c***}$	0.6
Problem-based learning	740	3.46_{c***}	0.7	717	2.5_{c***}	0.6
Use of educational technologies to support learning	749	3.45_{a**}	0.7	729	2.45	0.6
Instructional strategies for meeting the needs of diverse learners	750	$3.37_{a***, c***}$	0.7	728	$2.31_{a*, c***}$	0.7
Integrating science, technology, engineering, and math	750	3.37	0.8	728	2.44	0.6
Mathematical practices	749	3.30_{a***}	0.8	727	2.16_{a***}	0.8
Inquiry-based laboratory activities	748	$3.26_{a**, b*}$	0.9	723	2.37_{a*}	0.7
Strategies for student use of mobile technologies	751	3.24	0.8	728	2.38	0.7
Aligning instruction and curriculum with standards	744	$3.24_{a***, c***}$	0.9	724	2.16_{a***}	0.8
Integrating literacy practices with STEM learning	748	3.12_{a***}	0.9	726	$2.18_{a***, c***}$	0.7
Supporting girls and minorities in STEM	746	$3.09_{a*, b***}$	1.0	723	$2.17_{a**, b*}$	0.8
Scientific practices (e.g., modeling and argumentation)	747	3.09_{a*}	0.9	721	2.14_{a*}	0.7
New Missouri learning standards	745	$3.08_{a***,b**}$	0.9	727	$2.16_{a***,b**}$	0.7
Formative assessment for STEM learning	745	3.02_{a**}	0.8	723	$2.18_{b**, c***}$	0.7
Integrating authentic STEM research into the classroom	745	3.01_{c***}	0.9	729	2.32_{a**}	0.7
Interdisciplinary STEM teaching	744	$2.95_{a*, c***}$	0.9	717	2.20_{c***}	0.7
Supporting classroom discourse	734	2.86_{c***}	0.8	717	$1.99_{a**, c***}$	0.7
Preparing students for achievement tests	749	2.86_{b***}	1.0	726	1.94_{b**}	0.8
Analysis of "big data"	741	2.78_{a*}	0.9	722	1.95_{a***}	0.7
Next Generation Science Standards	743	2.68_{a***}	1.0	721	1.88_{a***}	0.8

Engineering design practices	743	2.67 [a***, b*]	1.0	727	1.99 [a***]	0.8
Common Core State Standards for Mathematics	743	2.64 [a***]	1.0	724	1.80 [a***]	0.8

*[a] Significant differences based on grade level (ANOVA, **p-value < .01, ***p-value < .001)*
*[b] Significant differences based on district size (ANOVA, * p-value < .05)*
[c] Significant difference based on years of teaching experience (Pearson Correlation, p-value < .001)

Table 9: Differences in Interest in STEM PD Topics by Grade Level

PD Topics of More Interest to Elementary Teachers	Grade Level	Responses	Mean	SD
Mathematical practices***	Elementary	191	2.44	0.6
	Secondary	526	2.07	0.8
	Total	717	2.17	0.8
Aligning instruction and curriculum with standards***	Elementary	189	2.44	0.7
	Secondary	525	2.05	0.8
	Total	714	2.15	0.8
New Missouri learning standards***	Elementary	191	2.34	0.7
	Secondary	526	2.10	0.8
	Total	717	2.16	0.7
Next Generation Science Standards***	Elementary	187	2.06	0.8
	Secondary	524	1.81	0.8
	Total	711	1.88	0.8
Common Core State Standards for Mathematics***	Elementary	188	2.10	0.8
	Secondary	526	1.69	0.8
	Total	714	1.79	0.8
PD Topics of More Interest to Secondary Teachers	**Grade Level**	**Responses**	**Mean**	**SD**
Using real-world issues in the classroom***	Elementary	190	2.45	0.6
	Secondary	528	2.64	0.5
	Total	718	2.59	0.6
Analysis of "big data"***	Elementary	191	1.73	0.7
	Secondary	521	2.03	0.7
	Total	712	1.95	0.7
Engineering design practices***	Elementary	192	1.79	0.8
	Secondary	525	2.07	0.8
	Total	717	2.00	0.8

*ANOVA, ***p-value < .001*

Table 10: Differences in Interest in STEM PD topics by District Size

PD Topics	District Size	Responses	Mean	SD
Supporting girls and minorities in STEM***	Small	205	2.03	0.8
	Medium	291	2.20	0.8
	Large	213	2.26	0.7
	Total	709	2.17	0.8
New Missouri learning standards***	Small	207	2.26	0.7
	Medium	293	2.23	0.7
	Large	213	2.01	0.8
	Total	713	2.17	0.7
Formative assessment for STEM learning***	Small	207	2.26	0.6
	Medium	287	2.21	0.7
	Large	215	2.08	0.7
	Total	709	2.18	0.7
Preparing students for achievement tests***	Small	208	2.06	0.7
	Medium	291	2.00	0.8
	Large	213	1.75	0.8
	Total	712	1.94	0.8

*ANOVA, ***p-value < .001*

A separate block of items on the survey asked teachers to indicate the perceived importance of, and level of interest in eight PD topics with particular relevance to the Missouri Transect project. Scaled mean scores were calculated for perceived importance of each topic based on a four-point scale and the level of interest in attending PD on that topic were calculated based on a three-point scale. Table 11 shows the mean perceived importance of, and mean interest in, the project-specific PD topics and is organized from highest mean to lowest mean score for importance of the topic.

Table 11: Importance of, and Interest in, PD Topics

PD Topics	Importance			Interest		
	N	Mean	SD	N	Mean	SD
Plant sciences	745	2.30 $_{a***}$	1.1	717	1.76 $_{a***}$	0.8
Climate change	745	2.23	1.1	715	1.78	0.8
Local weather patterns	744	2.20 $_{a***}$	1.1	720	1.74 $_{a***}$	0.8
Robotics	742	2.10 $_{b*}$	1.1	726	1.84 $_{a*, b*}$	0.8
Coding/computer programming	746	2.06 $_{b**}$	1.1	723	1.75 $_{b***}$	0.8
Soil health	743	2.03 $_{a***}$	1.0	715	1.61 $_{a**}$	0.7
Genetic engineering	742	1.96 $_{a***}$	1.1	719	1.71 $_{a***, c***}$	0.8
Use of drones to collect scientific data	741	1.91 $_{a*}$	1.0	715	1.74 $_{a***, c***}$	0.8
Bioinformatics	736	1.85 $_{a**}$	1.0	711	1.58 $_{a***}$	0.7

$_a$ *Significant differences based on grade level (ANOVA, * p-value < .05, **p-value < .01, ***p-value < .001)*
$_b$ *Significant differences based on district size (ANOVA, * p-value < .05, **p-value < .01, ***p-value < .001)*
$_c$ *Significant difference based on years of teaching experience (Pearson Correlation, ***p-value < .001)*

Interest in PD and Experience

A trend observed across most areas of the survey was an inverse relationship between years of experience and interest in PD. On average, teachers with more experience were less enthusiastic about PD opportunities and topics than their colleagues with less experience. This trend was observed in the responses regarding teacher perspectives on the affordances of PD, PD formats, and PD topics.

Internet Access

The last group of items on the survey asked teachers to rate how often five types of online access were available to them. Table 12 shows the distribution of responses in relationship to the size of the respondent's district. The majority of teachers (>85%) from districts of all sizes indicated that they had reliable access to the Internet for activities such as email and web browsing. Important differences among teachers from different district sizes emerged for the following items:

- Reliable access to high-speed internet at my school for viewing videos and streaming content
- Access to online learning management systems (e.g., Blackboard, Moodle, and Global Classroom) at my school

Eighty percent of teachers in large districts and only 64% of teachers from small districts reported consistent access to high-speed Internet. Similar gaps between large and small districts were observed in response to an item regarding access to online management systems. In the Missouri context, all districts classified as small are in rural areas of the state. Therefore, these data suggest that while efforts have been made to narrow the digital divide between urban and suburban versus rural regions, important disparities remain for rural schools.

Table 12: Levels of Online Access in Respondent's School Building

Types of Online Access	Small District			Medium District			Large District			Total
	Never	Some-times	Always	Never	Some-times	Always	Never	Some-times	Always	
Reliable access to an internet connection at my school for email and web browsing	2 0.9%	29 13.6%	183 85.5%	1 0.3%	27 9.2%	265 90.4%	1 0.5%	13 6.1%	200 93.5%	721 100.0%
Reliable access to high speed internet at my school for viewing videos and streaming content	1 0.5%	76 35.8%	135 63.7%	1 0.3%	68 23.2%	224 76.5%	1 0.5%	42 19.6%	171 79.9%	719 100.0%
Access to online learning management systems (e.g., Blackboard, Moodle, and Global Classroom) at my school	29 16.2%	45 25.1%	105 58.7%	22 8.5%	65 25.0%	173 66.5%	9 4.7%	37 19.2%	147 76.2%	632 100.0%
Access to lesson portals (specialized websites with vetted collections of lesson plans, e.g., eThemes) at my school	22 13.7%	79 34.8%	142 51.6%	22 9.1%	79 32.5%	142 58.4%	17 10.2%	46 27.5%	104 62.3%	571 100.0%
Access to social media sites like Twitter and Facebook at my school	91 44.4%	61 29.8%	53 25.9%	101 36.6%	80 29.0%	95 34.4%	249 27.7%	207 32.0%	231 40.3%	687 100.0%

Key Findings and Recommendations

This section presents a summary of five key findings from the needs assessment of Missouri STEM teachers along with related recommendations. Each key finding is marked by a header and the related recommendations are in italics.

Key Finding 1 and Recommendation

STEM teachers in Missouri are participating in significant amounts of PD, but much of the PD fails to address STEM-specific themes. Secondary mathematics and science teachers report far more participation in STEM-focused PD than their elementary teacher colleagues. Teachers from small districts reported less participation in PD than those from medium and large districts. Most teachers who were surveyed expressed high levels of interest in STEM-focused PD and believed that their teaching and the learning of their students would likely improve as a result of STEM-focused PD. However, the negative correlation found in the sample of teachers with the most years of experience indicated they were less convinced that attending further STEM PD would improve the quality of their instructional practices or benefit their students..

In order to improve STEM teaching across the state and expand opportunities for high-quality, STEM learning experiences for all students, Missouri educators and PD providers need to:

- *Create opportunities for all STEM teachers, and elementary teachers in particular, to build their STEM teaching expertise;*
- *Explore new ways of providing and encouraging participation in PD for teachers in the small districts, which tend to be located in the rural areas of the state, and:*
- *Encourage teachers with more years of experience to be open to new STEM PD opportunities to stay at the cutting edge of their disciplines, building awareness of new knowledge and reformed teaching practices.*

Key Finding 2 and Recommendation

Teachers further indicated an interest in gaining access to materials and strategies as well as learning from other teachers and educational experts.

In order to meet the expectations of Missouri teachers, PD providers should highlight the ways in which PD provides access to teaching materials and strategies as well as opportunities to learn from teachers and educational experts.

Key Finding 3 and Recommendation

Teachers expressed strongest interest in PD opportunities that occurred in one-time formats (e.g. single half-day workshops). However, ample research in this area suggests that single-episode PD is not effective (Loucks-Horsley et al., 2003). Significant engagement with new ideas and teaching strategies is necessary for effecting positive change in teacher practices. This level of engagement requires intensive, multi-day PD efforts and/or ongoing support embedded in teachers' work. While respondents did report interest in PD programs that could provide ongoing support, they expressed relatively low interest in intensive summer workshops. In terms of delivery formats, the teachers were most interested in face-to-face learning opportunities as opposed to PD facilitated through virtual means. While technology offers important affordances for facilitating PD (Blanchard, LeProvost, Tolin & Gutierrez, 2016), Missouri teachers seem less interested in virtual formats as compared to more traditional face-to-face settings.

Preferences among Missouri teachers for PD timing and format tend to be at odds with what research indicates is best practice and with mechanisms (i.e., virtual formats) that may make delivery of PD easier. In order to address teacher preferences, PD providers should carefully consider the ways in which technology is used to support PD and attempt to avoid fully virtual PD offerings (when possible). In contrast, teacher preference for PD timing should not determine PD design. We know that the formats teachers expressed the most interest in (i.e., one-time workshops) do not work very well; therefore, PD providers are encouraged to help teachers understand why longer-term PD programs are designed with more intensive engagement opportunities.

Key Finding 4 and Recommendation

When asked to indicate the importance of topics for STEM-focused PD and interest in participating in PD that addressed those topics, teachers responded favorably to several ideas that can generally be considered as reform-oriented, student-centered strategies. Topics such as relating STEM content to real-world issues, problem-based learning, and inquiry activities were highly rated. Topics for which teachers provided less positive responses were clustered around standards and standardized testing. In rating specific topics, teachers expressed lower levels of interest in some topics that are critically important for modern STEM, including bioinformatics, genetic engineering, engineering design, and analysis of big data. The relatively low ratings for these topics may reflect the fact that these emerging ideas tend not to be featured in current standards or curricula. However, it seems extremely likely that these themes will continue to grow in terms of their significance for STEM fields.

There were a few statistically significant differences in topic interest between teachers from different sized districts, but one of those differences deserves special attention. Teachers from small districts were significantly less interested in PD that aims to support girls and minorities in STEM. Given the under-representation of women and individuals from racial and ethnic minority backgrounds in STEM and the potential of individuals from these groups to positively transform the trajectory of STEM fields, PD for teachers to support under-represented students is critical.

PD opportunities should be framed in terms of strategies for engaging students in student-centered, reform-oriented learning. These approaches often align with new standards such as the Next Generation Science Standards and Common Core, but PD providers should be encouraged to lead with a focus on innovative teaching and learning strategies. PD providers may also need to help educators better understand important, emerging ideas in STEM (e.g., big data and bioinformatics) and the significance of exposing students to these ideas. There is also a need for helping educators, particularly those working in small and rural districts, develop an appreciation for the need to broaden participation among groups under-represented in STEM.

Key Finding 5 and Recommendation

While most Missouri teachers report at least some Internet access for activities such as email and web browsing, teachers in small districts are less likely than those in medium and large districts to have access to high-speed Internet and online learning management systems in their schools.

PD providers should carefully consider limitations to high-speed Internet access and learning management systems, which may be problematic for teachers from small districts, as they design learning experiences for Missouri teachers. Tools such as streaming video designed for showcasing exemplar practices or videoconference software may be difficult to use in some of the smaller districts.

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